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Effect of Summer Shearing on Some Blood Constituents, Thyroid Gland and Cortisol Responses of Balady and Damascus Goats in Desert of Sinai, Egypt

M.S. Abdel-Fattah

Department of Animal Physiology, Animal and Poultry Production Division.
Desert Research Center, Egypt

Abstract: This study was performed to evaluate the effect of shearing under heat stress on some blood constituents, thyroid gland and plasma cortisol responses in two breeds of goat (Balady and Damascus). The study was carried out at the Experimental Unit of the Small Ruminant Research (at a small village namely Abou-Elfeta, east of Al-Arish city, Northern Sinai, Egypt), Desert Research Center (DRC), Egypt. A total 10 Bucks of two breeds of goats (five of each Balady and Damascus) were provided for this study. The animals were at 18 months of age, the live weights were 29.86±2.11 and 49.22±2.11 kg for Balady and Damascus breeds, respectively. The animals were placed in metabolic cages individually and maintained outdoor (exposed to direct solar radiation) throughout the experimental period (eight days). All animals were weighed at the beginning and end of each experimental period (pre and post-shearing periods). Plasma metabolites of total proteins (TP, g/dl), albumin (A, g/dl), globulin (G, g/dl), total cholesterol (TC, mg/dl), total lipids (TL, mg/dl), urea nitrogen (PUN, mg/dl), glucose (GLU, mg/dl) alakaline phosphates (ALP, u/dl), lactate dehydrogenase (LDH, u/dl), triiodothyronine (T_3, ng/ml), thyroxine (T_4, µg/dl) and plasma cortisol (COR, ng/ml) concentration were estimated. Results revealed that, live body weight (LBW) was decreased significantly ($P<0.01$) at the end of heat stress (pre-shearing period). The rate of change in LBW was -2.85 and -3.33% for Balady and Damascus breeds, respectively, while shearing had increased ($P<0.01$) LBW by 3.31 and 2.67% for Balady and Damascus breeds, respectively. Both breeds were marked consistent trend by minor decrease in TP, A and G concentrations at the 1st, 2nd and 3rd days of heat stress followed by pronounced increase in the 4th day of pre-shearing period, while shearing under heat stress increased TP, A and G concentrations about 20.30, 27.52 and 15.96%, respectively. Heat stress caused reduction in plasma PUN, TC, TL and GLU concentrations in both breeds during the first two days of pre-shearing period, while shearing under heat stress increased significantly ($P<0.01$) PUN, TC, TL and GLU concentrations by about 22.77, 11.50, 8.10 and 10.56%, respectively. For thyroid gland activity, plasma T_3 and T_4 were decreased significantly ($P<0.01$) during pre-shearing period with rate of change about -44.05 and -41.52 % vs. -43.62 and -25.52 % for Balady and Damascus breeds, respectively, while shearing under heat stress increased ($P<0.01$) T_3 and T_4 concentrations about 12.00 and 38.23 % vs. 7.26 and 12.33 % for Balady and Damascus breeds, respectively. In both breeds, plasma COR levels elevated only on the 1st and 2nd days of post-shearing period and recovered quickly to basal concentrations on the 3rd day after shearing.

Key words: Blood constituents · Cortisol · Goat · Heat Stress · Summer shearing · T_3 · T_4

INTRODUCTION

Studies of shorn and unshorn sheep, exposed to extreme environmental conditions, have long demonstrated the importance of the fleece for the maintenance of homeothermy [1, 2]. Previous study on Barki and Barki x Merino cross sheep in Egypt showed that shearing had no significant effect on lamb performance during summer [3], whereas in Iraq [4] found a slight but non-significant increase in lamb performance

Corresponding Author: M.S. Abdel-Fattah, Animal Physiology Department, Animal Production Division, Desert Research Centre, Cairo, Egypt.

as affected by autumn shearing. On contrast, Lamia [5] reported that summer shearing had no significant effect on daily gain and feed efficiency of fattening Awassi lambs. Shearing is a method by which producers attempt to reduce heat stress in growing or finishing lambs. Lambs are recommended to be shorn early in the feeding period to improve feed consumption, gain and efficiency of feed conversion, especially in warm weather. Research has supported this recommendation, indicating shorn sheep consume more hay and concentrates than non-shorn sheep under heat stress conditions [6]. Shearing modifying the direction and magnitude of heat exchange, shifts the zone of metabolic thermo-neutrality impeding the maintenance of homeothermy especially in extreme environment [7]. Sheep with long wool were reported to be less sensitive to solar heating than newly shorn animals [8, 9]. The removal of the fleece in animals adapted to grazing under the sun at the hottest times of day is considered a necessary practice by the shepherds, not only for hygienic reasons, but also to enable animals to better withstand exposure to high temperatures. The effect of shearing on physiological and haematochemical parameters was reported by Symonds *et al*. [10], Symonds *et al*. [11], Dy´rmundsson [12], Piccione *et al*. [13,14]. Shorn sheep are known to better withstand exposure to high ambient temperature [15-18].

