Effect of heat stress on some physiological characteristics of Awassi Sheep in Iraq

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Summary

Thirty four growing male Awassi I sheep were used in an attempt to assess a useful heat tolerance index by using some physiological and biochemical changes due to solar radiation exposure. The changes in body temperature, hemoglobin, haematocrit, total body water, triiodothyronine and cortisol was found to be not correlated with body gain decrease due to heat stress. Therefore, it can not be used to predict heat adaptability in this study.

During the hot-humid summer (temperature humidity index =76-89°) daily body and solids gain,, dry matter intake, thyroid, liver and kidney functions were reduced. However, total body water, water intake, rectal temperature and respiratory rate were increased. Treatment of heat stressed sheep by chilled drinking water significantly improved daily body and solids gain and reduced the effects of heat stress on thermal and water balances and thyroid, liver and kidney functions. Tap water sprinkling failed to alleviate the adverse effects of heat stress.

Keywords: Awassi sheep, heat stress, water cooling

Introduction

Sheep in Wasit(kut governorate) are considered as an important source of meat and to a lower extent as a wool producer. However Awassi sheep as affected by such conditions, is not yet evaluated. Wide variations were found between and within species and breeds in their relative adaptability to hot climates. Heat adaptability of an animal reflect its ability to balance metabolic heat production against environmental heat gains and heat losses. Consequently , traditional heat tolerance indices have been based on the stability of thermal, water and protein balance. But the methods used have neither been reproduced nor correlated with growth productive performance of the animals (Fabio and Rex John, 2003).

Water is an excellent cooling agent because of its high heat capacity and high latent of vaporization. Chilled drinking water is effective because it absorbs heat directly from the animal without evaporation (Al-Haidary, 2000). The thermal environment is a major factor that can negatively affect sheep performance. Increase body temperature and respiration rate are the most important sign for heat stress in sheep. The increase in body temperature is associated with marked reduction in feed intake , redistribution in blood flow and changes in endocrine functions that affect negatively the productive and reproductive performance of the sheep (West, 2003). Heat stress results in the significant decrease in dry matter intake and milk yield (Alam et al., 2011).

Excessive heat stress may cause hyperthermia and potentially have several physiological side effects and economical impact on the livestock industry. These include the aberration of reproductive functions (Roth et al., 2002), oxidative stress and enzymatic dysfunction (David et al., 2001), reduce meat quality (Kadima et al.,2004). Moreover under these conditions the animal's productive a limited data available with the effect of heat stress challenge on the thermoregulatory system of sheep in Iraq. Therefore, the present study was conducted to investigate the following specific objectives:

i) To investigate the effects of hot- humid summer of kut on some productive trail of Awassi sheep.
ii) To evaluate physiological parameters in sheep under heat stress and blood parameter after heat stress.
iii) To develop a useful index of heat adaptability that night predict at an early age heat- tolerant high- producing animals. Use of long- term efficacy of either chilled drinking water or water hose sprinkling in relieving heat stress on growing sheep was also evaluated.

