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Comparative Study of Heat Stress Effect on Thermoregulatory and Physiological Responses of Baladi and Shami Goats in Egypt

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ABSTRACT

The experimental study was managed to achieve the effect of heat stress on bodyweight, thermoregulatory and physiological responses of Baladi and Shami goats. Twenty adult female Baladi and Shami goats (10 of Baladi goats and 10 of Shami goats) were used for the study. The goats were exposed to three different times (T1, T2 & T3) of temperaturetreatment; T1, T2 in August and T3 in September, Baladi and Shami goats were divided into two exposed groups to solar radiation (n=10). The results showed thatT1 periods was significantly (P<0.05) increased in relative humidity, while T2 period was significantly (P<0.05) increasedin ambient temperature and temperature-humidity index. Bodyweight showed a significant (P<0.05) decrease at T3 in both breeds. Baladi goats showed a significant (P<0.05) increase at T2 compared to Shami goats in rectal and skin temperature, respiratory rate, white blood cells, albumin, serum ALT, and phosphorus. While Shami goats showed increase in coat and Ear temperatures, also, total protein, AST and CL at T1 compared with Baladi goats. It is accomplished that heat stress had a significant increaseeffect on body weight,thermoregulatory and physiological responses on Shami goats compared with Baladi goats.

Keywords: Goats, heat stress, thermoregulatory, bodyweight, physiology.

INTRODUCTION

It is well known that ambient temperature is high in tropical and semitropical zones,it consideredthe major factor on animal function mechanism and body temperature. Despite small ruminants having well developed mechanism of thermoregulation, they do not maintain strict homeothermy under heat stress (Silanikove, 2000 and Tushar *et al*., 2017).

small ruminants are considered the most important resources of small ruminant in the tropical regions (Ozung *et al*., 2011 and Okoruwa, 2014). Tropical regions characterized with a variation of different climatic conditions that give altitude to different adaptive mechanisms so that goats could overcome stresses of environmental conditions in tropics (Okoruwa, 2014). Baladi local goats are very adapted to environmental conditions of the north Sinai desert, which include a prolonged dry season, extreme climate fluctuations, and water scarcity (Helal *et al*., 2010b). However, there have been a lot of efforts to introduce Shami breed for crossbreeding with local Baladi breeds or used as a straight-breeds for more milk production (Helal *et al*., 2010a). The physiological reaction of goats to ecological stress during moisten and arid season showed athorough effects on bodyweight, thermoregulatory and physiological responses (Okoruwa, 2014). Recently ,many studies suggested thermo-physiological parameters to observe animal interest in hard environment such as rectal temperature, respiratory rate and blood parameters (Helal *et al*., 2010a; Sanusi *et al*., 2010).The ability of goats to maintain heat adaptationto hard environmental lacksneeds to be studied. Heat stress with high climatic conditions and relative humidity with extended exposure to direct solar radiation is more mutual especially in arid season (Okoruwa, 2014). Thus, heat stress effected on physiological balance of goats and theirendocrine, nervous and immunesystems that have been involved with responses and alternate regulatory performance (Castanheira *et al*., 2010). Changes in blood result of goats are delicate to environmental temperature variation, being an important indicator of physiological responses to stressing factor. The present data was infectious to investigate heat stress effects onbodyweight, thermoregulatory and physiological responses of Baladi and Shami goats.

MATERIALS AND METHODS

Place of experiment: The present study was executed at RaesSedr Research Station, belonging to Desert Research Center, Southern Sinai, and Egypt.

Animals and Experimental Design:

Twenty adult Baladi and Shami goats were randomly chosen from the breeding flock of the station (10 of Baladi goats and 10 of Shami goats). All goats were healthy and were kept under semi-open pens. The animals were allowed to adapt in the sheltered pens conditions (7 days) as adaptation period, no measurements were taken during this period. The two breeds were divided into 2 groups, 10 animals in each.

Goats were exposed daily to solar radiation from 5:00 am to 7:00 pm throughout the experimental period. Data were collected three times: time 1 (T1) at 1 August, time 2 (T2) at 15 August and time 3 (T3) at 1 September. Animals were fed twice daily (9:00 am and 15:00 pm) with alfalfa hay *ad. Lib* and supplemented with concentrate mixture (0.5 kg/head/day). Drinking water was available all day.