Cholesterol is synthesized mainly in the liver but its concentrations also depend on the diet supply [19]. The lipolytic glucocorticoids stimulate fat mobilization from adipose tissue and increase the circulating concentrations of free fatty acids [19, 20]. Thus, an increase of plasma cholesterol concentrations would be expected after a stress episode and some authors have found such increase [21, 22]. Fidan *et al*. [23] reported that, a moderate elevation of 11% of the cholesterolemia was observed after shearing. Plasma cholesterol concentrations would also be reduced during stress [24]. As both increases and decreases of serum cholesterol and triglyceride concentrations have been related to stress [25], these biochemical parameters are considered to poor indicators for stress and welfare [26]. Daramola *et al*. [27] mentioned that, although stress isn't the only reason that cortisol is secreted into the bloodstream, it has been termed ''the stress hormone'' because it's also secreted in higher levels during the body's response to stress and is responsible for several stress-related changes in the body. Shearing induces variations of plasma cortisol, T_3 and T_4 concentrations [28].

This work was designed to evaluate impact of summer shearing on some blood constituents, thyroid gland activity and plasma cortisol concentration in comparison between Balady and Damascus (Shami) breeds of goat in desert of Sinai, Egypt.

MATERIALS AND METHODS

Climatic Conditions: Meteorological data including ambient temperature (AT,°C) and relative humidity (RH, %) were recorded using Hygro-thermometer during measurement of the thermo-regulatory traits. Data were recorded each 6 hours (at 06:00 a.m., 12:00 m.d and 06:00 p.m). A temperature-humidity index (THI) is a single value representing the combined effects of air temperature and humidity. The mean temperature-humidity index (THI) was calculated using the following equation:

$$THI = 0.8 \times AT°C + (RH, \%) \times (AT°C - 14.4) / 100) + 46.4$$ [29].

Mean climatologically values of (AT, °C), (RH, %) and (THI, unit) for the experimental periods are shown in Table 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 [30]. 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 [31]. In the present study the THI was higher than 83 in mid-days during pre and post-shearing periods and classified as severe.

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 for Balady and Damascus breeds respectively. The animals were placed in the individual metabolic cages throughout the experiment. During pre-shearing period, both breeds were maintained in outdoor and left un-shorn (4-days) which served as control period (pre-shearing). At 06:00 am on the 5th day, before feed and water offering, the same animals were under handling fully shearing process by professional shearers (leaving only about 3 to 5 mm hair fibers above the skin surface). Then, shorn animals were replaced in their metabolic crates for 4-days served as treated period (post-shearing). The animals were feed

Table 1: Means±SE of ambient temperature (AT,°C), relative humidity (RH, %) and temperature-humidity index (THI) during pre and post-shearing periods.

		Climatic Parameters		
Period	Time of day	AT,°C	RH, %	THI
Period (I)	06:00 a.m.	29.5±0.04	47.5±0.65	77.2±0.05
(Pre-shearing)	12:00 m.d.	39.2±0.12	31.5±0.96	85.5±0.11
Un-shaded	06:00 p.m.	33.5±0.29	31.3±0.48	79.2±0.31
Average		34.10	36.80	80.63
Period (II)	06:00 a.m.	29.0±0.41	45.8±1.7	76.3±0.37
(Post-shearing)	12:00 m.d.	39.6±0.24	29.0±0.41	85.4±0.18
Un-shaded	06:00 p.m.	33.5±0.29	30.3±0.63	79.0±0.25
Average		34.03	35.03	80.23

MR= morning reading (at 06:00 hr); MD= mid-day reading (12:00 hr); EV= evening reading (at 06:00 hr);

Alfalfa hay twice daily (11:00 and 18:00 h) based on LBW to meet the metabolic energy maintenance requirement according to Kearl [32]. On average hay samples contained 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 [33]. 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.

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.

Blood Sampling: Daily, on the morning, approximately 10 ml of blood was taken from jugular vein of each animal in test tubes containing Lithium 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) and albumin concentrations (A, g/dl) were determined using available kits supplied by bioMèricux-France company according from which plasma globulin concentration (G, g/dl) was calculated as the difference between total plasma proteins and plasma albumin. Plasma urea nitrogen (PUN, mg/dl), total cholesterol (TC, mg/dl) total lipids (TL, mg/dl), glucose (GLU, mg/dl) concentrations were analyzed using available kits supplied by bioMèricux-France company. Plasma alkaline phosphatase (ALP, u/dl) and lactate dehydrogenase (LDH, u/dl) activities were estimated using specific kits supplied by bioMèricux-France Company.

Thyroid Gland Hormones Assays: Triiodothyronine (T_3, ng/ml) and thyroxine (T_4, µg/dl) concentrations were determined according to Barker and Silverto [34] by using commercial kits supplied by Monobind Inc.

Plasma Cortisol Hormone Assay: Plasma cortisol concentration (ng/ml) was determined by ELISA method as described by Munro and Lasley [35].

Statistical Analysis: The data for performance and carcass traits were statistically analyzed using general linear model of GLM procedure SAS [36]. Differences between means were tested by Duncan Multiple Range Test [37].

RESULTS AND DISCUSSION

Climatic Conditions: The environmental temperatures, relative humidity and temperature humidity index levels on the experimental days are presented in Table 1. The average values of climatic conditions (AT, RH and THI) during pre-shearing (34.10°C, 36.80 % and 80.63) and post shearing (34.03°C, 35.03 % and 80.23) periods are considered as heat load during the experimental period.