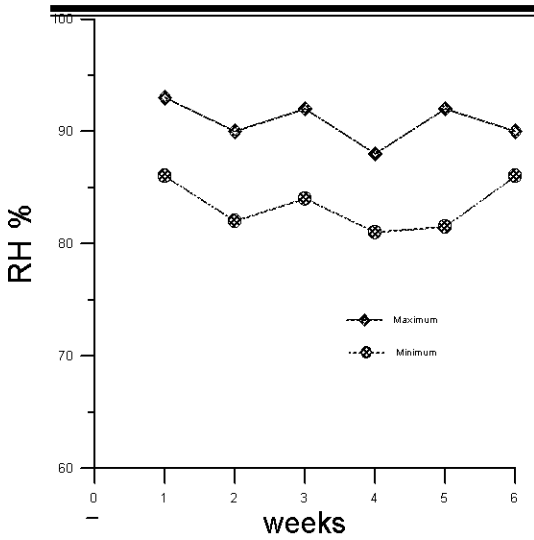
Materials and methods

The present study was carried out at Dejla Animal Production Farm in Kut governorate in 2013. It was comprised of two trails the first was carried during spring using 10 growing male Awassi sheep 9-12 months old and 15.9 kg average body weight and lasted for 6 weeks to study the effects of mild climate on growth and some related physiological and biochemical parameters (Group A). In the second trail. 24 sheep similar to those of trail 1 were divided to three groups (B,C and D) and subjected for 7 weeks to summer climate. Growth traits of sheep under warm-humid summer conditions (Summer control group.B) were compared, first, with the spring group (A) and second, with sheeps cooled either by providing chilled drinking water (group C) or by tap water sprinkling (group D).

Themeterological data during the experimental period are shown in Figure 1. The temperature humidity index (THI) as indicator of adverse climatic conditions was calculated from dry bulb temperature (db.°F) and relative humidity (RH% ÷100) by the following formula: THI = db - (0.55-0.55 RH) (db - 58).According to livestock and Poultry heat stress indices suggested by Agricultural Engineering Technology Guide.Clemson University, Clemson, SC. 29634. USA. THI values of less than 72 are considered not stressful. 72 to 78 are stressful, and over 78 to be extremely stressful Heat tolerance index (HTI) was determined according to Iberia heat tolerance test (Rhoad,1994) with a minor modification. The following formula was used: HTI = 100– (ART-39).where, ART is the average rectal temperature before and after 4 hoursexposure to solar radiation for 3 consecutive days and 39 is the average normal rectal temperature of sheep. HTI was determined, also, using other techniques based on the percentage change in each of hemoglobin (Hb), packed cell volume (PCV), total body water (TBW),triiodothyronine(T3) and cortisol due to solar radiation exposure. The following formula was used HTI= 100-AC. where AC is the average of percentage change dueto solar radiation exposure for 3 days, HTI was carried out during the first three days of summer treatment for eachsheep of group B. Solar radiation intensity averaged 1.52 langlay/minute, where 1 langlay= 1 $Cal.cm^{-2}$. HTI for each sheep was correlated with its daily body gain decrease due to summer condition todevelop a useful index of heat adaptability so as to predict at an early age heat-tolerant high producing sheep .

In group C, drinking water was chilled to 10-15°C by adding ice to the water container. While, drinking water temperature for the sheep in groups B and D was 23-30 °C. Tap water sprinkling for group D was carried out using a water hose 4 times daily, each of which lasted for about 3 minutes during the hottest time of the day (10.00 -17.00 hr).

