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Effect of Heat Stress on Coat Characteristics and Physiological Responses of Balady and Damascus Goats in Sinai, Egypt

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Abstract: This study was conducted to evaluate the effects of short- and long- term exposure to solar radiation during summer season on coat characteristics, some plasma biochemical constituents and thyroid activity in two breeds of goat (Balady, as an indigenous adapted breed and Damascus, as an exotic breed). The study was a part of project entitled "effect of acclimatization on energy requirements of goats" and carried out at the Experimental Unit of the Small Ruminant Research (at a small village namely Abou-El-feta, east of El-arish city, Northern Sinai, Egypt) which belongs to Desert Research Center (DRC), Ministry of Agriculture and Land Reclamation, Egypt. A total 10 bucks of two breeds of goats (five of Balady and five of Damascus breeds) were provided for this study. The animals were at 18 months of age at the commencement of the study, the live weights were 29.86 ± 2.41 and 49.22± 1.74 kg for Balady and Damascus breeds respectively. The animals were allowed to adapt in the sheltered pens conditions (7 days) as adaptation period followed by a pre-exposure period (period I) for 2 days inside the pens (shaded), followed by 4 days (period II, short- and long- term) of exposure to solar radiation (from sunrise till sunset), then by 2 days (period III) for recovery period. The same animals of each breed were used repeatedly in all experimental periods. Results indicated that Damascus has a great potentiality to be adapted to hot condition represented by higher in coat depth and hair long (2.1 and 13.00 cm) compared with Balady goats (1.6 and 9.75cm), while Balady goats had higher fiber diameter and medullated fiber percentage (101 μ and 68%) compared with Damascus one (79 μ and 41%).Results revealed that, live body weight (LBW) decreased significantly ($P<0.01$) at the end of heat stress (long-term). The rate of change in LBW was -2.85 and -3.33% for Balady and Damascus breeds, respectively. Plasma metabolites of TP, AL, GL, PUN, CHO, TL and GLU concentrations differed significantly by short (2 days) and long (4 days) period of exposure to solar radiation. Two days of heat stress (short period) decreased ($P<0.01$) significantly concentrations of these parameters. Prolonged exposure to solar radiation (4 days) increased ($P<0.01$) significantly concentrations of these parameters in both Balady and Damascus breeds. ALP and LDH activities followed the same trend of plasma parameters. Hypothyroidism due to significant reduction of T3 and T4 ($P<0.01$) was detected during short and long periods of exposure to solar radiation in both Balady and Damascus breeds.

Key words: Goat · Breed · Heat stress · Coat Characteristics · Plasma Metabolites · Thyroid activity

INTRODUCTION

The desert environment is characterized by a long hot summer with high solar radiation, along with poor and sparsely distributed pastures. Furthermore, water is limited and grazing animals depend on sparsely spaced watering points to satisfy their physiological needs. These harsh environments constitute stressful conditions to animals raised in these areas. Thus, these animals have developed various adaptive mechanisms that enable them to survive under these conditions of extreme heat and water stress. Goats are considered highly suitable animals for raising in such areas, as they were the first domesticated in the hot and arid regions of the world [1]. Heat stroke is more common in the summer and especially when the environmental temperature and relative humidity are high and with prolonged exposure to direct sunlight [2].

Fraction of radiation reflected by the animal's coat, the thermal resistance external to the animal's surface that retards loss of heat from the animal and the amount of the coat's thermal insulation through which radiation

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penetrates prior to absorption by a coat element [3, 4]. The physiological responses of animals to environmental stress during the summer and winter and their energy balance, showed that seasonal heat and cold stress have profound effects on some serum biochemical parameters [5, 6]. Heat stress as other types of stresses of chemical or psychosocial origin has been generally associated with detrimental effects on physiological equilibrium of the animal organism and various systems (nervous, endocrine and immune) have been implicated with specific responses and reciprocal regulatory influences [7]. Thyroid gland is one of the most sensitive organs to the ambient heat variation. It has been shown that thyroid hormones are important modulators of developmental processes and general metabolism [6, 8].

The present study was designed to evaluate coat characteristics. some plasma biochemical constituents and thyroid activity in comparison between Balady and Damascus (Shami) breeds of goat exposed to short- and long- term of solar radiation during summer season in Northern Sinai, Egypt.