Live Body Weight Changes: Means±SE of LBW changes during pre and post-shearing periods for Balady and Damascus breeds are presented in Table 2. At the start of study (pre-shearing period) the average of body weight was 29.86±2.11 and 49.22±2.11 kg for Balady and Damascus goats, respectively. Analysis of variance indicated that breed had highly ($P<0.01$) significant effect on LBW. The exposure of un-shorn animals to direct solar radiation for 4-days decreased LBW to 29.01±2.11 and 47.58±2.11 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 were reported by Khalil *et al.* [38], who found that the prolonged exposure to solar radiation for 12 hr increased the loss in LBW in local and crossbred sheep. Also, Rahardja [39] found that, exposure to direct sunlight and restricted

Table 2: Means±SE of live body weight (LBW, kg) for Balady and Damascus breeds during pre and post-shearing periods in summer season

	Period I (Pre-shearing)				Period II (Post-shearing)			
Breed	Initial	Final	Change,%	Average	Initial	Final	Change,%	Average
Balady	29.86^{a}	29.01^{b}	-2.85	29.43^{B}	29.01^{b}	29.97^{a}	3.31	29.49^{B}
±SE	2.11			1.5	2.11			1.5
Damascus	49.22^{a}	47.58^{b}	-3.33	48.39^{A}	47.58^{b}	48.85^{a}	2.67	48.215^{A}
±SE	2.11			1.5	2.11			1.5

^{a,b} within a row indicate a significant difference (P<0.05) daily between initial and final of each period

^{A,B} Average in the same column are statistically (P<0.05) difference between breeds

Table 3: Means±SE of daily plasma total proteins, albumin and globulin concentrations (g/dl) during pre and post-shearing periods of Balady and Damascus goats

		Pre-shearing (Un-shaded)			Post-shearing (Un-shaded)		
		Day mean±SE					
Days	Breed	TP	A	G	TP	A	G
Day 1	Balady	6.56±0.10	2.53±0.06	4.03±0.08	6.98±0.10	2.74±0.06	4.24±0.08
	Damascus	7.00±0.10	3.01±0.06	3.99±0.08	7.77±0.10	3.15±0.06	4.62±0.08
Day 2	Balady	5.88±0.10	2.08±0.06	3.80±0.08	7.46±0.10	2.84±0.06	4.61±0.08
	Damascus	6.74±0.10	2.97±0.06	3.77±0.08	8.02±0.10	3.42±0.06	4.60±0.08
Day 3	Balady	5.55±0.10	2.00±0.06	3.55±0.08	7.52±0.10	2.89±0.06	4.62±0.08
	Damascus	6.34±0.10	2.14±0.06	4.20±0.08	8.14±0.10	3.43±0.06	4.71±0.08
Day 4	Balady	6.82±0.10	2.71±0.06	4.11±0.08	7.70±0.10	2.90±0.06	4.80±0.08
	Damascus	7.90±0.10	3.23±0.06	4.67±0.08	8.05±0.10	3.45±0.06	4.60±0.08
Average±SE							
Balady		6.20±0.10^{B}	2.33±0.06^{B}	3.87±0.08^{B}	7.41±0.10^{B}	2.84±0.06^{B}	4.57±0.08^{B}
Damascus		7.00±0.10^{A}	2.84±0.06^{A}	4.16±0.08^{A}	7.99±0.10^{A}	3.36±0.06^{A}	4.57±0.08^{B}
Overall mean±SE		6.6±0.07^{b}	2.58±0.04^{b}	4.01±0.06^{b}	7.70±0.07^{a}	3.10±0.04^{a}	4.60±0.06^{a}

TP = total proteins; A = albumin; G = globulin; ^{a,b} within a row indicate a significant difference (P<0.05) daily between pre and post-shearing, ^{A,B} Average in the same column are statistically (P<0.05) difference between breeds.

water for 10 days decreased LBW from 16.92±1.44 to 15.30±1.25 in five does of Kacang goat placed in metabolism cages and attributed this decrease in body weight to a great loss of body water. Hafez [40] 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. Literature on goats reported a marked depression of food intake and weight when animal were exposed to high temperatures of tropical areas [41].

Concerning the effect of shearing stress on LBW, the obtained results indicated that LBW before shearing was 29.01±2.11 and 47.58±2.11 kg for Balady and Damascus goats, respectively. At the end of post-shearing period (4-days), LBW reached 29.97±2.11 and 48.85±2.11kg for Balady and Damascus goats, respectively. The rate of change in LBW after shearing recorded 3.33 and 2.67% for Balady and Damascus goats, respectively. Therefore, shearing increased significantly (P<0.01) LBW in both breeds. These results could be give evidence that both breeds were affected to heat stress, but it is evidently both breeds showed a different sensitivity to heat stress during pre and post-shearing periods in comparison with them. Aleksiev [42] reported that during the second and third month after shearing (on May 29th) the average daily gain in shorn sheep was higher (P<0.05) compared to unshorn ones. Also, Piccione *et al.* [18] found that, shearing has not a significant effect on body weight in ewes because the removal of the fleece, considered a necessary practice for hygienic conditions, does not involve a significant difference in weight between the shorn and un-shorn groups, since the weight of the fleece is minimal (0.80 kg).

