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Effect of Summer Shearing on Thermoregulatory, Hematological and Cortisol Responses in Balady and Damascus Goats in Desert of Sinai, Egypt

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Abstract: This study was conducted at Abou-Elfeta Research Station, east of Al-Arish city, Northern Sinai, Egypt, which belongs to the Desert Research Center, Egypt. The aim of the present study was to evaluate the influence of shearing during summer season on live body weight (LBW), thermoregulatory, hematological and plasma cortisol (COR) hormone responses. A total of 10 Bucks (five of each breed, i.e. Balady and Damascus) were provided for this study. The animals aged 18 months, the initial live body weights were 29.86 ± 2.11 and 49.22± 2.11 kg for Balady and Damascus breeds, respectively. The animals were placed individually in metabolic cages 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). Diurnal variations for rectal temperature, (RT, ºC), skin temperature, (ST, °C), respiration rate, (RR, bpm) and heart rate, (HR, bpm) were measured for 4-days before and 4-days after shearing as thermoregulatory parameters. Also, daily hematological parameters (erythrocyte count, RBC's; hemoglobin concentration, Hb, packed cell volume, PCV and total leukocytes count, WBC's) were determined. Erythrocyte indices (mean corpuscular volume, MCV, fl; mean corpuscular hemoglobin, MCH, pg and mean corpuscular hemoglobin concentrations, MCHC, %) were calculated. In addition, plasma cortisol (COR) concentration was estimated. Results revealed that, live body weight (LBW) decreased significantly ($P<0.01$) during pre-shearing period. The rate of change in LBW was -2.85 and -3.33%, while shearing increased ($P<0.01$) LBW by 3.31 and 2.67% for Balady and Damascus breeds, respectively. Thermoregulatory traits (RT, ST, RR and HR) in both breeds showed circadian rhythm characterized by one peak at midday time which was associated with high ambient temperature and high temperature humidity index during pre and post-shearing periods. Shearing decreased ($P<0.01$) RT and ST but increased ($P<0.01$) RR and HR In both breeds. Both breeds showed higher values in hematological parameters (Hb, PCV, RBC's and WBC's) and erythrocyte indices (MCH and MCHC) during post-shearing period compared to pre-shearing period. There were no significant changes of plasma COR concentration of un-shorn Balady and Damascus breeds due to their exposure to 4-days of direct solar radiation (pre-shearing period), while shearing under heat stress increased significantly ($P<0.01$) plasma COR concentration on the first two days after shearing, thereafter sharply declined ($P<0.01$) on the 3rd and 4th day of post-shearing period. It is concluded that, during summer shearing Balady and Damascus goats are under heat stress, but post-shearing period are less tolerant to heat stress and the hair coat is necessary for maintenance of homeothermy.

Key words: Cortisol hormone · Goat · Heat stress · Hematological · Shearing · Thermoregulation

INTRODUCTION

Fleece is thought to be the main factor determines the adaptive capacity of sheep to a wide range of climatic conditions. The type and depth of the fleece influence its insulative properties which, in turn, affect body heat balance. Shearing modifies the direction and magnitude of heat exchange as well as shifts the zone of metabolic

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thermo-neutrality impeding the maintenance of homeothermy especially in extreme environment [1]. Under sever heat stress, some breeds and their crosses have better heat regulation capacities, due to differences in metabolic rate, food and water consumption, sweating rate, in addition to coat color and characteristics. Also, because they have a higher heat loading at the skin, they must evaporate substantially more sweat than the others to maintain normal body temperatures [2].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.* [3], Dy´rmundsson [4], Piccione *et al.* [5, 6] and some of them demonstrated the influence of shearing on heat stress. Mohammed and Abdelatif [7] reported that shearing in different seasons significantly affected thermoregulation and blood parameters of desert Hamari rams. Shearing caused an increase in pulse rate and even on shearing day the mean afternoon values was higher than that recorded in un-shorn sheep [1]. The breadth of the thermo-neutral zone depends on age, species, breed, level of nutrition and fleece [8]. The breadth of the thermo-neutral zone which is significantly correlated to fleece length in the sheep [9] presents a lower critical temperature (LCT) of - 4°C [10] which increases to 28°C after shearing [11]. At an environmental temperature lower than body temperature, heat dispersal through conduction, radiation and evaporation should be aided by the absence of fleece: in fact, at an environmental temperature of 30°C, the shorn sheep disperses 50% more through evaporation than the unshorn sheep [12].

This work was designed to evaluate the effect of shearing during summer season on thermoregulation, blood hematology and plasma cortisol concentration in comparison between Balady and Damascus (Shami) breeds of goat in desert of Sinai, Egypt.

MATERIALS AND METHODS

Site of the Study: Geographically, the Experimental unit of the small ruminant research at Abou-Elfeta village which lies at 20 km of Al-Arish city, Northern Sinai, Egypt. The study was a part of project entitled "Effect of acclimatization on energy requirements of goats".

Animals and Experimental Design: A total of 10 bucks of two breeds of goat (5 of the short-eared Balady goats, characterized by its medium size, mainly black color and short hair in addition to 5 of the long-eared Damascus goats, characterized by its big size, light brown color and long hair) were used. Animals were at 18 months of age, the live weights were 29.86 ± 2.11and 49.22± 2.11 kg for Balady and Damascus breeds, respectively. Animals were placed into the individual metabolic cages throughout the experiment. During pre-shearing period, all goats of 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 which served as treated period (post-shearing). Rectal temperature (RT,°C), skin temperature (ST, °C), respiration rate (RR, rpm) and heart rate and (HR, bpm) were measured on 1, 2, 3 and 4 days post-shearing. The same animals of each breed were used during pre and post-shearing stress periods. The animals were fed Alfalfa hay twice daily (11:00 and 18:00 h) based on LBW to meet their metabolic energy maintenance requirement according to Kearl [13]. 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 [14]. 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.

Measurements:

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 (Table 1). Data were recorded every 6 hours (at 06:00 a.m. 12:00 m.d, 06:00 p.m and 12:00 m.n). 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:

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

[15].

Table 1: Means ± SE of ambient temperature (AT, °C), relative humidity (RH, %) and temperature-humidity index (THI) throughout the experimental periods.

Period	Time of day	Climatic Parameters AT,°C	RH, %	THI
Period (I)	MR	29.5±0.04	47.5±0.65	77.2±0.05
(Un-shorn)	MD	39.2±0.12	31.5±0.96	85.5±0.11
Un-shaded	EV	33.5±0.29	31.3±0.48	79.2±0.31
	MN	31.3±0.25	41.0±0.41	78.3±0.31
Average		33.82	37.82	80.05
Period (II)	MR	29.0±0.41	45.8±1.7	76.3±0.37
(shorn)	MD	39.6±0.24	29.0±0.41	85.4±0.18
Un-shaded	EV	33.5±0.29	30.3±0.63	79.0±0.25
	MN	30.8±0.25	39.3±1.2	77.4±0.27
Average		33.22	36.80	79.52

MR= morning (06:00 a.m.); MD= mid-day (12:00 m.d.); EV= evening (06:00 p.m.);
MN= mid-night (12:00 m.n.)