Collected of Data

Metrological data: Ambient temperature (AT, ºC) and relative humidity (RH%) were measured at 2.00pm (afternoon) using a thermometer, throughout the experiment. Temperature-humidity index (THI) was calculated by using the formula below as reported by Amundson *et al*. (2006).

$$THI = 0.8 X AT.^{o}C + ((RH\% \div 100) X (AT^{o}C - 14.4)) + 46.6$$

Thermoregulatory and Body weight results: Bodyweight (BW, Kg) of goats was measured through all experimental period in each group. Respiratory rate and rectal, skin, coat and ear temperature in each goat were measured at 2:00pm. Digital thermometer was used to measured rectal temperature, with a disinfected sensory tip and inserted into the rectum at the display of *LºC* by the thermometer (which indicated that the thermometer is set for the reading temperature) and was removed after the sound of the alarm signal, then recorded body temperature. Skin, coat and ear temperature were measured using infrared thermometer in four shaved regions (right and left shoulder with right and left hips). Respiratory rate was determined by counting the number of abdominal movement per minute.

Physiological Data: Two different (5ml) vacuum tubes used for blood samples which taken up from jugular vein from each animal. One of the (5ml) set of blood tubes contained ethylene diamine tetra-acetic acid (anti-coagulant) for haematological studies. The haemoglobin (Hb, g/dl), red blood cell ($RBC \times 10^{12}/L$), hematocrit (HCT %) and white blood cell ($WBC \times 10^{9}/L$) were analysed as described by Al-Eissa and Alkahtani (2011); Okoruwa and Ikhimioya (2014).

The second (5ml) vacuum set of blood tubes without anticoagulant were centrifuged for 20 minute at 3500rpm to collect serum and stored at -20ºC for chemical analysis. Total plasma proteins (TP, g/dl), albumin concentration (Al, g/dl) was determined according to the method reported by Helal *et al.* (2010). Alanine transferase (ALT, u/ml), aspartate transferase (AST, u/ml) by Swarup *et al*., 2007 and Sanusi *et al*. (2010), sodium (Na^+, mmol/L), chloride (Cl^-, mmol/L), calcium (Ca^{+2}, mmol/L) and potassium (K^+, mmol/L) were estimated according to the way reported by Al-Haidary *et al*. (2012).

Statistical Analysis: Data for each of body weight, thermoregulatory and physiological indices were analyzed using the Generalized Liner Model (GLM) of SAS (2003) software package. Statistical means were compared using Duncan Multiple Range Test (DMRT) Duncan, (1955).

RESULTS AND DISCUSSION

Table 1 showed climatic means value of ambient temperature (AT, °C), relative humidity (RH, %) and temperature-humidity index (THI) for the empirical periods of experiment. for T2 (42°C) showed a significant (P<0.05) increase compared in ambient temperature compared with T1(40°C) and T3 (38°C). In this study the ambient temperature for T2 (in the same time / year) for species showed a higher value than the critical temperature (24 to 27°C) indicated by Helal *et al*. (2010a). The observed relative humidity indicated a significant (P<0.05) lower values (32 and 38%)at T2 compared withT1 and T3. The obtained relative humidity data at this experiment showed high value compared with the values (9.20 to 33.93%) recorded by Al-Haidary *et al*. (2013).The observed data of temperature-humidity index was88.33, 98.25 and 84.93 forT1, T2 and T3,respectively were recorded. Temperature humidity index observed in T1 and T3 showed a significant (P<0.05) decrease than T2.Temperature humidity index values of 74 or less take into consideration inbred, and 75 to 78 is ultimatum case, while 79 to 83 is dangerous case and equal to or above 84 of temperature-humidity index is a critical case as indicated by Helal *et al*. (2010). The present study showed that the temperature-humidity index at T1, T2 and T3 was over than during the empirical periods and distributed as a result to heat stress. Consequently, the climatic results detected that exposed goats to direct sunlight pressure during all periods of this study showed highly heat stressed.