Blood Constituents:

Changes in Plasma Proteins: Table 3 summarizes the means±SE of plasma total proteins, albumin and globulin concentrations for Balady and Damascus goat during pre and post-shearing period. Statistical analysis indicated that there was breed differences on TP, A and G where during pre-shearing period Damascus breed had the higher (P<0.01) values (7.00±0.10, 2.84±0.06 and 4.16±0.08 g/dl) than those of Balady breed (6.20±0.10, 2.33±0.06 and 3.87±0.08 g/dl) for TP, A and G, respectively. The corresponding values during post-shearing period were (7.99±0.10, 3.36±0.06 and 4.63±0.08 g/dl vs. 7.41±0.10, 2.84±0.06 and 4.57±0.08 g/dl) for Damascus and Balady breeds, respectively.

Regarding the effect of heat stress, the obtained results indicated that, both breeds were marked consistent trend by minor decrease was observed in TP, A and G concentrations at the 1st, 2nd and 3rd days of heat stress followed by pronounced increase in the 4th day of pre-shearing period. These changes in plasma proteins concentrations may be due to the fluid shift between the compartments of the organism that assume an important role in the physical protection in the comparisons of the temperature [13]. The reduction in plasma proteins at the 1st, 2nd and 3rd days of heat stress demonstrated by Pennisi *et al*. [43] observed a decrease in haematocrit values and total proteins concentrations in unshorn ewes in comparison to the shorn ewes and these values indicate a higher level of hydration in these animals. Olsson *et al*. [44] reported that hemodilution was observed in both fed and food-deprived goats during heat stress. As shown in Table 3 the rate of change in plasma TP, A and G recorded 3.96, 7.11 and 1.98 % for Balady breed. The corresponding values for Damascus breed were 11.39, 7.31 and 17.04 % at the end of pre-shearing period. It could be concluded that breed had strong effect on plasma proteins concentrations under heat stress. In accordance, El-Nouty *et al*. [45] on goats, found that the rise in ambient temperature during summer was associated with a significant increase in TP due to the significant increase in A and the slight rise in G concentrations. Additionally, El-Masry and Marai [46] related the variations in serum proteins to alteration in thyroid hormone level and in albumin or globulin concentrations. It can be noticed that both breeds recorded significantly ($P<0.05$) higher values of plasma albumin by similar value (7.11 and 7.31 %) for Balady and Damascus breeds, respectively. The significant increase in plasma albumin suggested normal status of liver function, since liver is the main organ of albumin synthesis. The obtained results are in accordance with those reported by El-Shaer [47], Mahrous and Abou Ammou [48] for sheep and Kholif [49] for goats. Concerning the effect of shearing stress, the results indicated that, regardless the effect of breed the overall means of TP, A and G concentrations were significantly ($P<0.05$) lower during pre-shearing period (6.60±0.07, 2.58±0.04 and 4.01±0.06 g/dl) than that during post-shearing period (7.70±0.07, 3.10±0.04 and 4.60±0.06 g/dl). Therefore, shearing increased TP, A and G concentrations about 16.70, 20.15 and 14.71%. In accordance, Mohamed and Abdelatif [50] reported that serum albumin concentration decreased significantly ($P<0.05$) during summer compared to winter season in unshorn rams. On the contrary, a significantly higher serum albumin concentration was reported in unshorn desert rams by Ahmed and Abdelatif [51].

With respect the effect of day, results in Table 3 stated that both breeds showed differences between the day mean values of TP, A and G concentrations during pre and post-shearing periods. The removal of the fleece, in fact, results changes in the metabolism of proteins in relation to exposure to heat stress [17]. The changes in serum concentration of total proteins may be due to fluid shift between the compartments of the organism that assume an important role as far as the physical protection in comparisons of the temperature. As previously observed for total proteins concentration was lower in unshorn ewes in comparison to the shorn ewes and these values indicate a higher level of hydration in these animals [43]. Therefore, it is possible to evidence a haemoconcentration characterized from an increase of total proteins in shorn ewes [52].

Changes in PUN, TC, TL and GLU Concentrations: The means±SE of plasma PUN TC, TL and GLU concentrations of Balady and Damascus breeds during pre and post-shearing periods are presented in Table 4. From our results, we observed that the overall means of TL and GLU for Damascus breed had the higher values (216.82±3.01 and 54.69±0.58 mg/dl), respectively compared with Balady breed (199.01±3.01 and 49.59±0.58 mg/dl), respectively. Statistical analysis showed that, breed had a higher significant effect ($P<0.01$) on plasma concentrations of TL and GLU for Damascus breed. The reduction in plasma PUN, TC, TL and GLU concentrations during the first two days of heat stress may be referred to an increase in plasma volume as a result of heat shock and subsequently the increase in blood volume leads to maintain both homeothermy peripheral vasodilation and sweating [38]. This increase in plasma volume during the first two days of pre-shearing period caused decreasing in plasma PUN TC, TL and GLU 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 direct solar radiation. Olsson *et al.* [44] reported that hemodilution was observed in both fed and food-deprived goats during heat stress. In accordance, Ocak *et al*. [53], Darcan [54] and Joshi *et al*. [55] reported that TC and GLU concentrations decreased with high ambient temperature in kids, crossbred goat and bucks,