MATERIALS AND METHODS

Site of Study: Geographically, the Experimental unit of the small ruminant research at Abou-El-feta village which lies between latitudes 31° 7' 54.84" N and longitudes 33° 48' 11.52" E. It lies at 20 km of El-arish City, Northern Sinai, Egypt.

Climatic Conditions: Ambient temperature (AT, °C) and relative humidity (RH, %) were measured three times daily at 6:00 (morning), 12:00 (mid-day) and 18:00 h (evening) using a thermometer and barometer throughout the study. Temperature–humidity index (THI) was calculated as follow:

$$THI = 0.8 \times AT.°C + (RH, \%) \times (AT°C - 14.4) / 100) + 46.4$$ [9].

Animals and Experimental Design: A total of 10 Bucks of two breeds of goat (5 of the short-eared Balady goat, characterized by its medium size, mainly black color and short hair and 5 of the long-eared Damascus goat, characterized by its big size, light brown color and long hair were used). The animals were at 18 months of age, the live weights were 29.86 ± 2.41and 49.22± 1.74 kg at the commencement of the study for Balady and Damascus breeds respectively. The animals were allowed to adapt in the sheltered pens conditions (7 days) as adaptation period, no measurements were taken during this period. The total duration of the experiment was 8 days, which was divided into three consecutive periods, 2 days for the pre-exposure period (period I) followed by 4 days for heat stress period (period II) and later 2 days for recovery period (period III). The same animals of each breed were used repeatedly in all experimental periods. The animals were feed Alflfa hay twice daily (11:00 and 18:00 h) based on LBW to meet the metabolic energy maintenance requirement according to Kearl [10]. On average hay samples contained [11] 87.5% DM, 12.9% ash, 14.2% crude protein (CP), 30.2% crude fiber (CF) and 3.2% ether extract (EE) on a dry matter (DM) basis. Fresh water was given once daily *ad.lib*. Throughout the experimental periods, animals proved to be free from internal and external parasites. All animals were kept under close clinical observation, according to Kelly [12].

Live Body Weight (LBW): Live body weight (LBW, kg) was measured at the beginning and end of each experimental period. The rate of change in LBW was calculated.

Sampling Methods: Four blood samples (two days interval) were taken from the jugular vein (at morning before access to feed and water) into 10 ml vacuum tubes contained Li-heparin as anticoagulant. Blood samples were centrifuged for 20 minutes at 3500 rpm to collect plasma and stored at -20 °C for biochemical analysis. For all metabolite assays, total plasma proteins, (TP, g/dl) was determined by the Biuret method according to Cannon *et al*. [13], albumin concentration (AL, g/dl) was determined by the method of Doumas *et al*. [14], total plasma globulins concentration (GL, g/dl) was calculated as the difference between total plasma proteins and plasma albumin, then albumin: globulin ratio (A/G, %) was calculated. Plasma urea nitrogen, (PUN, mg/dl) and plasma cholesterol, (CHO, mg/dl) concentrations were analyzed using available kits supplied by bioMe'ricux-France. Plasma total lipids (TL, mg/dl) and glucose (GLU, mg/dl) concentrations were estimated according to Stein, [15]. Plasma alkaline phosphatase (ALP, u/l) activity was estimated using specific kits supplied by bioMe'rieux-France according to Wahiefeid [16], plasma lactate dehydrogenase (LDH, u/l) activity was estimated using specific kits supplied by bioMe'rieux-France according to Cabaud and Wro'blewski [17]. Thyroxine (T_4) and triiodothyronine (T_3) concentrations were determined by radioimmunoassay, solid phase technique from Diagnostic Products Corporation, Los Angles, CA, USA.

Hair Samples: Coat depth was measured using a ruler and recorded as the distance between the skin surface and the coat surface in a vertical position. Hair samples from 10 X 10 cm patch of six body positions, three dorsals (Withers, Wth, Back, Bk and Rump, Rp) and three laterals (Shoulder, Sh, Mid-side, Ms and Britch, Br) using a metal square with 10 cm long of each side. Samples were taken from each animal as close as possible to the skin using fine scissors and then kept in plastic bags for further analysis. Fiber diameter (FD) was measured from ten samples using Image analyzer (LEICA Q 500 MC) with lens 4/0.12. A section of 0.2 mm in length was cut by a Hand-Microtom at a level of 2cm from the base of the staples of each sample. These cuttings were put on a microscope slide with 2-3 drops of paraffin oil and covered with a slide cover. About five hundred fibers were taken at random and measured from each sample. Medullated fibers percentage (M %) was recorded as the percentage of number of medullated fibers from the corresponding total fibers present in each sample during measuring FD. Fiber length measured in 50 fibers of each sample from back position using a ruler, much attention was taken not to stretch the fiber.