Table 1. Data of climatic parameters recorded during the study periods

Climatic parameters	T1	T2	T3	SEM ±
Ambient temperature (ºC)	40^{b}	42^{a}	38^{c}	0.54
Relative humidity (%)	38^{a}	32^{c}	37^{b}	0.32
Temperature humidity index	88.33^{b}	98.25^{a}	84.93^{c}	0.21

a,b,c Means within the same row with different superscripts differ significantly (P< 0.05).
SEM = Standard error of mean

Table 2. Data of thermoregulatory and body weight parameters on Baladi and Shami goats as affected by heat stress

Parameters	Exposed						SEM ±
	T1		T2		T3		
	Baladi	Shami	Baladi	Shami	Baladi	Shami	
Respiratory rate (breaths/min)	74.80^{c}	60.40^{d}	102^{a}	95.60^{b}	36.80^{e}	36.80^{e}	0.50
Rectal temperature (ºC)	41^{a}	40.20^{b}	41^{a}	40.10^{cb}	39.82^{cb}	39.56^{c}	0.22
Skin temperature (ºC)	39.20^{ba}	39.20^{ba}	39.40^{a}	38.60^{ba}	38.40^{bc}	38.20^{bc}	0.29
Coat temperature (ºC)	40.60^{c}	46^{a}	42.60^{b}	42.60^{b}	39^{ed}	39.40^{d}	0.34
Ear temperature (ºC)	38^{ba}	38.20^{a}	38^{ba}	38.20^{a}	37.80^{ba}	37.80^{ba}	0.26
body weight (kg)	24.10^{c}	33.50^{a}	19.70^{de}	33.10^{ba}	21.50^{dc}	30.20^{b}	0.95

a,b,c,d,e Means within the same row with different superscripts differ significantly (P< 0.05).
SEM = Standard error of mean.

Table 2, showed that thermoregulatory and bodyweight parameters affected with heat stress on Baladi and Shami goats.Respiratory rate showed no significant (P>0.05) change between Baladi and Shami at T3 (36.80, 36.80 breaths/min), but Baladi goats showed increase at T2 (102 breaths/min) and T3 (74.80 breaths/min) compared with Shami goats (95.60 and 74.80 breaths/min), respectively. Rate of respiration could be used as an assessment to inverse the effects of environmental temperature and as an exponent to the stress of heat (Al-Haidary *et al*. (2012). Rate of respiration is effective and responsible parameter of capacity of the heat and announced that rate of respiration over 12 to 20 breath/minute in small ruminants is a parameter to heat stress (Okourwa *et al*. (2013).Rectal temperature showed a significant (P<0.05) increase in Baladi goats at T1and T2 (41.02 $^{\circ}$C) followed by T3 compared with Shami goats. Rectal temperature increased case consider a better index to heat stress level as reported by Otoikhian *et al* (2009).Subsequently the observed altitude in the rectal temperature for goats at T1 and T2indicated that, they exposed to heat stress. Skin temperature data of Baladi and Shami goats that were obtained showed a significant (P<0.05) increase atT1 and T2 and lowest at T3. The increase in skin temperature for goats on T1 and T2 was also assign to be heat stressed, in which a state of vasodilatation of skin capillary bed has been detected then blood flow increased to surface of skin to favor losing of heat (McManus *et al*., 2009). Temperature of skin can be also increased due to exposed to direct sunlight, accordingly temperature of skin showed to be fair regarding to levels of ambient solar radiation(Schutz *et al*., 2011).Therefore, the observed precipitation of respiratory rate of goats at T1 and T2indicated increasing the panting of goats as a result of exposed to high heat stress. Marai *et al*., 2007 reported that heat loss evaporation mechanism and respiratory hesitation by panting sanatorium to pursue closely the heat loss by evaporation. Shami goats showed a significant (P<0.05) increase in coat temperature at T1 (46 $^{\circ}$C) compared with Baladi goats, but they showed no significant effect at T2 and T3. These results concomitant with Helal *et al*., (2010), who report that Shami goats had highly significant coat depth compared with Baladi goats, and that coat help Shami goats to protect themselves from direct sunlight. On the other hand ear temperature showed no significant effect between the two breeds. Both Baladi and Shami goats induced a significant (P>0.05) decrease by T3 compared with T1 and T2. Exposed of goats to direct sunlight for 12 hours raised body weight loss of goats (Helal *et al*. (2010). Lacked in live bodyweight during solar radiation exposure raising energy exhausted to heat waste through evaporation respiratory mechanism and thus to reduce in the water available amount that stored as reported by Ocak *et al*. (2009).