Table 4: Means±SE of daily plasma urea nitrogen, total cholesterol, total lipids and glucose concentrations (mg/dl) during pre and post-shearing periods of Balady and Damascus goats

		Pre-shearing (Un-shaded)				Post-shearing (Un-shaded)			
		Day mean±SE							
Days	Breed	PUN	TC	TL	GLU	PUN	TC	TL	GLU
Day 1	Balady	26.23	57.54	207.9	50.3	29.89	60.94	209.05	50.22
	Damascus	26.29	59.65	224.71	52.88	26.43	59.08	215.75	53.38
Day 2	Balady	23.79	49.71	175.4	42.63	31.25	64.67	211.14	53.25
	Damascus	24.55	55.90	203.03	50.86	31.47	61.35	219.85	55.51
Day 3	Balady	21.88	46.97	153.85	42.23	31.12	64.83	212.40	55.06
	Damascus	25.73	55.29	209.05	51.63	31.38	61.14	221.70	56.88
Day 4	Balady	29.58	61.75	210.01	47.76	32.92	64.69	212.43	55.32
	Damascus	27.46	60.94	218.75	59.46	31.61	61.68	221.77	56.96
±SE		0.06	1.16	4.26	0.82	0.60	1.16	3.01	0.80
Average±SE									
Balady		25.40±0.60^{A}	53.99±1.16^{B}	186.8±4.26^{B}	45.73±0.82^{B}	31.3±0.60^{A}	63.8±1.16^{A}	211.2±4.3^{B}	53.46±0.80^{B}
Damascus		26.01±0.6^{A}	57.94±1.16^{A}	213.88±4.26^{A}	53.71±0.82^{A}	30.2±0.60^{A}	60.8±1.16^{B}	219.8±4.3^{A}	55.68±0.80^{A}
Overall mean±SE		25.70±0.39^{b}	55.97±0.82^{b}	200.34±3.01^{b}	49.72±0.58^{b}	31.00±0.39^{a}	62.30±0.82^{a}	215.53±3.01^{a}	54.57±0.58^{a}

PUN=plasma urea nitrogen; TC= total cholesterol; TL= total lipids; GLU= glucose.

^{a,b} within a row indicate a significant difference (P<0.05) daily between pre-shearing and post-shearing.

^{A,B} Average in the same column are statistically (P<0.05) difference between breeds.

respectively. Similarly, Shaffer *et al*. [56], Abdel-Samee [57], Marai *et al*. [58] and Habeeb *et al*. [59] showed that TC concentration decreased with the increase in environmental temperature, the marked decrease in TC concentration may be due to the decrease in acetate concentration, which is the primary precursor for the synthesis of cholesterol. Marai *et al*. [58] and Habeeb *et al.* [59] reported that TC concentration decreased significantly with prolonged exposure to high environmental temperature. Such phenomenon may be due to the increase in utilization of fatty acids for energy production as a consequence of the decrease in GLU concentration.

Pennisi *et al*. [60] evaluated the effect of type of housing system during summer period and found that, there was a significant effect of the type of housing system (ewes stabled in a modern and efficient barn compared to ewes stabled in a net-shaded paddock) on energetic parameters: glucose (P<0.01), triglycerides (P<0.004), total cholesterol (P<0.001) and total lipids (P<0.001). The open-front barn provides a total degree of protection from sun direct radiations compared to the 80% offered by the net. Consequently the direct solar radiation could be responsible for the metabolic variations observed in net-shaded paddock ewes. Similar results were reported by Piccione *et al*. [61] and Cascone *et al*. [62].

Regarding the effect of shearing stress the results in Table 4 indicated that, shearing under heat stress increased (P<0.05) PUN TC, TL and GLU levels, the overall means of PUN TC, TL and GLU concentrations were significantly (P<0.05) lower during pre-shearing period (25.70±0.39, 55.97±0.82, 200.34±0.34 and 49.72±0.58 mg/dl) than that during post-shearing period (31.00±0.39, 62.30±0.82, 215.53±3.01 and 54.57±0.58 mg/dl). Therefore, shearing increased PUN, TC, TL and GLU concentrations by about 20.62, 11.31, 7.58 and 9.75%, respectively. These results agree with those obtained by Piccione *et al.* [14, 63] who observed a different trend in the energetic metabolic parameters after shearing, where both shearing and sheltering induce adaptive responses in the organism. Piccione *et al*. [13] reported that, shearing had very significant effect on serum total protein and urea nitrogen, while does not show any significant effect on total cholesterol and blood glucose of ewes, while, Da Silva *et al*. [64] reported that blood glucose increased under high temperatures in the shorn (from 56.36±0.65 mg/dl to 60.52±0.69 mg/dl) as in the unshorn sheep (from 54.72 +/- 0.74 mg/100 ml to 57.56 +/- 0.77 mg/100 ml). On the other hand, Fidan *et al.* [23] and Bonacic and Macdonald [65] found that plasma glucose concentration did not exhibit significant variation after the shearing in Chios sheep. Fidan *et al*. [23] reported that a moderate elevation of 11% of the cholesterolemia was observed in Chios sheep after shearing. From our results, statistical analysis showed that, the interaction of breed x treatment had a significant effect on plasma TC (P<0.004), TL (P<0.033) and GLU (P<0.001) concentrations.