The animals were provided with a basal ration consisting of pelleted concentrate, rice straw and acacia to cover their nutritional requirements (Table 1). Sheep watered three times daily during the heat of the day (10.00-17.00 hr) with natural well water (kut tap water). This water contained 3120, 198, 99, 45, 346, 51, 10,11, 97, 594, 767 ppm total dissolved solids,calcium, magnesium, potassium, sodium, zinc. Manganese carbonate, bicarbonate, sulphate and chloride, respectively and pH was 7.8.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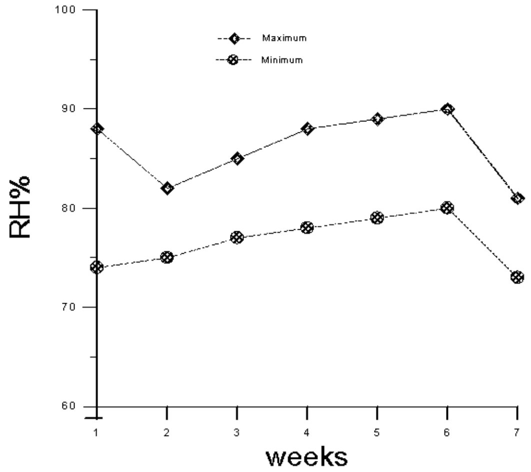
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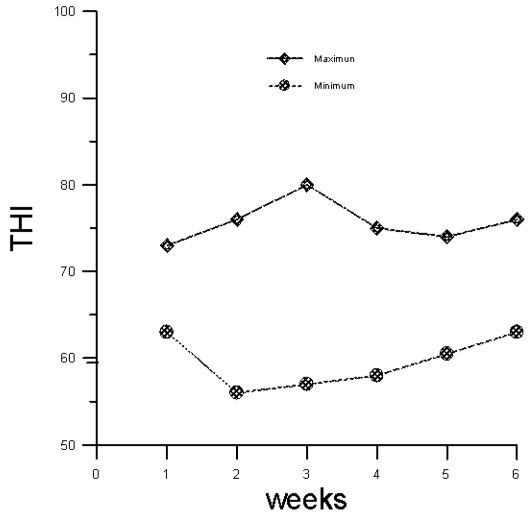
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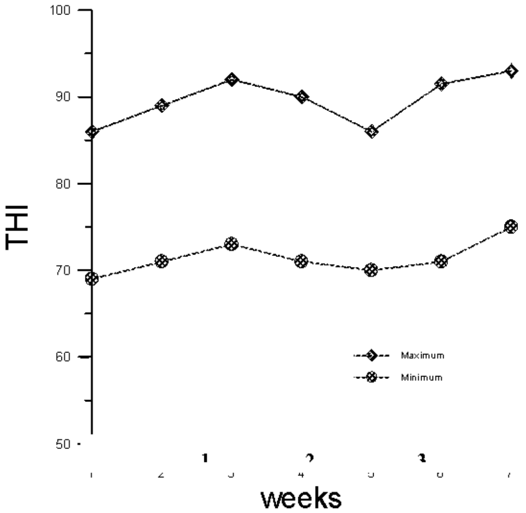
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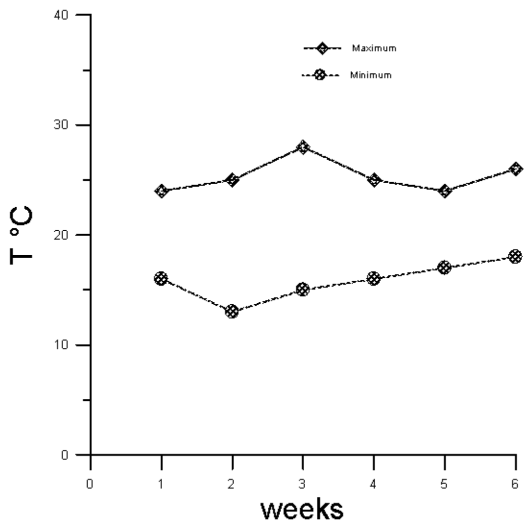
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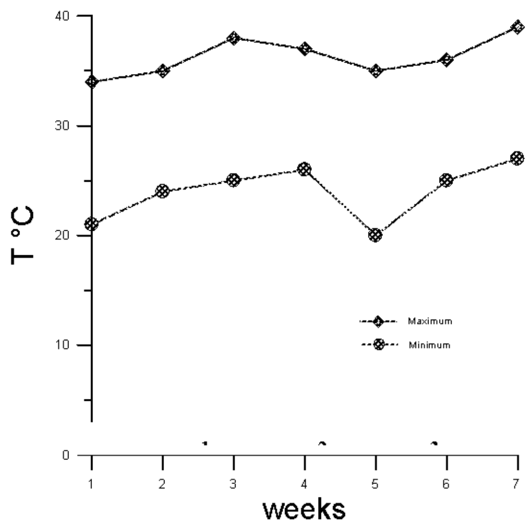
T °C
weeks
Maximum
Minimum

Spring

Summer

Figure 1 : Air temperature (T), temperature humidity index (THI) and relative humidity (RH%) during the experimental period.