Table 3. Effect of heat stress on haematological and serum biochemical parameters of exposed Baladi and Shami goats

Parameters	Exposed						SEM ±
	T1		T2		T3		
	Baladi	Shami	Baladi	Shami	Baladi	Shami	
Haematology							
RBCs (10^{12}/L)	10.29^{a}	10.00^{ab}	8.78e^{bc}	9.22^{ab}	8.45^{bc}	8.30^{cd}	0.21
HB (g/dl)	9.41^{a}	8.37^{b}	8.40^{b}	7.28^{cd}	7.96^{c}	7.26^{cd}	0.26
HCT (%)	17.46^{a}	16.52^{bc}	15.77^{c}	17.23^{ab}	14.69^{cd}	14.20^{d}	0.68
WBCs (10^{9}/*L)*	11.70^{ba}	6.42^{ef}	12.56^{a}	6.98^{e}	8.98^{dc}	9.65^{c}	0.35
Serum biochemistry							
Total protein (g/dl)	8.90^{dc}	12.37^{a}	10.30^{bc}	9.43^{c}	8.60^{d}	11.36^{b}	0.42
Albumin (g/dl)	2.97^{b}	3.60^{ba}	4.33^{a}	3.83^{b}	4.43^{a}	3.80^{ba}	0.39
ALT (u/ml)	14.87^{e}	17^{d}	21.53^{a}	17.63^{cd}	19.77^{b}	18.87^{c}	0.50
AST (u/ml)	23.67^{cb}	24.29^{a}	24.10^{ab}	22.38^{cd}	23.67^{cb}	21.88^{d}	0.45
Na (mmol/L)	126.78^{c}	138.89^{b}	148^{a}	124.27^{d}	126.83^{c}	121.93^{ed}	0.60
Cl (mmol/L)	101^{bc}	110.33^{a}	100^{bc}	102.83^{b}	99^{d}	102.33^{b}	0.54
K (mmol/L)	0.53^{ab}	0.29^{d}	0.57^{ab}	0.32^{c}	0.60^{a}	0.34^{c}	0.23
Ph (mmol/L)	10.47^{d}	20.83^{a}	20.83^{a}	16.67^{c}	18.23^{b}	18.27^{b}	0.49

^{a,b,c,d,e} **Means within the same row with different superscripts differ significantly (P< 0.05). SEM = Standard error of mean.**

Table 3, showed that haematological and serum biochemical index as affected by heat stress in baladi and Shami goats. All obtained parameters of haematology showed a significant (P<0.05) influenced in treated goats. The haemoglobin (Hb) concentration and red blood cell (RBC) showed a significant (P<0.05) increase at T1 in Baladi (9.41 g/dl and 10.37x10^{12}/L) and decrease value in Shami goats at T3 (7.26 g/dl and 8.30 x10^{12}/L). The difference that observed may be assign to the high heat stress on goats which imparteda physiological need for raising in haemoglobin concentration and red blood cell to collaborate with the circulation of oxygen during panting. That explication was in regularity with the data obtained by Sanusi *et al*. (2010)who found increase in haemoglobin concentration and red blood cells number in sheep as a result of heat stress increasing. White blood cell (WBC) showed a significant (P<0.05) decrease at T3 in Baladi goats (8.98x10^{9}/L) compared to T2