Enzymes Activity: The means±SE of plasma ALP and LDH concentrations for Balady and Damascus breeds during pre and post-shearing periods are summarized in

Table 5: Means±SE of daily plasma alkaline phosphatase (u/dl) and lactate dehydrogenase (u/dl) concentrations during pre and post-shearing periods of Balady and Damascus goats.

		Pre-shearing (Un-shaded)		Post-shearing (Un-shaded)	
		Day mean±SE			
Days	Breed	ALP	LDH	ALP	LDH
Day 1	Balady	5.95±0.10	14.82±0.20	6.00±0.21	15.4±0.21
	Damascus	5.66±0.10	14.60±0.20	5.61±0.21	15.1±0.21
Day 2	Balady	5.03±0.10	13.50±0.20	6.19±0.21	16.1±0.21
	Damascus	5.25±0.10	13.35±0.20	6.29±0.21	16.3±0.21
Day 3	Balady	4.45±0.10	9.89±0.20	6.26±0.21	16.2±0.21
	Damascus	5.41±0.10	12.68±0.20	6.45±0.21	16.9±0.21
Day 4	Balady	6.39±0.10	16.82±0.20	6.28±0.21	16.3±0.21
	Damascus	5.52±0.10	15.37±0.20	6.17±0.21	16.8±0.21
Average±SE					
Balady		5.45±0.1^{A}	13.8±0.2^{A}	6.18±0.12^{A}	16.01±0.21^{A}
Damascus		5.46±0.1^{A}	14.0±0.2^{A}	6.13±0.12^{A}	16.28±0.21^{A}
Overall mean±SE		5.45±0.08^{b}	13.88±0.31^{b}	6.16±0.08^{a}	16.15±0.31^{a}

ALP= alkaline phosphatase; LDH= lactate dehydrogenase.

^{a,b} within a row indicate a significant difference (P<0.05) daily between pre-shearing and post-shearing.

^{A,B} Average in the same column are statistically (P<0.05) difference between breeds.

Table 5. The obtained results indicated that there was no significant effect of breed on plasma ALP and LDH concentrations where the overall means of ALP and LDH recorded (5.81±0.08 and 14.88±0.31 u/dl vs. 5.79±0.08 and 15.14±0.31 u/dl) for Balady and Damascus breeds, respectively. Helal *et al.* [66] reported that there was non-significant effect on ALP and LDH concentrations between Balady and Damascus breeds of goats. Also, Al-Harbi and Amer [67] reported that, Alkaline phosphatase did not show significant variations among most five different breeds of goat. As shown in Table 5, our results showed that changes on hepatic function occurred during pre and post-shearing periods. Regarding the effect of heat stress, plasma ALP and LDH concentrations declined during the 2nd and 3rd days of heat stress followed by sharp increase on the 4th day of heat stress. The decline in plasma ALP and LDH levels may be referred to an increase in plasma volume as a result of heat shock and subsequently the increase in blood volume leads to maintain both homeothermy. In accordance, Helal *et al.* [66] reported that ALP and LDH tended to decrease (P<0.01) in both Balady and Damascus breeds at the second day of heat stress. Also, Nazifi *et al.* [68] found that the concentration of LDH was higher in cold stress than in heat stress. Helal *et al.* [66] reported that, the prolonged heat stress for 4days increased (P<0.05) ALP and LDH concentrations in both Balady and Damascus breeds. Sevi *et al.* [69] 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.

Regarding the effect of shearing stress the results in Table 5 indicated that, the overall means of ALP and LDH concentrations were significantly (P<0.05) lower during pre-shearing period (5.45±0.08 and 13.88±0.31 u/dl) than that during post-shearing period (6.16±0.08 and 16.15±0.31 u/dl). Therefore, shearing stress increased ALP and LDH concentrations by about 13.03 and 16.35%, respectively. This increase in plasma ALP and LDH concentrations in parallel with plasma PUN TC, TL and GLU levels during post-shearing period may be attributed to decrease in plasma volume occurred (vasoconstriction).