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.

Thermoregulatory Parameters: Rectal temperature (RT, °C) was measured by using a clinical thermometer which was inserted about 6-7 cm, into the animal rectum for one minute. Skin temperature (ST,°C) was measured to the nearest of 0.1°C using a YSI 408 Banjo surface probe from the middle to side position of the animal and read out with the YSI 46 Tele-thermometer. Respiration rate (RR, b.p.m) was measured in breath per minute, by counting flank movements per minute. Heart rate (HR, b.p.m) was measured in beat per minute by using a clinical stethoscope from the jointing point of left-front leg and body. All thermoregulatory parameters were measured 4 times daily (at 06:00 a.m. 12:00 m.d. 06:00 p.m. and 12:00 m.n.).

Blood Sampling: Daily, in the morning, approximately 10 ml of blood was taken from jugular vein of each animal in test tubes containing Lithium heparin as anticoagulant. Hemoglobin concentration (Hb, g/dl) was estimated in blood according to Drabkin and Austin [16]. The packed cells volume (PCV %) was estimated by the use of the microhematocrit method according to Cheryl *et al.* [17]. The blood samples were packed in heparinized capillary tubes sealed at one end and then the tubes were centrifuged in a microhematocrit centrifuge at 12.000 r.p.m for 5 minutes. Erythrocytes count (RBC's $\times 10^6$ cells/µl) was made by Thom's hemocytometer as cited by Cheryl *et al.* [17]. Total leukocytes (WBC's $\times 10^3$ cells/µl) count was made by a Neubauer's hemocytometer as cited by Cheryl *et al.* [17].

Erythrocyte Indices: Red blood cells are responsible for gas exchange, carrying oxygen and carbon dioxide in their heme structures. The mean corpuscular volume (MCV, fl), mean corpuscular hemoglobin (MCH, pg) and mean corpuscular hemoglobin concentration (MCHC,%) are characteristics of the RBC's indicating average cell size, average cell hemoglobin content and average cell hemoglobin concentration, respectively and they were calculated as follows:

MCV (fl) = (PCV) / (RBC's, $x10^6$/µl) X 10,
MCH (pg) = (Hb) / (RBC's, $x10^6$/µl) X 10,
MCHC (%) = (Hb) / (PCV) X 100

Plasma Cortisol Hormone Assay: Plasma cortisol concentration was determined by ELISA method as described by Munro and Lasley [18].

Statistical Analysis: The data were statistically analyzed using general linear model of GLM procedure SAS [19]. Differences between means were tested by Duncan Multiple Range Test [20].

RESULTS AND DISCUSSION

Live Body Weight Changes: During the pre-shearing period, the average 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 ($P<0.01$) 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 (Table 2). These results

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^{b}	29.01^{a}	-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^{b}	47.58^{a}	-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); ^{A,B} average in the same column are statistically (P<0.05) difference between breeds

Table 3: Mean ± SE of daily values of rectal temperature (RT,°C) for Balady and Damascus breeds during pre and post-shearing in summer season

		Pre-shearing (Un-shaded)	Post-shearing (Un-shaded)
Days	Breed	Day mean ± SE	Day mean ± SE
Day 1	Balady	39.20±0.02^{b}	38.58±0.03^{b}
	Damascus	39.31±0.02^{a}	38.71±0.03^{a}
Average ± SE		39.26±0.02^{a}	38.64±0.02^{b}
Day 2	Balady	39.24±0.02^{b}	38.69±0.03^{b}
	Damascus	39.30±0.02^{a}	38.94±0.03^{a}
Average ± SE		39.27±0.02^{a}	38.82±0.02^{b}
Day 3	Balady	39.23±0.02^{b}	38.67±0.03^{b}
	Damascus	39.35±0.02^{a}	38.86±0.03^{a}
Average ± SE		39.29±0.02^{a}	38.80±0.02^{b}
Day 4	Balady	39.25±0.02^{b}	38.69±0.03^{b}
	Damascus	39.35±0.02^{a}	38.92±0.03^{a}
Average ± SE		39.30±0.02^{a}	38.81±0.02^{b}
Overall mean ± SE		39.28±0.01^{a}	38.76±0.01^{b}

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

revealed that the rate of decrease was higher in Damascus compared to Balady breed. Similar results reported by Khalil *et al.* [21] who found that the prolonged exposure to solar radiation for 12 hr. increased the loss in LBW in local and crossbred sheep. Also, Rahardja [22] found that, exposure to direct sunlight and restricted water for 10 days decreased LBW from 16.92±1.44 to 15.30±1.25 in five does of Kacang goats placed in metabolism cages and attributed this decrease in body weight to a great loss of body water. Hafez [23] 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 was exposed to high temperatures of tropical areas [24].

Concerning the effect of shearing on LBW, the obtained results indicated that shearing increased significantly (P<0.01) LBW in both breeds. These results could give evidence that both breeds were affected to heat stress, but it is evidently that both breeds showed a different sensitivity to heat stress during pre and post-shearing periods. Aleksiev [25] reported that during 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. On the other hand, Piccione *et al.* [26] found that, shearing has no significant effect on body weight in ewes because the removal of the fleece, is considered a necessary practice for hygienic conditions and did 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).

Thermoregulatory Responses:

Rectal Temperature (RT): Statistical analysis indicated that there was breed difference in RT where Damascus breed had the higher (P<0.05) value than that of Balady breed. With respect the effect of shearing, the results indicated that, the overall mean of RT was significantly (P<0.05) higher during pre-shearing period than that during post-shearing period (Table 3). Therefore, shearing decreased RT by about 0.52 °C. On the contrary, Piccione *et al.* [27] reported a long term elevation of RT in three breeds of young sheep after shearing at ambient temperatures much higher compared to those recorded in the present study. Also, Parer [28] and Hopkins *et al.* [29] reported that Merino sheep, yarded in pens and exposed to solar radiation, showed slightly higher maximum rectal temperatures after shearing compared to before shearing. Concerning the effect of day, results in Table 3 demonstrated that the differences among the day mean values of RT recorded -0.62, -0.45, -0.49 and -0.49°C decreases between pre and post-shearing periods on the 1st, 2nd, 3rd and 4th day, respectively. Therefore, shearing caused a significant (P<0.05) decrease in RT along the 4- days post shearing period and the lowest value in RT was observed (-0.62°C) on the first day after shearing.