Statistical Analysis: Data were analyzed with the general linear model (GLM) of SAS [18]. Sources of variation for all dependent variables were tested. All effects were assumed fixed (breed and treatments). Animals within breeds considered as repeated measurements to avoid the individual differences among animals. Comparisons among means within each classification were tested using Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

Climatic Conditions: Mean climatologically values of ambient temperature (AT, °C), relative humidity (RH, %) and temperature-humidity index (THI) for the experimental periods are shown in Figure (1). From these data we can notice that, climatic conditions values in the mid-day were higher than the critical temperature of 24 to 27°C, for most species [19]. A THI of 74 or less is considered normal, 75 to 78 is alert status, 79 to 83 is danger status and a THI equal to or above 84 is an emergency [20]. In the present study the THI was higher than 83 in mid-days during short- and long-term of exposure to solar radiation (Fig. 1) and classified as severe.

Physical Coat Characteristics and Insulation: Coat is the first defense layer protecting animals from direct sunlight and this protection differs according to many factors like coat depth and hair characteristics. Damascus goats had significantly higher ($P<0.01$) coat depth compared with Balady one at back position (2.02 vs. 1.52 cm, respectively), that could help Damascus goat to protect itself especially from direct sunlight. Similar result was observed by Monteith, [21] who reported that thermal insulation by coat increased with increasing coat depth and attributed to the air spaces between the hair fibers. Coat depth was varied significantly ($P<0.01$) among body positions which reached the maximum depth in rump (Rp) position (2.6 and 2.1 for Damascus and Balady goats, respectively) and decreased till reached the minimum depth in shoulder (Sh) position (0.90 and 0.66 cm for Damascus and Balady goats, respectively). As seen in Figure 2 the dorsal line which faced solar radiation found to be higher significantly ($P<0.01$) compared with the lateral one (1.1 and 0.9 cm) in both Damascus and Balady goats, respectively. These differences between the dorsal and lateral lines and between breeds give a good indication to the importance of coat role in thermoregulation as well as the capability of Damascus goat to be adapted to hot areas like Balady one.

Helal [22] reported that wool production from the fleece could be represented by weight of hair produced from 100 cm^2. Damascus goats produce twice times compared with Baladi one (11.7 and 5.7 g, respectively). Body positions had a significant effect ($P<0.01$) on hair productivity. Back position (the intermediate position along the dorsal line) produce higher amount of hair compared with mid-side (the intermediate position along the lateral line of animal body positions) as shown in Fig. 3. The above results also emphasized that the insulation layer of hair coat found to be significantly higher in Damascus goats compared with Balady one as well as the importance of coat in animal thermoregulation during heat stress.

The obtained results revealed that the length of hair fibers in back position was higher in Damascus goats (13 cm) compared to Balady goats (9.75 cm). Acharya, *et al.* [23] illustrated that long haired goats tolerate radiant heat better than short haired goats and it will be important to select long haired goats for breeding and rearing in the hot tropics. Bertipaglia, *et al.* [24] reported that coat characteristics are very important for the adaptability to heat stress and great attention must be considered to coat characteristics especially when making