Thyroid Gland Response: 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 [70]. The mean±SE of plasma concentrations of T_3 and T_4 for Balady and Damascus breeds during pre and post-shearing periods are summarized in Table 6. The T_3 and T_4 levels were comparable between the two breeds during pre and post-shearing periods where Plasma T_3 and T_4 concentrations during pre-shearing period were (1.15±0.06 ngml^{-1} and 4.14±0.21 µgdl^{-1} vs. 1.32±0.06 ngml^{-1} and 4.63±0.21 µg/dl^{-1}) for Balady and Damascus breeds, respectively. The corresponding values during post-shearing period were (1.10±0.06 ngml^{-1} and 3.91±0.21 µgdl^{-1} vs. 1.33±0.06 ngml^{-1} and 4.94±0.21 µgdl^{-1}) for Balady and Damascus breeds, respectively. Therefore, plasma T_3 and T_4 values were highest in Damascus compared with Balady breed. Todini [71] reported that concentrations of thyroid hormones depend on many factors: genetic, environmental and nutritional. Statistical analysis indicated that there was breed

Table 6: Means±SE of daily plasma concentrations of triiodothyronine (ngml^{-1}), thyroxine (µgdl^{-1}) and cortisol (ngml^{-1}) hormones during pre and post-shearing periods of Balady and Damascus goat

		Pre-shearing (Un-shaded)			Post-shearing (Un-shaded)		
		Day mean±SE					
Days	Breed	T_3	T_4	COR	T_3	T_4	COR
Day 1	Balady	1.68±0.06	5.54±0.21	16.6±0.30	1.00±0.06	3.06±0.21	20.2±0.30
	Damascus	1.88±0.06	5.72±0.21	16.2±0.30	1.24±0.06	5.54±0.21	20.2±0.30
Day 2	Balady	1.19±0.06	4.20±0.21	17.0±0.30	1.19±0.06	4.20±0.21	20.2±0.30
	Damascus	1.40±0.06	4.62±0.21	16.8±0.30	1.40±0.06	5.13±0.21	20.0±0.30
Day 3	Balady	0.81±0.06	3.58±0.21	16.8±0.30	1.09±0.06	4.17±0.21	16.0±0.30
	Damascus	0.96±0.06	3.92±0.21	16.4±0.30	1.36±0.06	5.03±0.21	16.2±0.30
Day 4	Balady	0.94±0.06	3.24±0.21	16.4±0.30	1.12±0.06	4.23±0.21	16.6±0.30
	Damascus	1.06±0.06	4.26±0.21	16.6±0.30	1.33±0.06	5.10±0.21	16.4±0.30
Average±SE							
Balady		1.15±0.06^B	4.14±0.21^B	16.7±0.30^A	1.0±0.06^A	3.91±0.21^A	18.2±0.30^A
Damascus		1.32±0.06^A	4.63±0.21^A	16.5±0.30^A	1.3±0.06^B	4.94±0.21^B	18.2±0.30^A
Overall mean±SE		1.24±0.04^b	4.38±0.14^b	16.6±0.20^b	1.30±0.04^a	4.43±0.14^a	18.20±0.20^a

T_3 = triiodothyronine ; T_4 = thyroxine ; COR= cortisol.

^{a,b} within a row indicate a significant difference (P<0.05) daily between pre-shearing and post-shearing

^{A,B} Average in the same column are statistically (P<0.05) difference between breeds

differences (P<0.01) on plasma T_3 and T_4 concentrations. Regarding the effect of heat stress, the obtained results revealed that, plasma T_3 and T_4 as estimated began by 1.68 ngml^{-1} and 5.54 µgdl^{-1} vs. 1.88 ngml^{-1} and 5.72 µgdl^{-1} for Balady and Damascus breeds, respectively and reached 0.94 ngml^{-1} and 3.24 µgdl^{-1} vs. 1.06 ngml^{-1} and 4.26 µgdl^{-1} after 4-days of exposure to direct solar radiation, with rate of change about -44.05 and - 41.52 % vs. -43.62 and -25.52 %) for Balady and Damascus breeds, respectively. Falconer [72] reported that thyroid hormones secretion in sheep increased in cold and decreased in warm environment. Also, Prakash and Rathore [73] showed that in the goat a significant decrease in serum T_3 and T_4 levels was noticeable from May to July month. These authors believed that during summer the exposure of animals to the high environmental temperature depressed the functional activity of thyroid gland. Ross *et al*. [74] 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 in sheep. In contrast, Al-Haidary [75] reported that exposure of Naimey sheep to heat stress did not detect any significant changes in thyroid hormones concentrations. Stockman, [76] reported that T_3 and T_4 concentrations decreased in response to heat stress in adult rams, while adult withers was having a significant decrease in T_3 concentration only. Previous studies have found that exposure to hot environment causes a decrease in thyroid secretion rate and suppression of the thyroid gland in sheep and is related to decrease in metabolic rate and feed intake [40, 66, 77].

Concerning the effect of shearing stress the results in Table 6 indicated that, shearing under heat stress increased (P<0.05) T_3 and T_4 concentrations, the overall means of T_3 and T_4 concentrations were significantly (P<0.05) lower during pre-shearing period (1.24±0.04 ngml^{-1}and 4.38±0.14 µgdl^{-1}) than that during post-shearing period (1.30±0.04 ngml^{-1} and 4.43±0.14 µgdl^{-1}). Therefore, shearing increased T_3 and T_4 concentrations about 4.84 and 1.14 %, respectively. Similarly, Symonds *et al*. [11] reported that shorn ewes had lower values of thyroid hormones this finding might be due to stress caused by the direct effect of solar radiation that affects the biological functions, but after day 30 the shorn ewes had higher values of thyroid hormones. Capen and Martin [78] reported that the overall effects for T_3 and T_4 are to increase the basal metabolic rate, to make more glucose available to cells, stimulate protein synthesis, increase lipid metabolism and stimulate cardiac and neural functions.