With respect, the effect of diurnal variation, the obtained results indicated that morning RT values were lower compared to midday, evening and midnight for pre

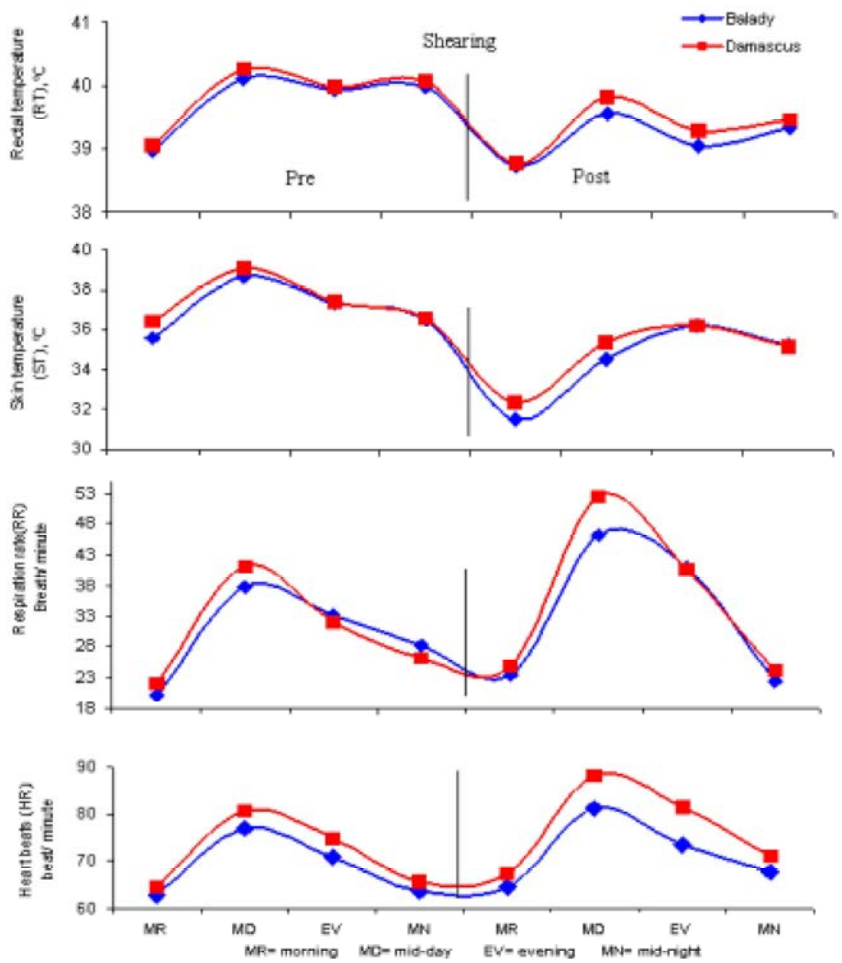

Fig. 1: Effect of shearing on diurnal variation rhythm of physiological responses for Balady and Damascus breeds during pre and post-shearing in summer season

and post-shearing periods, respectively (Fig.1). This may reflect an increase in sensitivity to morning temperatures compared to midday, evening and midnight, Similar results reported by Aleksiev [1], who found that shearing caused a drop significant (P< 0.01) in the morning RT values and a less reduction in the afternoon ones during the first 3 days post shearing in Blackhead ewes. The obtained results indicated that RT decreased at all the periodic times (MR, MD, EV and MN) along the 4-days after shearing compared to the same times before shearing. In both Balady and Damascus breeds, the daily average values of RT were minimal in the morning and peaked in the midday during both pre and post-shearing periods where THI were maximal (Fig. 1). Ayo *et al.* [30] reported that, the diurnal fluctuations in RT of the goat shows higher significant correlation between time of the day and rectal values. The high diurnal ranges of degree confirm that harmattan season is thermally stressful to the goat. Also, studies conducted on goat's body temperature rhythm reveal a robust daily rhythm with an ascent phase during the day and a descent phase during the night [31, 32]. Similarly, Ndlovu and Simela [33] and Olajide [34] found that RT and ST of goats were higher in the afternoon than morning because goats are homotherms, which tend to maintain a constant body temperature between the environment through a balance of heat gain and loss. Piccione and Caola [35] reported that, the circadian rhythm of body temperature reflects the adaptation of animals to changes in external environmental temperature.

Skin Temperature (ST): Statistical analysis indicated that there was breed difference in ST where Damascus breed had the higher (P<0.01) value than that of Balady breed.

Table 4: Mean ± SE of daily values of skin temperature (ST, °C) for Balady and Damascus breeds during pre and post-shearing in summer season.

Days	Breed	Pre-shearing (Un-shaded) Day mean ± SE	Post-shearing (Un-shaded) Day mean ± SE
Day 1	Balady	37.02±0.03[b]	34.37±0.04[b]
	Damascus	37.38±0.03[a]	34.80±0.04[a]
Average ± SE		37.20±0.02[a]	34.57±0.02[b]
Day 2	Balady	37.04±0.03[b]	34.39±0.04[b]
	Damascus	37.04±0.03[b]	34.72±0.04[a]
Average ± SE		37.20±0.02[a]	34.56±0.02[b]
Day 3	Balady	36.96±0.03[b]	34.40±0.04[b]
	Damascus	37.40±0.03[a]	34.81±0.04[a]
Average ± SE		37.18±0.02[a]	34.61±0.02[b]
Day 4	Balady	37.01±0.03[b]	34.34±0.04[b]
	Damascus	37.40±0.03[a]	34.81±0.04[a]
Average ± SE		37.19±0.02[a]	34.57±0.02[b]
Overall mean ± SE		37.19±0.12[a]	34.58±0.18[b]

[a,b] between breeds indicate a significant difference (P<0.05) daily during pre-shearing and post-shearing

Concerning the effect of shearing, the results indicated that the overall mean of skin temperature decreased significantly (P< 0.05) during post-shearing period compared with pre-shearing period. Therefore, shearing decreased ST by about 2.61°C (Table 4). This result explained that after shearing process the surface body of shorn goats had a higher conductance to the surrounding environment than pre-shearing period and subsequently decreasing their skin temperatures as expected and dramatically reduced heat loss from the body to the environment accordance with the findings of Webster and Blaxter [36] in two breeds of sheep and Setlalekgomo and Winter [37] in adult Angora goats.

Concerning the effect of day, results in Table 4 indicated that the differences among the day mean values of ST recorded -2.63, -2.64, -2.57 and -2.62 °C decreases between pre and post-shearing periods on the 1st, 2nd, 3rd and 4th day, respectively (Table 4). Therefore, shearing caused a significant (P < 0.05) decrease in ST along the 4- days post shearing period with rate of change was constant approximately. We believe that differences resulted from shearing stress is associated with a cold spell as a result of the loss of fleece compared with before shearing. In accordance, Hetem *et al.* [38] found that, abdominal temperatures of shorn Angora goats remained lower than pre-shearing temperatures for weeks, even up to 3 months, after shearing in both September and March. Concerning the effect of diurnal variation, the results in indicated that diurnal variation has high level of significant (P < 0.01) effect on ST, where the morning values were the lower for pre and post-shearing periods (Fig. 1). One of the thermoregulatory mechanisms available to animals to conserve body heat is vasoconstriction and our goats seemingly employed that mechanism at morning times, during pre and post- shearing periods. Bianca and Kunz [39] stated that vasoconstriction leads to a reduction in heat delivery to the skin, so that, when ambient temperature is below core temperature, a low skin surface temperature would reduce the outer temperature gradient and consequently slow the sensible heat dissipation from the goat's body.