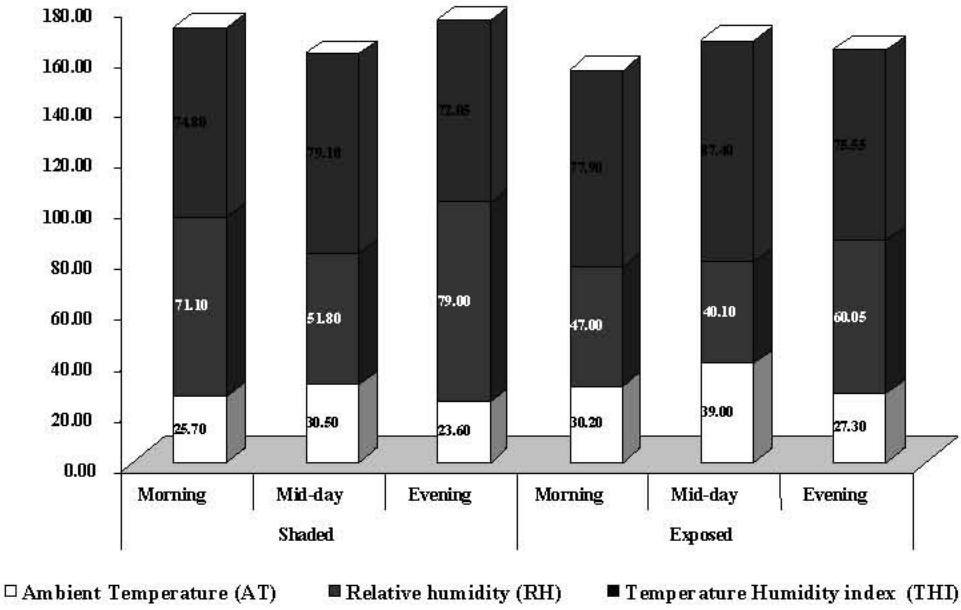

Fig. 1: Meteorological data during the experimental periods

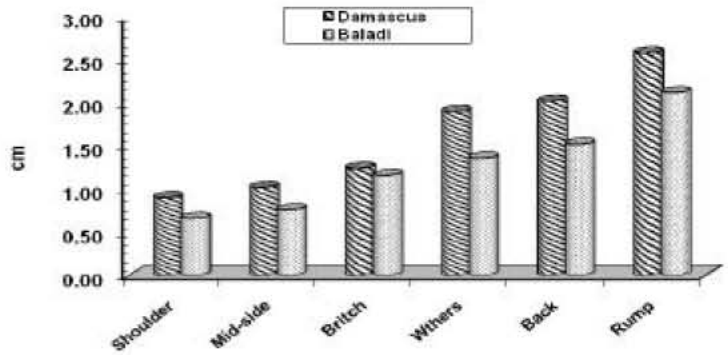

Fig. 2: The variation of coat depth among positions within breeds

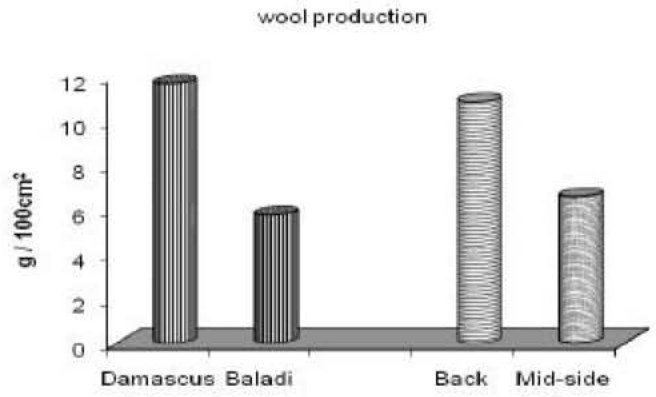

Fig. 3: Wool production between positions and breeds

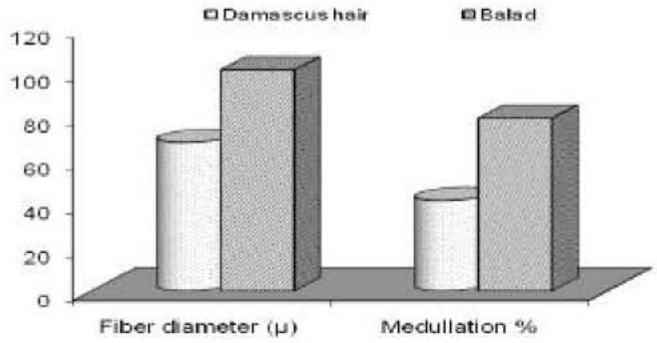

Fig. 4: Differences of fiber diameter and medullation percentage in both Damascus and Balady goats.

a selection for genetic progress of adaptation in tropical environment. The above results illustrated the capability of Damascus goats to live in semi-arid conditions. On the other hand, fiber diameter as shown in Fig. 4 illustrated that fiber diameter tended to be higher (101 vs. 68µ) in Balady compared to Damascus goats. The same trend was found for medullated fibers percentage, which was 79 vs. 41% in Balady and Damascus goats, respectively. The important of medulla in thermoregulation that it consists of cells full of space tended to reflect the rays and dispersal it through its walls. Also medulla structure in general similar to the cavity walls structure which contains a double cortex layers with space kept in-between which decrease the passage through the fiber from both sides. This explanation was in harmony with the result found by Øritsland and Ronald [25] who reported that the hair transmittance was negative correlated with medullation. Moreover, Fiber diameter tended to increase in summer and decrease in winter as reported by Litherland, *et al.* [26]. The previous result is glanced furtively to the important role of fiber diameter and medulla in heat stress conditions.

