Der Tropenlandwirt, Beiträge zur tropischen Landwirtschaft und Veterinärmedizin,
97. Jahrgang, Oktober 96, S. 137 - 147.

Heat Adaptability of Growing Bedouin Goats in Egypt

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Abstract

Key Words: Goats, water cooling, growth, heat adaptability.

Thirty four growing male goats were used. An attempt to assess a useful heat tolerance index using some physiological and biochemical changes due to solar radiation exposure was carried out. The changes in body temperature, haemoglobin, haematocrit, total body water, triiodothyronine and cortisol did not correlate 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 = 80.7. ± 8.9°) 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 goats 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 significantly failed to alleviate bad effects of heat stress.

1 Introduction

The goats in Sinai desert area represent an appreciable part of the meat and to a minor extent milk sources. They are the second ranking source of milk after cattle. Animal production in this desert is still confronting several constraints, the most limiting being heat stress during the long warm-humid summer. Wide variations exist between and within species and breeds in their relative adaptability to hot climates. Heat adaptability of an animal reflects 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 balances. But the methods used have neither been reproduced nor correlated with growth and productive performance of animals (RHOAD, 1944; KAMAL, 1982; JOHNSON et al., 1988 and ABDEL-SAMEE, 1991).

Various management practices have been used to reduce or eliminate negative impact of heat stress on farm animals (ABDEL-SAMEE, 1995 & 1996, ABDEL-SAMEE and IBRAHIM, 1992 and ABDEL-SAMEE et al., 1992 & 1994). Water is an excellent

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cooling agent because of its high heat capacity and high latent heat of vaporization. Chilled drinking water is effective because it absorbs heat directly from the animal without evaporation. This has been successful in lactating goats and cattle (WILKS et. al. 1990 and ABDEL-SAMEE et. al.,1992). Direct wetting of the animal is a very effective practice. It is often used in an emergency situation to reduce heat stress. The use of direct wetting by sprinkling as a measure for increased animal performance is still unsetteled (HAHN, 1985).

In light of these reports, the present study was carried out to develop a useful index of heat adaptability that may predict at an early age heat-tolerant hight-producing animals and to evaluate long-term efficacy of either chilled drinking water or water hose sprinkling in relieving heat stress on growing goats.

2 Materials and methods

The present study was carried out at Animal Production Department, Environmental Agricultural Sciences College, Suez Canal University, El-Arish, Egypt. It comprised 2 trials, in the first, 10 growing male Bedouin goats 9 - 12 months old and 15.9 kg were exposed to spring climate 6 weeks to study the effects of mild climate on growth and some related physiological and biochemical changes (Group A). In the second trial, 24 goats similar to those of trail 1 were divided to three groups (B, C and D) and exposed 7 weeks to summer climate. Growth traits of goats under warm-humid summer conditions (Summer control group, B) was compared, first, with the spring group (A) and, second, with goats cooled either by providing chilled drinking water (group C) or by tap water sprinkling (group D).

The meteorological 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). THI values of less than 72 are probably not stressful, 72 to 78 are stressful, and over 78 extreme distress occurred and animals were unable to maintain thermoregulatory mechanisms or normal body temperature (According to Livestock and Poultry heat stress indices suggested by Agricultural Engineering Technology Guide, Clemson University, Clemson, SC. 29634, USA).

Heat tolerance index (HTI) was determined according to Iberia heat tolerance test (RHOAD, 1944) with a minor modification. The following formula was used: HTI = 100 - (ART - 39), where, ART is the average rectal temperature before and after 4 hours exposure to solar radiation for 3 consecutive days and 39 is the average normal rectal temperature of goats. HTI was determined, also, using other techniques based on the percentage change in each of haemoglobin (Hb), packed cell volume (PCV), total body water (TBW), triiodothyronine (T_3) and cortisol due to solar radiation exposure. The following formula was used HTI = 100 - AC, where AC is the average of percentage change due to solar radiation exposure for 3 days. HTI was carried out during the first three days at the beginning of summer treatment for each goat of group B. Solar radiation intensity averaged 1.52 langlay/min, where 1 langlay = 1 Cal. cm^{-2}. HTI for each goat was correlated with its daily body gain decrease due to summer treatment to develop a useful index of heat adaptability so as to predict at an early age heat-tolerant hig-producing goat.

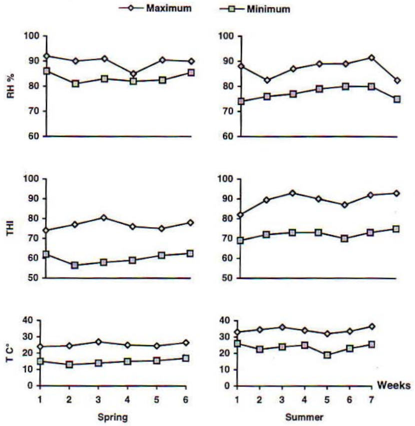

Figure 1: Air temperature (T), temperature humidity index (THI) and relative humidity (RH %) during the experimental period.