Table 1.Proximate analysis of the experimental feed stuffs.

Items	Concentrate*	Rice straw	Acacia**
Moisture	7	7.1	67.7
Composition of dry matter (%):			
Crude protein	14.5	3.05	16.3
Ether extract	5.3	1.35	5.6
nitrogen free extract	46.4	37.7	45.2
crude fiber	19.2	42.5	22.4
Ash	14.6	15.4	10.5

* concentrate feed mixture was composed of 35% undecorticared cotton seed cake, 33% wheat bran, 22% yellow corn, 4% rice bran, 2% lime stone, 1% sodium chloride and 3% molasses.

** Acacia is a natural shrub vegetation in Kut. It is a perennial legume gave green forages around the year and grows in marshy areas near fresh and salt water on sandy soils. It tolerate flooding and drought and it is considered as a palatable pasture shrub rich in protein.

The animals were weighed every 10 days to determine daily body gain. At the first and last day of each treatment, each animal was injected intramuscularly with antipyrine (1g/100 kg live body weight, LBW)for estimating total body water (TBW) according to Kamal and Habeeb.(1984). Total body solids (TBS) was calculated at the beginning and at the end of each treatment as the difference between LBW and TBW. Total solids gain was estimated by the difference between TBS at the end and at the beginning of each treatment and daily solids gain (DSG) was thus calculated. Rectal temperature and respiratory rate were recorded two times weekly at 13.00 hr.Blood samples were withdrawn before feeding and drinking from the Jugular vein every two weeks during each treatment and two times daily for 3 days before and alter solarradiation exposure. Blood hemoglobin (Hb).packed ceil volume (PCV) andred blood cells (RBC's) were estimated immediately after blood samples collection. Plasma or serum was separated within one hour and stored at-20 °C until assayed. Serum total protein, total lipids, cholesterol and creatinine were determined using reagent colorimetric methods. The globulin values were obtained by subtracting albumin from total protein. Serum urea-N.albumin, alkaline phosphatase (ALP), acidphosphatase (ACP) andglutamic pyruvic transaminase (SGPT) weremeasured using commercial kits (Bio Meriux. Laboratory Reagents and Products. France). Plasma triiodothyronine (T3) and cortisol were estimated with the radioimmunoassay technique using labelled kits purchased from Diagnostic Production Corporation.Los Angleus California. USA(Table 2).Data were tabulated and subjected to statistical analysis according to Snedecor and Cochran (1982).

Table 2.Correlation coefficients between daily gain decrease due to summer climate and HTI based on the changes due to solar radiation exposure in each of RT, Hb, PCV, TBW, T3 and cortisol.

	Iberia HTI	HTI=100– Percentage change due to solar radiation*				
		Hb	PCV	TBW	T3	cortisol
Daily gain** decrease due to summer	–0.308	-0.178	-0.444	-0.047	-0.236	-0.039

* $\frac{\text{Before exposure} - \text{after exposure}}{\text{Before exposure}}$ x ١٠٠ ** $\frac{\text{Spring} - \text{Summer}}{\text{Spring}}$ x ١٠٠

Table 3. Heat stress and amelioration effects on daily gain and some related physiological parameters (X ±SE) of Awassi sheep.