Live Body Weight Changes: At the start of study (pre-exposure to solar radiation) the average body weight was 29.86±2.41 and 49.22±1.74 kg for Balady and Damascus goats, respectively. Analysis of variance indicated that breed had highly (P<0.01) significant effect on LBW. Regarding the effect of heat stress on LBW, exposure to solar radiation for 4 days declined LBW to 29.01± 2.44 and 47.58± 1.53 kg for Balady and Damascus goats, respectively. The rate of change in LBW recorded -2.85 and -3.33% for Balady and Damascus goats, respectively. This result revealed that the rate of decrease was higher in Damascus compared to Balady breed. Similar results reported by Khalil *et al.* [27] who found that the prolonged exposure to solar radiation for 12 hr increased the loss in LBW and increased PCV in local and crossbred sheep.Hafez, [28] attributed the loss of body weight during exposure to solar radiation to the increase in energy expended for heat dissipation through respiratory evaporation and subsequently to the reduction in the amount of water available for storage.

Plasma Metabolites Responses

Plasma Proteins: The means ± SE of plasma TP, AL, GL concentrations and A/G ratio of Balady and Damascus breeds during the experimental periods are presented in Table 1. From our results we observed that, Damascus breed had the higher values in TP, Al, GL concentrations and A/G ratio (7.60±0.13, 3.02±0.07, 4.59±0.14 g/dl and 0.65±0.04%), respectively compared with Balady breed (6.56±0.19, 2.53±0.08, 4.03±0.17 g/dl and 0.63±0.03%), respectively. Statistical analysis showed that, breed had a high significant (P<0.01) effect on plasma proteins values (TP, Al, GL and A/G ratio) for Damascus breed.

Concerning the effect of heat stress, both Balady and Damascus breeds demonstrated that, at the 2nd day of heat stress (short period) TP, AL, GL and A/G ratio decreased significantly (P<0.01). The rate of change for TP, AL, GL and A/G ratio were (-10.39, -17.79, -5.71 and -11.11% vs. -11.31, -14. 90, -9.15 and -6.15%) for Balady and Damascus breeds, respectively. The above results may be referred to an increase in plasma volume as a result of heat shock during the first two days (short period) and subsequently the increase in blood volume leads to maintain both homeothermy peripheral vasodilation and sweating [29]. This increase in plasma volume during the first two days of heat stress caused decreasing in plasma proteins concentrations in both Balady and Damascus breeds. The increase in blood volume (hemodilution) may suggest the suffering of these animals at the first two days of exposure to heat stress.

Table 1: Means ±SE of plasma total protein (TP), albumin (AL), globulin (GL) concentration and Albumin/globulin ratio (A/G) in Balady and Damascus goats exposed to direct solar radiation

		Experimental periods					
		P1	P II Exposed for 2 days(A) and 4 days (B)				P III
Item	Breed	Pre-exposure	A	Change% P1 and A	B	Change % P1 and B	Recovery
TP, (g/dl)	Balady	6.56^{a} ±0.19	5.88^{a} ±0.21	-10.39	6.82^{a} ±0.07	3.96	6.64^{a} ±0.07
	Damascus	7.60^{b} ±0.13	6.74^{b} ±0.06	-11.31	7.90^{b} ±0.12	3.95	6.94^{a} ±0.15
AL, (g/dl)	Balady	2.53^{a} ±0.08	2.08^{a} ±0.04	-17.79	2.71^{a} ±0.05	7.11	2.41^{a} ±0.02
	Damascus	3.02^{b} ±0.07	2.57^{b} ±0.07	-14.90	3.23^{b} ±0.08	6.62	2.81^{a} ±0.06
GL, (g/dl)	Balady	4.03^{a} ±0.17	3.80^{a} ±0.21	-5.71	4.11^{a} ±0.07	1.98	4.23^{a} ±0.09
	Damascus	4.59^{b} ±0.14	4.17^{b} ±0.08	-9.15	4.67^{b} ±0.14	1.74	4.13^{a} ±0.11
A/G, (%)	Balady	0.63^{a} ±0.03	0.56^{a} ±0.03	-11.11	0.66^{a} ±0.02	4.76	0.57^{a} ±0.02
	Damascus	0.65^{b} ±0.04	0.61^{b} ±0.03	-6.15	0.69^{b} ±0.05	6.15	0.68^{a} ±0.02

P = Period.