As shown in Table 4, the results stated that AT and THI had an effect on the skin temperature of both breeds during pre and post-shearing periods. Our results agreed with those of Setlalekgomo and Winter [37] on Angora goats and with Webster and Blaxter [36], who reported a drop in the skin temperature of Cheviot and Suffolk sheep when air temperature was reduced. Similarly, Olajide [34] and Ndlovu and Simela [33] found that RT and ST were higher in the afternoon than morning because goats are homeotherms animals, which tended to maintain a constant body temperature between the environment through a balance of heat gain and loss. Furthermore, Rensing and Ruoff [40] showed that temperature is one of the most important environmental parameters which affect practically all parts of an microorganism's physiology; for this reason there is a need for regulatory mechanisms which assure a proper clock function within a certain important physiological temperature range [41]. According to these studies the differences that we observed in ST during pre and post-shearing periods may be the expression of how well the mechanisms of heat loss pass the body surface of goats. Changes in heat loss via convection, conduction and evaporation are primarily caused by variations in skin blood flow (vasodilation or vasoconstriction), with consequent changes in skin temperature. From our results, during pre-shearing period, vasodilation becomes a more effective way of controlling heat exchange when the resistance of the heat transferring region is relatively high. However, during post-shearing period, vasoconstriction becomes a more effective way of controlling heat regulation in both breeds. Acharya *et al.* [42] showed hair length in goats under full sun conditions in the summer had a protective mechanism against heat stress. Also, Setlalekgomo and Winter [37] and Fourie [43] found that increasing the conductance of skin surface of Angora and Boer goats with decreasing hair length.

Table 5: Mean ± SE of daily values of respiration rate (RR, rpm) for Balady and Damascus breeds during pre and post-shearing in summer season.

Days	Breed	Pre-shearing (Un-shaded) Day mean ± SE	Post-shearing (Un-shaded) Day mean ± SE
Day 1	Balady	29.8±0. 30[b]	38.1±0. 33[b]
	Damascus	30.6±0. 30[a]	40.0±0. 33[a]
Average ± SE		30.20±0.73[b]	39.07±0.73[a]
Day 2	Balady	29.8±0. 30[b]	31.4±0. 33[b]
	Damascus	30.6±0. 30[a]	33.5±0. 33[a]
Average ± SE		30.20±0.73[b]	32.50±0.73[a]
Day 3	Balady	29.6±0. 30[b]	31.7±0. 33[b]
	Damascus	30.1±0. 30[a]	34.5±0. 33[a]
Average ± SE		29.90±0.73[b]	33.12±0.73[a]
Day 4	Balady	29.9±0. 30[b]	31.9±0. 33[b]
	Damascus	30.0±0. 30[a]	32.8±0. 33[a]
Average ± SE		29.97±0.73[b]	32.37±0.73[a]
Overall mean ± SE		30.07±1.34[b]	34.30±1.51[a]

[a,b] between breeds indicate a significant difference (P<0.05) daily during pre-shearing and post-shearing

Table 6: Mean ± SE of daily values of heart rate (HR, bpm) for Balady and Damascus breeds during pre and post-shearing in summer season.

Days	Breed	Pre-shearing (Un-shaded) Day mean ± SE	Post-shearing (Un-shaded) Day mean ± SE
Day 1	Balady	68.5±0. 30[b]	74.4±0. 45[b]
	Damascus	71.7±0. 30[a]	80.5±0. 45[a]
Average ± SE		70.12±0.41[b]	77.45±0.41[a]
Day 2	Balady	68.6±0. 30[b]	71.8±0. 45[b]
	Damascus	71.5±0. 30[a]	75.6±0. 45[a]
Average ± SE		70.10±0.41[b]	73.72±0.41[a]
Day 3	Balady	68.8±0. 30[b]	71.7±0. 45[b]
	Damascus	71.5±0. 30[a]	75.8±0. 45[a]
Average ± SE		70.15±0.41[b]	73.77±0.41[a]
Day 4	Balady	68.6±0. 30[b]	71.6±0. 45[b]
	Damascus	71.6±0. 30[a]	75.8±0. 45[a]
Average ± SE		70.12±0.41[b]	73.72±0.41[a]
Overall mean ± SE		70.12±1.33[b]	74.70±2.02[a]

[a,b] between breeds indicate a significant difference (P<0.05) daily during pre-shearing and post-shearing

Cardio-Respiratory Response: Statistical analysis indicated that there was breed difference on both RR and HR where Damascus breed had the higher (P< 0.01) values than those of Balady breed. As shown in Table 1, although climatic conditions were similar between pre and post-shearing periods for AT, RH and THI. However, there were increases in both RR and HR along post-shearing period. It is proposed that increasing respiration rate in domestic animals due to the activation of warm receptors on the skin when exposed to higher ambient temperature. Activation of these receptors in turn sends neural signals to the hypothalamus that increases respiratory activity to accelerate heat loss from the body [23]. Concerning the effect of shearing, the results indicated that, shearing under heat stress produced significant (P< 0.05) increase in both RR and HR (Tables 5 and 6). Similarly, Mousa-Balabel and Salama [44] reported that increases in respiratory and pulse rates were observed after shearing, which continues for a short period after shearing.

Means of RR increased by 8.87 rpm on the 1st day after shearing and continued to increase slowly by 2, 3, 3.22 and 2.4 rpm on the 2nd, 3rd and 4th day of post-shearing period. The same trend was observed for HR, where mean HR increased by 7.33 bpm on the 1st day after shearing and continued to increase slowly by 3.62, 3.60 and 3.60 rpm on the 2nd, 3rd and 4th day of post-shearing period. In accordance, Fidan *et al*. [45] reported that, respiration and heart rates of Chios sheep increased (P< 0.05) during shearing procedure compared to the initial values. Also, Pennisi *et al.* [46] reported that RR and HR increased (P< 0.01) on non-sheltered sheep after shearing. Webster and Lynch [47] reported that heart rates increased relatively gradually in Merino sheep for one week after shearing but Romney sheep remained at high rates for three weeks after shearing.

Concerning the effect of diurnal variation the results indicated that diurnal variation has high level of significant (P<0.01) effect on both RR and HR where the morning values were the lower in the morning during pre and post-shearing periods (Fig. 1). It is reported that respiration rate is positively correlated with ambient temperature and humidity [48, 49]. Similarly, pulse rate increases at higher ambient temperature [48]. Alamer and Al-Hozab [50] stated that respiration rate can be used as indicator of heat stress and to estimate the adverse effect of environmental temperature. Therefore, the observed acceleration of RR in both Balady and Damascus breeds indicated that the animals were exposed to heat load, particularly under midday and evening times during both pre and post-shearing periods. During the pre and post-shearing periods under heat stress, both Balady and Damascus breeds did not show any clinical signs of stresses (heat or shearing stress) and both respiration and heart rates not surpass the mean values of goats [51]. According the present results, the observed differences in RT, ST, RR and HR in both breeds during pre and post-shearing periods under heat stress may be the expression of how will the mechanism of heat regulation works in goats (Tables 5, 6 and Fig. 1).

Table 7: Means ± SE of daily hemoglobin, packed cell volume and erythrocyte count during pre and post- shearing periods of Balady and Damascus goat.