In group C, drinking water was chilled to 10 - 15 °C by adding ice to the water container. While, drinking water temperature for the goats in groups B and D was 23 - 30 °C. Tap water sprinkling for group D was carried out using a water hose 4 time daily (each hose duration about 3 minutes) during the heat 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 satisfy their nutritional requirements (Table 1). Goats were watered three times daily during the heat of the day (10.00 - 17.00 hr) with natural well water (El-Arish tap water). This water contained 3120, 198, 99, 45, 436, 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.

Table 1: Proximate analysis of the experimental feed stuffs.

Items	concentrate*	Rice straw	Acacia**
Moisture	7.0	7.1	67.7
Composition of dry matter (%)			
Crude protein	14.5	3.05	16.3
Ether extract	5.30	1.35	5.60
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 % undecorticated cotton seed cake, 33 % wheet bran, 22 % yellow corn, 4 % rice bran, 2 % lime stone, 1 % sodium chloride and 3 % molasses.

** Acacia is a natural shrub vegetation in Sinai.

The animals were weighed every 10 days to determine daily body gain. At the first and final day of each treatment, each animal was injected intramuscularly with antipyrine (1 g/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 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 after solar radiation exposure. Blood haemoglobin (Hb), packed cell volume (PCV) and red blood cells (RBC's) were estimated immediately after blood samples collection. The 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), acid phosphatase

(ACP) and glutamic pyruvic transaminase (SGPT) were measured 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 Angeles, California, USA.

Data were tabulated and subjected to statistical analyxsis according to Snedecor and Cochran (1982).

3 Results

Heat Adaptability:

HTI based on the change in each of rectal temperature, Hb, PCV, TBW, T3 and cortisol due 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).

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

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

* $= \frac{\textit{Before exposure - after exposure}}{\textit{Before exposure}} \times 100$

** $= \frac{\textit{Spring - Summer}}{\textit{Spring}} \times 100$

Warm-humid climate influences:

The HTI was 4 to 17 units above the critical value and the animals gained more heat from the environment than could be dissipated. This is evidenced by the increase ($P<0.01$) 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 ($P < 0.01$) by 34, 48 and 40 %, respectively (Table 3). Thyroid, liver and kidney functions also were reduced as indicated by the decrease of blood metabolites including 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).

Table 3: Heat stress and amelioration effects on daily gain and some related physiological parameters ($\bar{x} \pm SE$) of Bedouin goats.[1]

Items	Spring	Summer (THI = 76 - 89°)		
	(THI = 59 - 72°)	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 ± 10.7
Daily solids gain, g (ab)	57.4 ± 2.95	29.7 ± 3.06	45.6 ± 3.17	36.1 ± 3.25
TBW/100 kg LBW (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 effiiciency, DMI/gain	7.83 ± 0.41	7.17 ± 0.54	8.03 ± 0.44	7.21 ± 0.58
Water intake, l/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 ± 7.18	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

Table 4: Heat stress and amelioration effects on blood haematology and thyroid and adrenal gland functions ($\bar{x} \pm SE$) of Bedouin goats.[1]

Item	Spring	Summer (THI = 76 - 89°)		
	(THI = 59 - 72°)	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, U/ml	13.9 ± 2.52	12.1 ± 3.64	13.7 ± 2.19	13.0 ± 4.38

[1] 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 ($\bar{x} \pm SE$) of Bedouin goats.[2]

Items	Spring	Summer (THI = 76 - 89)		
	(THI = 59 - 72°)	Control	Cool water	Sprinkling
Animal groups (No.)	A(10)	B(10)	C(7)	D(7)
Liver function:				
Total protein, g/l (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/l (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/l (ab)	5.23 ± 0.17	3.81 ± 0.21	4.91 ± 0.15	4.08 ± 0.27
Cholesterol, g/l (ab)l	0.97 ± 0.05	0.68 ± 0.07	0.89 ± 0.06	0.74 ± 0.07
ALP, Unit/ml	112 ± 5.43	118 ± 6.39	117 ± 7.67	110 ± 6.53
ACP, Unit/ml	32.2 ± 1.57	34.1 ± 1.65	35.6 ± 2.09	32.5 ± 1.97
Kidney function:				
Creatinine, mg/l (ab)	16.7 ± 0.53	12.8 ± 0.60	15.1 ± 0.54	14.0 ± 0.65
Urea, mg/l (ab)	174 ± 6.36	140 ± 7.17	168 ± 6.65	156 ± 7.78
SGPT, Unit/l (ab)	0.76 ± 0.03	0.60 ± 0.04	0.71 ± 0.03	0.65 ± 0.04