In each column means followed by different letters are significantly different

Table 2: Means ±SE of plasma urea nitrogen (PUN), total cholesterol (CHO), total lipids (TL) and glucose concentrations (GLU) in Balady and Damascus goats exposed to direct solar radiation

		Experimental periods					
		P1	P II Exposed for 2 days(A) and 4 days (B)				P III
Item	Breed	Pre-exposure	A	Change% P1 and A	B	Change % P1 and B	Recovery
PUN (mg/dl)	Balady	26.32^{a}±2.06	23.79^{a}±1.48	-9.961	29.58^{a}±1.34	12.39	25.51^{a}±0.58
	Damascus	26.29^{b}±1.46	24.55^{b}±1.45	-6.62	27.46^{b}±1.13	4.45	27.14^{b}±0.80
CHO(mg/dl)	Balady	57.54^{a}±3.61	49.71^{a}±2.19	-13.61	61.75^{a}±4.09	7.32	55.73^{a}±2.38
	Damascus	59.65^{b}±3.6	55.90^{b}±1.96	-6.92	60.94^{b}±1.95	2.16	59.11^{b}±1.42
TL(mg/dl)	Balady	207.88^{a}±27.32	175.37^{a}±10.52	-15.64	210.01^{a}±11.52	1.02	205.00^{a}±4.90
	Damascus	224.71^{b}±10.35	203.03^{b}±21.54	-9.65	229.47^{b}±11.08	2.12	224.76^{b}±6.59
GLU(mg/dl)	Balady	50.30^{a}±2.31	42.63^{a}±0.70	-15.25	47.76^{a}±1.19	14.83	45.73^{a}±0.88
	Damascus	52.88^{b}±1.92	50.86^{b}±2.25	-3.82	59.46^{b}±1.75	12.44	53.26^{b}±1.98

P = Period

In each column means followed by different letters are significantly different

The prolonged exposure to solar radiation for 4 days period increased plasma TP, AL, GL concentrations and A/G ratio in both breeds. The rate of changes were (3.96, 7.11, 1.98 and 4.76% vs. 3.95, 6.62, 1.74 and 6.15%) for Balady and Damascus breeds, respectively. The opposite trend of plasma proteins at the fourth day of exposure to solar radiation indicated that decrease in plasma volume occurred (vasoconstriction) and subsequently prolonged heat exposures give rise to changes in plasma proteins concentrations. In accordance results were registered by Khalil *et al*, [27] who exposed local and crossbred sheep to solar radiation and found that plasma proteins (TP, AL, GL and A/G ratio) tended to increase at 6 hr of heat stress and the prolonged exposure to solar radiation for 12 hr followed the same trend in both local and crossbred sheep. Nazifi *et al.* [6] studied the influence of thermal stress on serum parameters of dromedary camels and found that, the concentrations of TP,GLU and the activities of ALT,AST and ALP were higher in summer ($P<0.05$) than in winter.

During recovery period, the mean values of plasma TP, AL, GL concentrations and A/G ratio were 6.64±0.07, 241±0.02, 4.23±0.09 g/dl and 0.57±0.02% vs. 6.94±0.15, 2.81±0.06, 4.13±0.11 g/dl and 0.68±0.02% for Balady and Damascus breeds, respectively. These results showed that, both breeds were able to rapid recovery from heat stress but recovery was more rapid in Balady breed.

Plasma PUN, CHO, TL and GLU: The means ± SE of plasma PUN, CHO, TL and GLU concentrations of Balady and Damascus breeds during the experimental periods are presented in Table 2. From our results we observed that, Damascus breed had the higher values in PUN, CHO, TL and GLU concentrations (26.29±1.46, 59.65±3.68, 224.71±10.35 and 52.88±1.92 mg/dl), respectively compared with Balady breed (26.32±2.06, 57.54±3.61, 207.88±27.32 and 50.30±2.31 mg/dl) respectively. Statistical analysis showed that, breed had a high significant ($P<0.01$) effect on plasma concentrations of PUN, CHO, TL and GLU for Damascus breed.