		Pre-shearing (Un-shaded)			Post-shearing (Un-shaded)		
		Day mean ± SE					
Days	Breed	Hb	PCV	RBC's	Hb	PCV	RBC's
Day 1	Balady	9.79±0.02	26.4±0.15	10.4±0.02	10.5±0.03	27.6±0.21	11.0±0.03
	Damascus	8.96±0.02	24.2±0.15	9.92±0.02	10.3±0.03	26.0±0.21	10.6±0.03
Day 2	Balady	9.81±0.02	26.2±0.15	10.36±0.02	10.8±0.03	27.4±0.021	10.9±0.03
	Damascus	8.91±0.02	23.2±0.15	9.72±0.02	10.3±0.03	25.8±0.21	10.6±0.03
Day 3	Balady	9.85±0.02	26.2±0.15	10.47±0.02	10.7±0.03	26.8±0.021	10.8±0.03
	Damascus	8.92±0.02	23.4±0.15	9.79±0.02	10.3±0.03	25.8±0.21	10.6±0.03
Day 4	Balady	9.79±0.02	26.0±0.15	10.48±0.02	10.7±0.03	27.2±0.021	10.8±0.03
	Damascus	9.15±0.02	23.6±0.15	9.64±0.02	10.3±0.03	25.6±0.21	10.5±0.03
Average ± SE							
Balady		9.8±0.03^{A}	26.2±0.21^{A}	10.4±0.03^{A}	10.7±0.03^{A}	27.2±0.21^{A}	10.9±0.03^{A}
Damascus		8.9±0.03^{B}	23.6±0.21^{B}	9.8±0.03^{B}	10.3±0.03^{B}	25.8±0.21^{B}	10.6±0.03^{B}
Overall mean ± SE		9.4±0.02^{b}	24.9±0.15^{b}	10.1±0.02^{b}	10.5±0.02^{a}	26.5±0.15^{a}	10.7±0.02^{a}

Hb = hemoglobin, (g/dl); PCV = packed cell volume,(%); RBC's = Erythrocyte count, (x10^{6}cells/µl).

^{a,b} Overall 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.

Hematological Parameters: Hemoglobin, Packed Cell Volume and Erythrocyte Count Responses: Regardless the effect of shearing, the results indicated that, breed had highly (P< 0.01) significant effect on Hb, PCV and RBC's count where Balady breed had the higher values in Hb, PCV and RBC's count compared to Damascus breed (Table 7). With respect to the effect of shearing, the results indicated that, shearing caused significantly (P<0.05) increases in Hb, PCV and RBC's count. Therefore, it is possible to evidence a hemoconcentration characterized by the increases in Hb, PCV and RBC's count this could be due to a reduction in heat tolerance caused by fully fleeced animals and amount of heat loss that occurs through cutaneous evaporation and respiratory system. Piccione *et al.* [52, 53] reported that the increases on Hb, PCV and RBC's were evidence to a hemoconcentration. As previously observed for hematocrit values and the total proteins concentration were lower in unshorn ewes in comparison to the shorn ewes [46]. Piccione *et al.* [26] reported that, packed cell volume and total proteins concentration reflected changes in plasma volume. Therefore, the present study involved significant hemodynamic where the decrease in PCV values during pre-shearing period may refer to hemoconcentration, while the increase in the PCV corresponds to an increase in the viscosity of the blood (hemoconcentration). Similar results reported by Hales [54] and Hales *et al.* [55].

Shearing under heat stress induce marked changes in Hb, PCV and RBC's values compared to pre-shearing period. The rate of change in these parameters between Balady and Damascus breeds reflected the level of response in each breed. The results indicated that the rate of change recorded 9.07, 3.76 and 4.81 vs. 14.7%, 9.32% and 8.16% for Hb, PCV and RBC's in Balady and Damascus breeds. These findings revealed that higher response in Damascus breed was clearly associated with the capable of Balady breed to tolerate shearing stress under exposure to direct solar radiation. Statistical analysis showed a significant effect (P<0.05) of breed on these parameters.

Erythrocyte Indices: Regardless the effect of shearing, the results indicated that, breed had highly (P<0.01) significant effect on MCV, MCH and MCH where Balady breed had higher values compared to Damascus. Concerning the effect of shearing, with the exception of MCV, the results indicated that MCH and MCHC increased significantly (P< 0.05) after shearing. The rate of increase in MCH and MCHC recorded 5.40 and 4.80 %, respectively. This increase in MCH and MCHC might explain the pronounced decrease in plasma volume. Although MCV unchanged in both breeds before and after shearing, so the increase in PCV values in both breeds (Table 7) could indicate a release of erythrocytes from the spleen to the blood stream as a result of sympathetic-adrenal stimulation. Therefore, the results indicated that, MCH and MCHC concentrations were related to the changes observed in PCV percentage and RBC's count in both breeds during post-shearing period. Statistical analysis indicated that shearing stress had no significant effect (P>0.05) on MCV in both breeds (Table 8).

Table 8: Means ± SE of daily mean corpuscular volume, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration during pre and post-shearing periods of Balady and Damascus goats.

		Pre-shearing (Un-shaded)			Post-shearing (Un-shaded)		
		---Day mean ± SE---					
Days	Breed	MCV	MCH	MCHC	MCV	MCH	MCHC
Day 1	Balady	24.5±0.15	9.4±0.03	37.1±0.24	25.11±0.20	9.56±0. 04	38.13±0.34
	Damascus	24.6±0.15	9.04±0.03	36.8±0.24	24.5±0.20	967±0. 04	39.52±0.34
Day 2	Balady	25.3±0.15	9.5±0.03	37.5±0.24	25.15±0.20	9.90±0. 04	39.41±0.34
	Damascus	23.9±0.15	9.17±0.03	38.5±0.24	24.4±0.20	9.74±0. 04	39.91±0.34
Day 3	Balady	25.01±0.15	9.4±0.03	37.6±0.24	24.9±0.20	9.95±0. 04	40.14±0.34
	Damascus	23.9±0.15	9.11±0.03	38.2±0.24	24.4±0.20	9.74±0. 04	39.89±0.34
Day 4	Balady	24.8±0.15	9.3±0.03	37.7±0.24	25.12±0.20	9.88±0. 04	39.36±0.34
	Damascus	24.5±0.15	9.51±0.03	38.8±0.24	24.32±0.20	9.80±0. 04	40.35±0.34
Average ± SE							
Balady		25.1 ± 0.20^{A}	9.4 ± 0.04^{A}	37.5 ± 0.34^{A}	25.1 ± 0.20^{A}	9.88 ± 0.04^{A}	39.2 ± 0.34^{A}
Damascus		24.2 ± 0.20^{B}	9.2 ± 0.04^{B}	38.1 ± 0.34^{B}	24.4 ± 0.20^{B}	9.72 ± 0.04^{B}	39.9 ± 0.34^{B}
Overall mean ± SE		24.7 ± 0.15^{a}	9.3 ± 0.03^{b}	37.8 ± 0.24^{b}	24.7 ± 0.15^{a}	9.80 ± 0.03^{a}	39.6 ± 0.24^{a}

MCV= mean corpuscular volume (fl); MCH= mean corpuscular hemoglobin (pg).