Items	spring (THI=59-72°)	Summer (THI=76-89°)		
		Control	Cool water	Sprinkling
Animal groups (No).	A(10)	B(10)	C(7)	D(7)
Daily body gain,g(ab)	161 ± 8.19	106 ±9.97	137 ±9.15	122 ± 0.7
Daily solids gain, g(ab)	57.4± 2.95	29.7 ±3.06	4.5.6 ± 7 5 7	36.1 ±3.25
TBW/100kgLBW (ab)	64.1 ±1.58	73.0 ±1.83	66.8 ± 1.62	70.4 ± 1.95
TBS/100 kg LBW (ab)	35.**9** ± 1.23	27.0 ±1.17	33.2 ± 1.25	29.6 ± 1.68
Daily dry matter intake, kg(ab)	1.26 ±0.13	0.76 ± 0.09	1.10 ±0.11	0.88 ±0.14
Feed efficiency, DMI/gain	7.83 ±0.41	7.17 ±0.54	8.03 ± 0.44	7.21 ±0.58
Water intake, 1/day (ab)	1.45 ±0.21	2.18 ±0.16	1.69 ±0.12	2.03 ± 0.25
Water intake, ml/kg LBW/day(ab)	65.0 ± 7.94	101 17.18	74.8 ± 7.09	91.0 ± 11.5
Rectal temperature, C° (ab)	39.1 ±0.07	40.9 ±0.12	39.8 ±0.11	40.5 ± 0.11
Respiratory rate, r/min. (ab)	34.5 ± 3.88	118 ± 10.6	69.9 ± 6.59	96.7 ± 11.9

a and b= effects of summer (AXB) and cool water (BXC) treatments, respectively (P<0.05).

Table 4. Heat stress and amelioration effects on blood haematology and thyroid and adrenal gland functions(X ± SE) ofAwassi sheep.

Items	spring (THI=59-72°)	Summer (THI=76-89°)		
		Control	Cool water	Sprinkling
Animal groups (No).	A(10)	B(10)	C(7)	D(7)
Blood haematology:				
Hb,g% (ab)	11.9 ±0.44	9.73 ± 0.56	11.4 ± 0.49	10.8 ± 0.74
PCV.% (ab)	34.9 ± 0.78	27.2 ±0.83	31.1 ±0.55	29.5 ±0.98
RBCs(X $10^6 mm^3$) (ab)	12.3± 0.29	10.8 ±0.34	11.9 ± 0.24	11.1 ±0.36
Thyroid function:				
T3, ng/ml (ab)	0.83 ± 0.06	0.55 ± 0:07	0.76 ± 0.06	0.67 ±0.09
Adrenal function:				
Cortisol, Ug/ml	13.9 ±2.52	12.1 ±3.64	13.7 ±2.19	13.0 ±4.38

a and b= effects of summer (AXB) and cool water (BXC) treatments, respectively (P<0.05)

Table 5. Heat stress and amelioration effects on liver and kidney functions (X±SE) of Awassi sheep.

Items	spring (THI=59-72°)	Summer (THI=76-89°)		
		Control	Cool water	Sprinkling
Animal groups (No).	A(10)	B(10)	C(7)	D(7)
Liver function				
Total protein g/1 (ab)	65.6 ±2.41	52.0 ±2.13	61.9 ±2.09	56.4 ± 2.96
Albumin (A), g/l (ab)	32.9 ±1.12	25.4 ±1.53	29.9 ±1.37	27.7 ± 1.51
Globulin (G) g/1 (ab)	32.7 ±1.27	26.6 ±1.42	32.0 ± 1.35	28.7 ±1.39
A/G ratio	1.01 ±0.09	0.95 ±0.11	0.93 ±0.12	0.97 ±0.14
Total lipids, g/1 (ab)	5.23 ±0.17	3.81± 0.21	4.91 ±0.15	4.08± 0.27
Cholesterol, g/l(ab)	0.97± 0.05	0.68 ± 0.07	0.89 ±0.06	0.74 ±0.07
Alp. Unit/1	112 ±5.43	118 ±6.39	117± 7.67	110 ±6.53
ACP,Unit/l	32.2 ±1.57	34.1 ± 1.65	35.6 ±2.09	32.5± 1.97
SGPT, Unit/l (ab)	0.76 ±0.03	0.60 ± 0.04	0.71 ± 0.3	0.65 ± 0.04
Kidney function:				
Creatinine, mg/1 (ab)	16.7 ±0.53	12.8 ±0.60	15.1 ±0.54	14.0 + 0.65
Urea, mg/1 (ab)	174 ± 6.36	140± 7.17	168 ±6.65	159 ±7.78

a and b= effects of summer (AXB) and cool water (BXC) treatments, respectively (P<0.05)

Results

Heat tolerance index (HTI):

HTI based on the change in each of rectal temperature, Hb, PCV, TBW, T3 and cortisoldue to short- term exposure to solar radiation did not correlate significantly with the decrease in daily body gain due to long-term summer treatment (Table **2)**.