Regarding the effect of heat stress, as seen in Table 2 the trend of plasma PUN, CHO, TL and GLU concentrations differed by short (2 days) and long (4 days) period of exposure to solar radiation. At the 2nd day of exposure to solar radiation (short period) PUN, CHO, TL and GLU concentrations decreased significantly (P<0.01) where these parameters followed the same trend of plasma proteins. The rate of change for PUN, CHO, TL and GLU were (-9.61, -13.61, -15.64 and -15.25 % vs. -6.62, -6.29, -9.65 and -3.82%) for Balady and Damascus breeds respectively. In accordance, Ocak *et al.* [30], Darcan [31] and Joshi *et al.* [32] reported that GLU and CHO concentrations decreased with high ambient temperature in kids, crossbred goat and bucks, respectively. Similar results were reported by Shaffer *et al.*[33], Abdel-Samee [34], Marai *et al.*[35] and Habeeb *et al.* [36] showed that cholesterol concentration decreased with the increase in environmental temperature, the marked decrease in CHO concentration may be due to dilution as a result to the increase in total body water or to the decrease in acetate concentration, which is the primary precursor for the synthesis of cholesterol. Marai *et al.* [35] and Habeeb *et al.* [36] reported that total lipids concentration decreased significantly with prolonged exposure to high environmental temperature. Such phenomenon my be due to the increase in either body water content or utilization of fatty acids for energy production as a consequence of the decrease in glucose concentration.

The prolonged exposure to solar radiation (at the 4th day of heat stress) increased significantly (P<0.01) plasma PUN, CHO, TL and GLU concentrations. The rate of change for PUN, CHO, TL and GLU were (12.39, 7.32, 1.02 and 14.83 % vs. 4.45, 2.16, 2.12 and 12.44 %) for Balady and Damascus breeds respectively. Webster, [37] demonstrated that the increase in plasma glucose during hot conditions may be due to the decrease in the glucose utilization, depression of both catabolic and anabolic enzyme secretions and subsequent reduction of metabolic rate.

During recovery period, the mean values of plasma PUN, CHO, TL and GLU concentrations were 25.51±0.58, 55.73±2.38, 205.00±4.90 and 45.73±0.88 mg/dl vs. 27.14±0.80, 59.11±1.42, 224.76±6.59 and 53.26±1.98 mg/dl for Balady and Damascus breeds, respectively. These results show that, both breeds were able to rapid recovery from heat stress but recovery was more rapid in Balady breed.

Enzymes Activity: As seen in Table 3, mean values of ALP and LDH concentrations at pre-exposure to solar radiation were (5.95±1.19 and 14.82±0.53 vs. 5.66±0.23 and 14.60±0.70) for Balady and Damascus goats, respectively. Analysis of variance indicated that, breed had non-significant effect on ALP and LDH.

Regarding the effect of heat stress, the results in Table 3 showed that ALP and LDH tended to decrease (P<0.01) at the 2nd day of heat stress (short period). The rate of change was (-15.16 and -8.91 vs. -7.24 and -8.56) for Balady and Damascus, respectively. Nazifi *et al.* [38] found that the concentration of LDH was higher in cold stress than in heat stress. Also, Collier *et al.*[39], Kamal *et al.*[40] and Sevi *et al.* [41] reported that the rise in ambient temperature decreased ALT and ALP concentrations in dairy animals and in Friesian cows, respectively. This decrease may be due to a reduction in thyroid hormones secretion, which has been found by several groups in heat stressed animals. The prolonged heat stress (4 days) increased (P<0.01) ALP and LDH concentrations. The rate of change was (7.39 and 13.49 vs. 5.48 and 5.27) for Balady and Damascus, respectively. This increase in both ALP and LDH concentrations may be due to the reduction in plasma volume. During recovery period, the mean values of plasma ALP and LDH concentrations were 5.30±0.11 and 14.32±0.66 u/l vs. 5.32±0.27 and 14.60±0.70 u/l) for Balady and Damascus breeds, respectively. These results showed that, both breeds were able to rapid recovery from heat stress but recovery was more rapid in Balady breed.