MCHC= mean corpuscular hemoglobin concentration (%).

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

^{a,b} Overall within a row indicate a significant difference (P<0.05) daily between.

Table 9: Means ± SE of daily total leukocytes count and plasma cortisol concentration during pre and post-shearing periods of Balady and Damascus goats.

		Pre-shearing (Un-shaded)		Post-shearing (Un-shaded)	
		---Day mean ± SE---			
Days	Breed	WBC's	COR	WBC's	COR
Day 1	Balady	13.3±0.04	16.6±0.30	13.78±0.04	20.2±0.30
	Damascus	12.53±0.04	16.2±0.30	13.70±0.04	20.2±0.30
Day 2	Balady	13.26±0.04	17.0±0.30	13.88±0.04	20.2±0.30
	Damascus	12.68±0.04	16.8±0.30	13.82±0.04	20.0±0.30
Day 3	Balady	13.37±0.04	16.8±0.30	13.87±0.04	16.0±0.30
	Damascus	12.71±0.04	16.4±0.30	13.75±0.04	16.2±0.30
Day 4	Balady	13.14±0.04	16.4±0.30	13.76±0.04	16.6±0.30
	Damascus	12.76±0.04	16.6±0.30	13.78±0.04	16.4±0.30
Average ± SE					
Balady		13.3 ± 0.04^{A}	16.7 ± 0.30^{A}	13.8 ± 0.04^{A}	18.2 ± 0.30^{A}
Damascus		12.7 ± 0.04^{B}	16.5 ± 0.30^{A}	13.8 ± 0.04^{B}	18.2 ± 0.30^{A}
Overall mean ± SE		12.97 ± 0.03^{b}	16.60 ± 0.20^{b}	13.79 ± 0.03^{a}	18.22 ± 0.20^{a}

WBC's= total leukocytes count (x10^3/µl); COR= cortisol.

^{a,b} Overall 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.

Leukocytes Response: The present results indicated that, breed had highly (P<0.01) significant effect on WBC's count, where Balady breed had higher values compared to Damascus (Table 9). According to Johnson *et al.* [56] and Elvinger *et al.* [57], thermal stress may cause dilution, concentration or have no effect on plasma volume. Therefore, the low value of WBC's count during pre-shearing period may be due to the hemodilution, while during shearing stress a stressful on animals as evidenced by the pronounced increase (P<0.05) in total circulating leukocytes count. The rate of increase recorded 6.32%. This increase in leukocytes count may be due to the hemoconcentation. This is in agreement with McManus *et al.* [58] who reported increase in total circulating leukocytes of sheep considered physiologically as they are due to an increase in blood pressure and heart rate. Also, Paludo *et al.* [59] who found an increase in leukocyte number after exercise and exposure to the sun in several horse breeds. On the contrary, Piccione *et al.* [6] reported that, both shorn and unshorn sheep subjected to heat stress, but higher sensitivity of shorn sheep to heat stress in comparison with unshorn sheep it is evident by a greater lessening of white blood cells in shorn group. Likewise, Da Silva *et al* [60] reported that a significant (P<0.001) effect for the interaction of shearing and temperature treatment, under temperatures >25°C, sheep presented a decrease of RBC, WBC, Hb and Ht, these differences being greater in the shorn than in the unshorn animals. Concerning the effect of breed, the use of leukocytes count as a tool for assessing the effect of shearing stress was important to explain the immunological function level of each breed under study. The present results indicated that, Balady breed had higher value of WBC's count during pre-shearing period compared with Damascus breed while both breeds reached 13.8±0.04 x10^3/µl at the end of post-shearing period.

Plasma Cortisol Response: Analysis of variance indicated that breed had not significant (P> 0.05) effect on plasma COR. The estimated plasma COR levels during the eight sampling periods are in agreement with reported in goats by Shamay *et al.* [61]. 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% (Table 9). In previous studies, Olsson *et al.* [62] 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, in addition, Meza-Herrera *et al.* [63] on six goat genotypes in northern Mexico. Likewise, Moneva *et al.* [64] 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.* [65] found that plasma COR level showed an increasing trend with enhancement of the degree of heat stress (40, 42 and 45°C) for 4 hrs in young and adult Murrah buffaloes.

The results in Table 8 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 4^{th} day of post-shearing period. Therefore, both breeds tended to had higher increase in plasma COR for short duration (2-days) after shearing. With the respect of shearing, results indicated that shearing caused 10.24% increase for plasma COR. Also, the results obtained show that plasma COR levels were only elevated on the 1^{st} and 2^{nd} days of post-shearing period and recovered quickly to basal concentrations on the 3^{rd} day after shearing. In accordance, previous studies conducted on Sarda sheep, Chios sheep and Lama guanicoe by Carcangiu *et al.* [66], Fidan *et al.* [45] and Camanchahi *et al.* [67], respectively, found that plasma cortisol levels showed a clear increase (P<0.01) in sheared groups compared with un-sheared. Other studies on the plasma cortisol concentration following shearing on sheep reported peak levels of 72.7ng/ml [68] and 78.8ng/ml [69] 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 [70]. 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 [71].

CONCLUSION

Both Balady and Damascus goats were under heat stress during pre and post-shearing periods, but the higher sensitivity were the exposure of shorn goats to heat stress in comparison with unshorn period. So, shearing induced modifications of thermoregulatory and some hematological parameters. In fact, in the hot environment, the presence of hair coat are important for the maintenance of homeothermy, where the fleece is an insulating layer protecting the animal against both heat and cold.

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REFERENCES

1. Aleksiev, Y., 2009. The effect of shearing on the behaviour of some physiological responses in lactating Pleven blackhead ewes. Bulg. J. Agric Sci., 15: 446-452.
2. Blackshaw, J.K. and A.W. Blackshaw, 1994. Heat stress in cattle and effect of shade on production and behavior: a review. Aust. J. Exp. Agric., 34: 285-295.
3. Symonds, M.E., M.J. Bryant and M.A. Lomax, 1986. The effect of shearing on the energy metabolism of the pregnant ewe. Br. J. Nutr., 56: 635-643.
4. Dy´rmundsson, O.R., 1991. Shearing time of sheep with special reference to conditions in northern Europe: a review. Bùvìsindi Icel Agric. Sci., 5: 39-46.
5. Piccione, G., S. Casella, F. Fazio and P. Pennisi, 2008. Effect of shearing on some haematochemical parameters in ewes. Czech J. Anim. Sci., 53(3): 106-111.
6. Piccione, G., L. Lutri, S. Casella, V. Ferrantelli and P. Pennisi, 2008a. Effect of shearing and environmental conditions on physiological mechanisms in ewes. J. Environ. Biol., 29: 877-880.