Warm- humid climate influences:

The THI was 4 to 17 units above the critical value (72°) and the animals gained more heat from the environment than could he dissipated. This isevidenced by the increases (P<0.05) in rectal temperature (1.8°C), respiration rate (342%)TBW (14%) and water intake (50%). Daily body and solids gain and dry matter intake. Contrarily decreased ($P<0.05$) by 34, 48 and 40%, respectively (Table 3). Thyroid, liver and kidney functions also were reduced as indicated by the decreases in blood Hb, PCV, RBC's, T3 , total protein, albumin, globulin, total lipids, cholesterol,creatinine,urea-N and SGPT by 18, 22,12, 34, 21, 23, 19, 27, 30, 23, 20 and 21%. respectively. While, plasma cortisol, ALP and ACP did not change appreciably as a function of heat stress (Tables 4 and 5).

Heat stress alleviation;

Using chilled drinking water treatment improved productivity of heat stressed sheep during the summer season, Daily body and solid gain and dry matter intake were increased ($P<0.05$) by 31, 54 and 45%, respectively (Table 3). In addition, the disturbances in thyroid, liver, and kidney functions and thermoregulation in growing heat stressed sheep were partially corrected by this technique (Tables 3, **4**and 5). This was obvious from the significant decrease in rectal temperature, respiratory rate. TBW and water intake and the significant increases in blood metabolites studied. These includes Hb (17%),PCV (14%). RBC's (10%). T3 (38%). total protein (19%)**,**albumin **(18%)**globulin (20%), total lipids (29%)cholesterol (31%), SGPT (18%), creatinine (18%) and urea-N (20%).

Using sprinkling tap water did not significantly affect growth traits and related physiological and biochemical changes of heat stressed growing sheep (Tables 3,4 and 5).

Discussion

High ambient temperature impairs growth rate with variable degrees amongindividuals of the same breed, thus the intention of this study was to develop HTI thatpredict the heat tolerant animal in early ages in subtropics. Traditional heat toleranceindices have been based on the stability of body temperature (Johnson **et al.,**1988 and Alam et a.l, 2011) . Rectal temperature is anindex of heat adaptability, but it continues to be controversial for numerous reasons such as differences in response time to rising ambient temperature due to body size. This study was designed to use body biochemical responses to heat stress in an attempt to assess a useful HTI. The correlation estimate between the decrease in body weight due to heat stress and the calculated HTI based on the changes in each of rectal temperature ,Hb, PCV, TBW,T3 and cortisol due to heat stress were not significant. Consequently, the abovementionedphysiological and biochemical changes can not be used to detect heat adaptability under conditions of this study. Similarly, Johnson **et al.,**(1988) failed to find a significant correlation between the decrease animal productivity and HTI based on the increase in rectal temperature due to heat stress. However, Abdel-Samee et al.,(1992) found a useful HTI (based on the increase in rectal temperature due to heat stress) that was correlated significantly with die productivity of heat stressed Hampshire x Suffolk weathers maintained under South. Carolina, USA conditions. This may be attributed to the fact that Awassi sheep after prolonged exposure to heat stress in their natural habitat became more adapted to heat stress and the changes in the abovementioned physiological and biochemical parameters vary greatly so that its values may not be reliable indicators of animal ability to adjust to short or long stressful conditions. Also, these result agreement with the findings of Srikandakumar et al., (2003) in sheep and Alam et al., (2011) in goats. This increase of hemoglobin and PCV levels could be due to either increased attack of free radicals on the RBC membrane, which is rich in lipid content, and ultimate lyses of RBC or adequate nutrient availability for hemoglobin synthesis as animal consumes more feed or decrease voluntary intake under heat stress (Srikandakumar et al., 2003).