Thyroid Activity: As seen in Table 4, plasma T_3 and T_4 concentrations were similar in pre-exposure to direct solar radiation in Balady and Damascus breeds. Plasma concentrations of T_3 and T_4 decreased (P<0.01) by short (2 days) and long (4 days) exposure to direct solar radiation. Gal [42] reported that the environmental temperature has been associated with the activity of the thyroid gland. As expected, thyroid function in animals should decline as an acclimation response to increased heat after a few days to alleviate heat stress [43, 44]. This decline in thyroid function during heat stress may be due to effect of heat on hypothalamic pituitary axis to cause reduction in thyrotropin releasing hormone which enables the animal to reduce basal metabolism [45]. Many investigators have reported that the higher body temperature during exposure to heat stress is associated with significant depression in thyroid gland activity resulting in a lowering of thyroid hormones level [46, 47].

Table 3: Means±SE of plasma alkaline phosphatase (ALP) and lactate dehydrogenase (LDH) concentrations in Balady and Damascus goats exposed to direct solar radiation

		Experimental periods					
		P1	P II Exposed for 2 days(A) and 4 days (B)				P III
Item	Breed	Pre-exposure	A	Change% P1 and A	B	Change % P1 and B	Recovery
ALP (µ/l)	Balady	5.95^{a}±1.19	5.03^{a}±0.20	-15.46	6.39^{a}±0.09	7.39	5.30^{a}±0.11
	Damascus	5.66^{a}±0.23	5.25^{b}±0.30	-7.24	5.97^{b}±0.27	5.48	5.52^{a}±0.27
LDH (µ/l)	Balady	14.82^{a}±0.53	13.50^{a}±0.36	-8.91	16.82^{a}±0.82	13.49	14.32^{a}±0.66
	Damascus	14.60^{a}±0.70	13.35^{b}±1.03	-8.56	15.37^{b}±0.45	5.27	14.60^{a}±0.70

P = Period.

In each column means followed by different letters are significantly different

Table 4: Means ±SE of plasma concentrations of triiodothyronine (T_3) and thyroxine (T_4) in Balady and Damascus goats exposed to direct solar radiation

		Experimental periods					
		P1	P II Exposed for 2 days(A) and 4 days (B)				P III
Item	Breed	Pre-exposure	A	Change% P1 and A	B	Change % P1 and B	Recovery
T_3 (ng/ml)	Balady	1.68^{a}±0.171	1.19^{a}±0.161	-29.17	0.94^{a}±0.089	-44.05	1.4^{a}±0.158
	Damascus	1.88^{a}±0.178	1.40^{b}±0.148	-25.54	1.06^{b}±0.066	-43.62	1.34^{a}±0.074
T_4 (µg/dl)	Balady	5.54^{a}±0846	4.20^{a}±0.535	-24.19	3.24^{a}±0.397	-41.52	5.34^{a}±0.524
	Damascus	5.72^{a}±0.886	4.62^{b}±0.818	-19.23	4.26^{b}±0.742	-25.53	5.00^{a}±0.658

P = Period. In each column means followed by different letters are significantly different

During recovery period, the mean values of plasma T_3 and T_4 concentrations were 1.4±0.158 ng/ml and 5.34±0.524 µg/dl vs. 1.34±0.047 ng/ml and 5.00±0.658 µg/dl) for Balady and Damascus breeds, respectively. These results showed that, both breeds were able to rapid recovery from heat stress but recovery was more rapid in Balady breed.

CONCLUSION

In both Balady and Damascus goats, plasma biochemical parameters differed by the period of exposure to solar radiation. Short period of heat stress (2 days) caused significant ($P<0.01$) decreases in TP, AL, GL, PUN, CHO, TL and GLU concentrations. The prolonged heat stress (4 days) caused increases in concentrations of these parameters. Hypothyroidism due to reduced triiodothyronine (T_3) and thyroxine (T_4) concentrations was induced at short and long periods of exposure to heat stress in both breeds. Coat characteristics are very important for the adaptability to heat stress. Damascus have a great potentiality to be adapted to hot condition represented b y higher in coat depth at Back position and hair long (2.02 and 13.00 cm) compared with Balady goats (1.52 and 9.75 cm), while Balady goats had higher fiber diameter and medullated fiber percentage (101 µ and 68 %) compared with Damascus one (79 µ and 41 %), respectively. Both coat and physiological parameters support, predict and forecast that Damascus goats had the potentiality to grow in semi-arid conditions. Further studies n eed for the contribution of hair and skin color in the adaptability of both Damascus and Balady goats.

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