7. Mohammed, Suhair S. and M.A. Abdelatif, 2013. Effects of seasonal changes and shearing on thermoregulation, blood constituents and semen characteristics of desert rams (*Ovis aries*). Pakistan Journal of Biological Sciences, 16(24): 1884-1893.
8. Yousef, M.K., 1987. Principles of Bioclimatology and Adaptation. In: Johnson HD (Ed) Bioclimatology and the Adaptation of Livestock, Elsevier, Amsterdam, Oxford, New York, Tokyo, pp: 17-31.
9. Hecker, J.F., 1983. Climate Physiology. In: The Sheep as an Experimental Animal. Academic Press, London, pp: 87-90.
10. Slee, J., 1987. Sheep. In: Johnson H.D. (Ed) Bioclimatology and the Adaptation of Livestock, Elsevier, Amsterdam, Oxford, New York, Tokyo. pp: 229-244.
11. Ruchebush, Y., 1986. Physiologie Pharmacologie Thérapeutique Animales. Maloine S.A. Ed. Paris.
12. Bettini, T.M. and L. Ferrara, 1987. Ambiente e adattamento. In: Bettini TM (Ed) Elementi di scienza delle produzioni animali, Edagricole, Bologna. pp: 556-557.
13. Kearl, L.C., 1982. Nutrient Requirements of Ruminants in Developing Countries. Utah Agric. Exp. Station, Utah State University, Logan, USA. pp: 20-45.
14. A.O.A.C. 1995. Official Methods of Analysis. Association of Analytical Chemists. Washington, D.C.
15. Amundson, J.L., T.L. Mader, R.J. Rasby and Q.S. Hu, 2006. Environmental effects on pregnancy rate in beef cattle. J. Anim. Sci., 84: 3415-3420.
16. Drabkin, D.L. and J.H. Austin, 1932. Spectrophotometric studies: Spectrophotometric constants for common hemoglobin derivatives in human, dog and rabbit blood. J. Biological Chemistry, 719 Cit. In Practical Hematology, 1975.
17. Cheryl, A., 1992. Lotsperch-Steininger, E. Anne Stiene-Martin and M.D. John and A. Koepke, 1992. Clinical Hematology: Principles, Procedures and Correlations. J/B/Lippincott Company. Philadelphia, New York. London. Hagerstown
18. Munro, C. and B. Lasley, 1988. Non-radiometric Methods for Immunoassay of Steroid hormones. In: Non-radiometric Assays Technology and Applications, Alan Liso Inc. New York, pp: 289-329.
19. SAS Institute Inc.2003. SAS/STAT Procedures Guide for Personal Computer.
20. Duncan, D.B., 1955. Multiple Ranges and Multiple F tests. J. Biometrics, 11: 1-42.
21. Khalil, M.H., H.M. El-Gabbas, H.S. Khalifa and M.S. Abdel-Fattah, 1990. Effect of exposure to solar radiation on some physiological and hematological parameters in local and crossbred sheep. Egyptian J. Animal Production, 27: 47-60.
22. Rahardja, D.P., 2007. Water Balance of Goats in Jeneponto-South Sulawesi under Sunlight Exposure and Water Restriction. JITV 12(3): 218-224.
23. Hafez, E.S.E., 1968. Adaptation of domestic animals. Lea & Febiger, Philadelphia, USA, pp: 103.
24. Akusu, M.O. and G.N. Egbunike, 1990. Pre-weaning performance of kids of the West Africa Dwarf (WAD) goat in their native environment. Bull. Anim. Health Prod. Afr., 38: 399.
25. Aleksiev, Y., 2007. Effects of time of shearing on growth rate and some physiological responses in fine wool of two tooth sheep. Biotechnology in Animal Husbandry, 23(5-6):179-189.
26. Piccione, G., S. Casella, D. Alberghina, A. Zumbo and P. Pennisi, 2010. Impact of shearing on body weight and serum total proteins in ewes. Spanish Journal of Agricultural Research, 8(2): 342-346.
27. Piccione, G., G. Caola and R. Refinetti, 2002. The circadian rhythm of body temperature of the horse. Biology Rhythm Research. 33(1): 113-119.
28. Parer, J.T., 1963. The effects of wool length and nutrition on heat reactions of Merino sheep in the field. Australian Journal of Experimental Agriculture, 3: 243-248.
29. Hopkins, P.S., G.I. Knights and A.S.L. Feuvre, 1978. Studies of the environmental physiology of tropical Merinos. Australian Journal of Agricultural Research, 29: 161-171.
30. Ayo, J.O., S.B. Oladele, A. Fayomi, S.D. Jumbo and J.O. Hambolu, 1998. Body temperature, respiration and heart rate in the Red Sokoto goat during the harmattan season. Bull. Anim. Produc. Afric., 46: 161-166.
31. Piccione, G. and R. Refinetti 2003. Thermal chronobiology of domestic animals. Front Bioscience, 8: s258-s264.
32. Piccione, G., G. Caola and R. Refinetti, 2003. Circadian rhythms of body temperature and liver function in fed and food-deprived goats. Comp. Biochem. Physiol. A 134: 563-572.
33. Ndlovn, L.R. and L. Simela, 1996. Effect of season of birth and sex of kid on the production of live weaned single born kids in smallholder East African goat flocks in North East Zimbabwe. Small Rum. Res., 22: 1-6.