Warm-humid climate influences:

Daily body and solids gain of growing Awassi sheep were significantly lower in summer than spring. This may be attributed to the reduction in feed intake and disturbances of normal body thermoregulation as indicated by increased respiratory rate and rectal temperature. Another explanation, is the disturbance of water and body fluids as indicated by increased water intake and TBW in an attempt to provide water for evaporative cooling via panting and sweating. Reduction of thyroid, liver and kidney functions may also contributed to the observed low production in summer. From another point of view, the decrease in feed intake, T3 and SGPT may serve to diminish heat production and so counteract the increased heat load due to heat stress, but depressing the blood metabolites needed for growth. Consequently, daily gain and other growth traits decreased under hyperthermia condition,

Heat stress alleviation:

Chilled drinking water alleviated the heatload on growing male sheep and improved it's growth performances. This maybe attributed to the improvements in dry matter intake and thermal balance as indicated bydecreased rectal temperature and respiratory rate. Also this treatment enabled the animals to maintain water balance as indicated by decreased TBW and water intake. Another reason, is the improvements of thyroid, kidney and liver functions due to thistechnique. Abdel-Samee (1997) reported that drinking cool water improved productivity and reproductively of heat-stressed farm animals. They added that drinking cool water is effective because of its high heal capacity and high latent heat of vaporization and because it absorbs heat directly from the animal and climate it away from the animal body via warm urine.

Sprinkling tap water was less effective ascooling technique since it failed to reach a significant improvement in growth performances of heat-stressed goals. This may be due to the opposing effect of high air relative humidity during the experimentalperiod (74-91% RH) that limits evaporation. It's alsoknown that panting is the most important way for heat loosen sheep not skin vaporization. Alam et al., (2011)reported that sweating is an evaporative heat loss mechanism supplementary to that of panting in sheep. Indairy cattle, sprinkling has-been shown to be effective in reducingheat stress (West, 2003). Other responses have ranged from response (Kadima et al.,2004) to a variable response over three summers (Brown et al, 1974) which showed that water Sprinkling of heal stressed lactating cows in summer 1970 improved milkproduction significantly,though in summer of 1971 and 1972 the same treatment showed no significant responses in milk production due to the difference in air relative humidity.

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تأثير الضغط الحراري على بعض الصفات الفسيولوجية للاغنام العواسية في العراق

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الملخص

استخدام اربع وثلاثون ذكر من اغنام العواسي لقياس فائدة دليل التحمل الحراري وذلك باستخدام بعض التغيرات الفسيولوجية والكيميائية الحيوية من خلال تعرضيها لاشعة الشمس. التغيرات في حرارة الجسم ، الهيموجلوبين، الهيماتوكريت، ماء الجسم الكلي، الثيروكسين، الكورتيزول، وقد وجد بانها لم ترتبط مع نقص وزن الجسم بسبب انخفاض الضغط الحراري، لذلك هذا الاختيار لا يستخدم في التنبأ عن التاقلم الحراري في هذه الدراسة .

خلال الصيف الحار الرطب (دليل الحراري الرطوبة = 76 – 89 °) سوف تقل الزيادة اليومية والمواد الجافة الماخوذة ووظائف الكلية والكبد والدرقية. لكن ماء الجسم الكلي، تناول الماء ، حرارة المستقيم ومعدل التنفس سيزيد. وباعطاء الاغنام المعرضة للضغط الحراري الماء المنعش سوف يتحسن بشكل ملحوظ الاخذ اليومي للجسم والمواد الصلبة ويقل تاثير الضغط الحراري على التوازن المائي والحراري داخل الجسم. ووظائف كل من الكبد والكلية والدرقية ، لكن الرش بماء الحنفية فشل في معالجة الضغط الحراري.