Plasma Cortisol Response: Mean values±SE of plasma COR concentration (ngml^{-1}) during pre and post-shearing periods in both Balady and Damascus goat are presented in Table 6. At the start of study (pre-shearing period) the average of plasma COR estimated 16.60±2.11 and 16.20±2.11 ngml^{-1} for Balady and Damascus goats, respectively. Analysis of variance indicated that breed had not significant effect on (P>0.05) plasma COR. The estimated plasma COR levels during the eight sampling periods are in agreement with reported in goats by Shamay *et al*. [79]. Concerning the effect of heat stress during pre-shearing period, irrespective the effect of breed the obtained results revealed that, plasma COR as estimated began by 16.40±2.11 ngml^{-1} and reached 16.50±2.11 ngml^{-1} after 4-days of exposure to direct solar radiation with rate of change about 0.60%. In previous studies performed by Olsson *et al*. [44] who reported that an increase (P<0.05) in plasma COR in Swedish goats exposed to starvation, whereas heat stress did not increase plasma COR level and by Meza-Herrera [80] on six goat genotypes in northern Mexico. Likewise, Moneva *et al*. [81] reported that exposure of cows to transportation induced a mark increase (P<0.05) in plasma COR levels, which declined sharply after exposure to acute heat load (P<0.001) in spite of the extreme stress load indicated by the elevated rectal temperature. On the contrary, Haque *et al*. [82] found that plasma COR level showed increasing trend with enhancement of the degree of heat stress (40, 42 and 45°C) for 4hrs in young and adult Murrah buffaloes.

The results in Table 6 revealed that plasma COR had greater increase (P<0.01) by about 21.70 and 23.45% for Balady and Damascus breeds, respectively on the second day of post-shearing period, thereafter sharply declined (P<0.01) by about -17.82 and -18.00% for Balady and Damascus breeds, respectively on the 4th day of post-shearing period. Therefore, both breeds tended to be had higher increase in plasma COR for short duration (2-days) after shearing. With the respect of shearing stress, regardless the effect of breed, results indicated that shearing caused 10.24% increase for plasma COR where the overall means recorded 16.60±0.20 and 18.20±0.20 ngml^{-1} for pre and post-shearing periods, respectively. Also, the results obtained show that plasma COR levels were only elevated on the 1st and 2nd days of post-shearing period and recovered quickly to basal concentrations on the 3rd day after shearing. Therefore, cortisol hormone is a good indicator for evaluate the short-term stress from handling such as shearing procedure. Mousa-Balabel and Salama [83] reported that a significant increase in the blood cortisol level in all shorn compared with unshorn ewes, which subsided gradually till its return to the baseline level. These results could be related to the emotional stimuli of restraint and contact of shears that stimulate the HPA axis leading to acute cortisol responses, which after reaching the peak level, fall again by negative feedback mechanism. These results are in concert with those obtained by Hargreaves [84, 85] but disagree with the findings of *Symonds et al*. [10], who reported that the decline of cortisol to the base level occurs within 90 minutes after shearing.

In accordance, previous studies conducted on Sarda sheep, Chios sheep and Lama guanicoe by Fidan *et al*. [23], Carcangiu *et al*. [86] and Camanchahi *et al*. [87], respectively, found that plasma cortisol levels showed a clear increase (P< 0.01) in sheared groups compared with un-sheared. Also, Panaretto and Vickery [88] reported that shearing alone had a significant (P<0.01) effect on plasma cortisol of sheep and returned to near their pre-shearing levels by about 27 hr. Bonacic and Macdonald [65] reported that COR concentrations were higher in shorn vicunas than in controls 48 h after shearing. Cortisol concentrations in shorn vicunas increased from 38.5±7.4 to 59.5±15.6 nmol/l, while unshorn group decreased COR concentrations from 35.3±5.2 to 30.7±4.8 nmol/l.

Other studies of the plasma cortisol concentration following shearing on sheep reported peak levels of 72.7ng/ml [84] and 78.8ng/ml [85] which is much higher than the peak in the present study (20.2ng/ml). However the baseline in the present study is much lower compared with these studies. It is important to note that under stress, the release of cortisol initiates two primary defense mechanisms; 1) the immuno-defense and 2) the initiation of gluconeogenesis in an effort to provide energy for the stress/recovery process [89]. Previous study reported that, cortisol is considered one of the few hormones essential for life. Moderate increases in plasma cortisol have been shown to stimulate glycogenolysis, increase appetite, caloric intake and lipogenesis [90].

CONCLUSION

In conclusion it can be affirmed that, the shearing to which the goats were subjected, both Balady and Damascus goats were under heat stress during pre and post-shearing periods, but the higher sensitivity were during exposure of shorn goats to heat stress in comparison with unshorn period. So, shearing procedure will be considered as a stressful condition as evidenced by the strongly increased circulating cortisol and some plasma biochemical parameters (plasma total proteins, total cholesterol, glucose and thyroid hormones concentrations). Therefore, the increase of plasma cortisol concentration in response to shearing could be an additional factor responsible for oxidative stress.

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