($12.56x10^9$/L) and T1 ($11.70x10^9$/L), otherwise, Shami goats showed increase at T3 ($9.65x10^9$/L) compared with T2 ($6.98x10^9$/L) and T1 ($6.42x10^9$/L). The variation in W.B.Cs may be as a result of rectal temperature and immunological challenged effects of the experimental goats which assign to modification in their physiology that found versus noxious the effect of antigen. The present result also was observed by Okoruwa *et al*. (2013) who found a significant (P<0.05) decrease in W.B.Cs for experimental dwarf bucks because of increase in rectal temperature. Biochemical results in serum also significantly (P<0.05) influenced by treated goats. Shami goats showed a significant (P<0.05) increase at T1 in total protein (TP, 12.37g/dl), albumin (AL, 3.60g/dl), Aspartate transferase (AST, 24.29u/ml), chloride (Cl, 110.33mmol/L) and Phosphorus (Ph, 20.83mmol/L) compared with T2 and T3, and a significant (P<0.05) increase in sodium (Na+,138.89mmol/L) at T2, potassium (K, 0.60mmol/L)at T3.On the other hand, Baladi goats showed a significant (P<0.05) increase in albumin (4.33 g/dl), ALT (21.53u/ml), AST (24.10u/ml), Na+ (148mmol/L), K (0.57) and Ph (20.83mmol/L) at T2 compared with T1 and T3, while TP showed increase at T3 (3.80g/dl) and Cl induced increase at T1 and T2 (101 and 100mmol/l) respectively. The increased in serum concentration of total protein and AL in both breeds could be result of dehydration that happened as a result of raising the rate of breathing(Erickson and Poole, 2006). AI Qarawi *et al*., 2003 and Rashid *et al*., 2013 explained the observed the increase in ALT and AST explained by increasing uric acid in summer season due to the elevation of blood urea might be due to the combined pre-renal effects of reduced infusion with lower glomerular filtration and greatest load due to increased metabolic activity. The observed decreased of serum K+ may be a result to the heat stress that stimulate activate secretion of cortical and the consequentstimulation of gluconegenesis and K+ supprestion of cellular glucose uptake and profiteering(Marai *et al*., 2007). Pervious studied agreement with our data and reported that heat stressed animals lost more potassium and chloride in sweat than non-heat stressed animals (Aryal *et al*., 2012 and Hooda and Upadhyay, 2014). The decrease in electrolytes concentration observed in this study may also be due to expanded blood volume where water is transported in the circulatory system for evaporative cooling as suggested by Al-Haidary (2004).

CONCLUSION

The observed showed diversity on thermoregulatory, bodyweight and physiological parameters in the experimental animals, which were correlated with nature of the surrounding environment, type of goats and the variation in their exposed time to solar radiation. Thus, the results of this study correlate that local goat (Baladi) are more adaptable than foreign goats (Shami) to heat stress. However goat's production under that status in Egypt and other parts of the world could demand ecologicaland nutritional adjustment to qualify the effect of heat stress on goats.

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دراسة مقارنة لتأثير الإجهاد الحراري على الاستجابات الحرارية والفسيولوجية للماعز البلدي والشامي في مصر

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تم إجراء هذه الدراسة لمعرفة تأثيرالإجهاد الحراري على حرارة الجسم، ووزن الجسم الحي والاستجابات الفسيولوجية لكل من الماعز البلدي والشامي. أستخدم عشرين من إناث الماعز البالغة (عشره من كلا النوعين) تم اختيارهم لإجراء هذه التجربة. لقد تم خضوع تلك الماعز لثلاث مرات مختلفة (١,٢,٣) من درجات الحرارة, فالمرة الاولي والثانية تمت في شهر اغسطس أما الثالثة فكانت في شهر سبتمبر, وقد تم تقسيم الماعز إلي مجموعتين من الماعز البلدي والشامي المعرضة لأشعة الشمس المباشرة.اظهرت النتائج وجود زيادة ملحوظة خلال الفترة الأولي في الرطوبة النسبية, بينما في الفترة الثانية كانت درجه الحرارة المحيطة ومؤشر درجة الحرارة والرطوبة هما الأعلى. أما وزن جسم الحيوانات فيشير إلي نقص عالي في كلا المجموعتين في الفترة الثانية. أظهرت الماعز البلدي زيادة عالية في الفترة الثانية مقارنة بالماعز الشامي بالنسبة لدرجة حرارة المستقيم والجلد، معدل التنفس، وعدد خلايا الدم البيضاء، وتركيز الألبيومين، ناقل الأمين ألانين (ALT) والفوسفور.كما أظهرت الماعز الشامي زيادة في درجات حرارة الغطاء الخارجي للحيوان والأذن وأيضًا في تركيز البروتين وناقل الأمين الإسبارتاتي (AST)، والكلوريد في الفترة الأولي مقارنة بالماعز البلدي. وقد أوضحت الدراسة إلى أن الإجهاد الحراري كان له تأثير معنوي على درجات الحرارة ، ووزن الجسم والاستجابات الفسيولوجية تحت الدراسة للماعز الشامي مقارنة بالماعز البلدي.