34. Olajide, M., 2011. Effect of coat colour, diurnal variation, sex and age on physiological parameters of West African Dwarf goats. A project report submitted to the department of animal physiology, college of animal science and livestock production, university of agriculture, Abeokuta, Ogun State Nigeria. In partial fulfillment of the requirement for the Award of Bachelor of Agric. (B. Agric.).
35. Piccione, G. and G. Caola, 2003. Influence of shearing on the circadian rhythm of body temperature in the sheep. Journal of Veterinary Medicine, A. 50(5): 235-240.
36. Webster, A.J.F. and K.L. Blaxter, 1966. The thermal regulation of two breeds of sheep exposed to air temperatures below freezing point. Res. Vet. Sci., 7: 466-479.
37. Setlalekgomo, M.R. and P.E.D. Winter, 2012. Effects of Changing Ambient Temperature on the Oxygen Consumption and the Body Temperature of Adult Angora Goats (*Capra aegagrus*). Journal of Animal Sciences Advances, 2(11): 890-896.
38. Hetem, R.S., B.A. De Witt, L.G. Fick, A. Fuller, G.I.H. Kerley and S.K. Aloney, 2009 Shearing at the end of summer affects body temperature of free-living Angora goats (*Capra aegagrus*) more than does shearing at the end of winter. Animal, pp: 1-12
39. Bianca, W. and P. Kunz, 1978. Physiological reactions of three breeds of goats to cold, heat and high altitude. Livestock Production Science, 5: 57-69.
40. Rensing, L. and P. Ruoff, 2002. Temperature effect on entrainment, phase shifting and amplitude of circadian clocks and its molecular bases. Chronobiol. Int., 19: 807-864.
41. Ruoff, P. and L. Rensing, 2004. Temperature effect on circadian clocks. J. Therm. Biol., 29: 445-456.
42. Acharya, R.M., U.D. Gupta, J.P. Sehgal and M. Singh, 1995. Coat characteristics of goats in relation to heat tolerance in the hot tropics. Small Rumin. Res., 18(3): 245-248.
43. Fourie, T.J., 1984. ‘n Vergelykende studie van die effek van koue blootstelling op die hitteproduksie van Angora *(Capra aegagrus)* en boerbokke *(Capra hircus)*. M.Sc. thesis, University of Port Elizabeth.
44. Mousa-Balabel, T.M. and M.A. Salama, 2010. Impact of shearing date on behaviors and performances of pregnant Rahmani Ewes. World Academy of Science, Engineering and Technology, 41: 1196-1200
45. Fidan, A.F., I. Kucukkurt, A. Eryavuz, I.H. Cigerci, M. Yardimci and A. Ozdemir, 2009. Effects of shearing procedures on oxidant-antioxidant status in Chios sheep. Revue Med. Vet., 160: 349-355.
46. Pennisi, P., A. Costa, L Biondi, M. Avondo and G. Piccione, 2004. Influence of the fleece on the thermal homeostasis and body condition in Comisana ewe lambs. Anim. Res., 53: 13-19.
47. Webster, M.E.D. and J.J. Lynch, 1966. Some physiological and behavioural consequences of shearing. Aust. Soc. Anim. Prod., 6: 234-239.
48. Brown-Brandl, T.M., J.A. Niennaber, R.A. Eigenberg, G.L. Hahn and H. Freetly, 2003. Thermoregulatory responses of feeder cattle. J. Therm. Biol. 28: 149-157
49. Singh, V.P., W.I. Singh and N.P. Singh, 2003. Comparative physiological responses and heat tolerance of lactating Murrah buffalos under different seasons. Cheiron, 32: 129-131.
50. Alamer, A. and A. Al-Hozab, 2004. Effect of water deprivation and season on feed intake, body weight and thermoregulation in Awassi and Najdi sheep breeds in Saudi Arabia. J. Arid Enveron., 59: 71-84.
51. Derman, K.D. and T.D. Noakes, 1994. Comparative Aspects of Exercise Physiology. In: Hodgson, D.R, Rose, R.J. (Eds), the Althletic Horse: Principle and Practice of Equine Sports Medicine. Philadelphia. W.B Saunders, pp: 13-25.
52. Piccione, G., E. Fazio, F. Giofre and G. Caola, 1994. Andamento di alcuni metabolici energetici nel corso della tosatura nella pecora. XIII Congresso Nazionale SIPAOC. pp: 21-24. [In Italian].
53. Piccione, G., F. Grasso, F. Fazio, E. Giudice and P. Pennini, 2006. Evaluation of some physiological and haematological parameters in the ewes: influence of shearing and sheltering. Folia Vet., 50: 13-16.
54. Hales, J.R.S., 1973. Effects of exposure to hot environments on the regional distribution of blood flow and on cardio respiratory function in sheep. Pflug. Arch., 344: 133-148.
55. Hales, J.R.S., A.W. Bell, A.A. Fawcetta and R.B. King, 1984. Redistribution of cardiac output and skin AVA activity in sheep during exercise and heat stress. J. Therm. Biol., 9: 113-116.
56. Johnson, P.J., T.E. Goetz, J.H. Foreman, R.S. Vogel, W.E. Hoffman and G.J. Baker, 1991. Effect of whole-body gluteal muscle potassium concentration of healthy, adult horses, American Journal Veterinary Research, 52: 1676-1683.

57. Elvinger, F., R.P. Natzke and R.G. Eggert, 1992. Interactions of heat stress and bovine somatotropin affecting physiology and immunology of lactating cows, Journal Dairy Science, 75: 449-462.
58. McManus, C., G.R. Paludo, H. Louvandini, R. Gugel, L.C.B. Sasaki and S.R. Paiva, 2009. Heat tolerance in Brazilian sheep: Physiological and blood parameters. Trop. Anim. Health Prod., 41: 85-101.
59. Paludo, G.R., C. McManus, R.Q. Melo, A.G. Cordoso, F.P.S. Melo, M. Moreira and B. Fuck, 2002. Effect of heat stress and exercise on physiological parameters of horses of the Brazilian army. Revista Brasileira Zootecnia, 31: 1130-1142
60. Da Silva, R.G., M.J. Da Costa and A.G. Sobrino, 1992. Influence of hot environment on some blood variables of sheep. Int. J. Biometeorol., 36(4): 223-225.
61. Shamay, A., S.J. Mabjeesh, F. Shapiro and N. Silanikove, 2000. Adrenocorticotrophic hormone and dexamethasone failed to affect yield in dairy goats: Comparative Aspects. Small Rumin. Res., 38: 255-259.
62. Olsson, K., M. Josater-Hermelini, J. Hossaini-Hitali, E. Hybdring and K. Dahlborn, 1995. Heat stress causes excessive drinking in fed and food deprived pregnant goats. Comp. Biochem. Physiol. A. Physiol., 110(4): 309-317.
63. Meza-Herrera, C.A., J.A. Bocanegra V. R. Banuelos, C.F. Arechiga, R.M. Rincon, M.A. Ochoa-Cordero, A.S. Juarez-Reyes, M.A. Cerrillo-Soto and H. Salonas, 2007. Circannula fluctuations in serum cortisol and glucose concentrations and hair coat growth in goats. J. Appl. Anim. Res., 31: 79-82.
64. Moneva, P., S. Popova-Ralcheva, V. Sredkova, M. Krusteva and D. Gudev, 2011. Reliability of some endocrine and behavioral indices of stress. Bulgarian J. Agric. Sci., 17(1): 116-121.
65. Haque, N., A. Ludri, S.A. Hossain and M. Ashtosh, 2012. Alteration of metabolic profiles in young and adult Murrah buffaloes exposed to acute heat stress. Int. J. of Appl. Anim. Sci., 1: 23-29.
66. Carcangiu, V., G.M. Vacca, A. Parmeggiani, M.C. Mura, M. Pazzola, M.L. Dettori and P.P. Bini, 2008. The effect of shearing procedures on blood levels of growth hormone, cortisol and other stress haematochemical parameters in Sarda sheep. Animal., 2(4): 606-612.
67. Camanchahi, P.D., R. Ovejero, C. Marull, G.C. Lopez, N. Schroeder, G.A. Jahn, A. J. Novaro and G.M. Somaza, 2011. Physiological response of wild guanacos to capture for live shearing. Wildlife Research, 38: 61-68.
68. Hargreaves, A.L. and G.D. Hutson, 1990. The stress response in sheep during routine handling procedures. Appl. Anim. Behav. Sci., 26: 83-90.
69. Hargreaves, A.L. and G.D. Hutson, 1990a. Changes in heart rate, plasma cortisol and haematocrit of sheep during a shearing procedure. Appl. Anim. Behav. Sci., 26: 91-101.
70. Dantzer, R. and P. Mormede, 1983. Stress in farm animals: a need for re-evaluation. J. Anim. Sci., 57: 6-18.
71. Ray, D.E., W.J. Hansen, B. Theurer and G.H. Stott, 1972. Physical stress and corticoid levels of steers. Proceedings Western Section of American Society of Animal Scientists, 23: 255-259.