Heat stress alleviating:

Using chilled drinking water treatment improved production of heat stressed goats during the summer season. Daily body and solids gain and dry matter intake were improved ($P < 0.05$ and $P < 001$) by 31, 54 and 45 %, respectively (Table 3). In addition, the disturbances in thyroid, liver, and kidney functions and thermoregulation in growing heat stressed goats were partially corrected by this technique (Tables 3, 4 and 5). This is observed by the significant decrease in rectal temperature, respiratory rate, TBW and water intake and the significant increase in blood metabolites studied. These includes Hb (17 %), PVC (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 goats (Tabs. 3, 4, 5).

[2] a and b = effects of summer (AxB) and cool water (BxC) treatments, respectively ($P<0.05$).

4 Discussion

The high ambient temperature impairs the growth rate with variable degrees among individuals of the same breed, thus the intention of this study was to develop HPI that predict the heat tolerant animal in early ages in subtropics. Traditional heat tolerance indices have been based on the stability of body temperature (RHOAD, 1944; KAMAL, 1982; JOHNSON et al., 1988 and ABDEL-SAMEE, 1991 and 1996). Rectal temperature is an index 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. In this study, try to use body biochemical responses to heat stress to assess a useful HTI was made. The correlation estimates 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 above mentioned physiological and biochemical changes can not be used to detect heat adaptability under conditions of this study. Similarly, Kamal (1982) and Johnson et al. (1988) failed to find a significant correlation between the decrease in animal productivity and HTI based on the increase in rectal temperature due to heat stress. However, Abdel-Samee (1991) found a useful HTI (based on the increase in rectal temperature due to heat stress) correlated significantly with the productivity of heat stressed Hampshire X Suffolk maintained under South Carolina, USA, weathers conditions. This may be attributed to that the Bedouin goats in this study may be more adapted to heat stress and the changes in the above mentioned 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.

Warm-humid climate influences:

Daily body and solids gain of growing Bedouin goats significantly decreased 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 by animals to dissipate heat load through water intake and water retention increasing. Reduction of thyroid, liver and kidney functions is another reason for this phenomenom. From another point of view, the decrease in feed intake, T3 and SGPT may serve to diminish heat production and so counteract in increased heat load due to heat stress, but depressing the blood metabolities needed for growth. Consequently, daily gain and other growth traits decreased under hyperthermic condition.

Heat stress alleviating:

Chilled drinking water alleviated the heat load on growing male goats and improved it's growth performances. This my be attributed to the improvements in dry matter intake, thermal balance as indicated by decreased rectal temperature and respiratory rate and water balance as indicated by decreased TBW and water intake. Another reason, is the improvements of thyroid, kidney and liver functions due to this technique. Wilks et al. (1990), Abdel-Samee et al. (1992) and Abdel-Samee (1996) reported that drinking cool water improved productivity and reproductivity of heat-stressed farm animals. They added that drinking cool water is effective because of its high heat capacity and high latent heat of vaporization and because it absorbs heat directly from the animal. This technique acts through the difference between the cool drinking water and warm urine excretion temperature which help in heat dissipation.

Sprinkling tap water technique failed to reach a significant improvement in growth performances of heat-stressed goats. This may be due to the high relative air humidity during the experimental period (74-91 % RH) and to that the panting is the most important way for heat loss in goats not skin vaporization. Shalaby and Johnson (1993) reported that sweating is an evaporative heat loss mechanism supplementary to that of panting in goats. In dairy cattle, sprinkling has been shown to be effective in reducing heat stress (HER et al., 1988 and ABDEL-SAMEE and IBRAHIM, 1992). Other responses have ranged from no response (MACFARLANE and STEEVENS, 1972) to a variable response over three summers (BROWN et al. 1974) which showed that water sprinkling of heat stressed lactating cows in summer 1970 improved milk production significantly, through in summer of 1971 and 1972 the same treatment showed no significantly responses in milk production due to the difference in relative air humidity.

Hitzeverträglichkeit wachsender Bedouinziegen in Ägypten

Zusammenfassung

Vierunddreißig wachsende männliche Ziegen wurden für einen Versuch verwendet, einen brauchbaren Hitzetoleranzindex mittels einiger durch solare Strahlungseinwirkung verursachten physiologischen und biochemischen Veränderungen abzuschätzen. Die Veränderungen bei Körperkerntemperatur, Hämoglobin, Hämatokrit, Gesamtkörperwasser,Trijodthyronin und Kortisol korrelierte nicht mit der durch Hitzestreß verursachten Abnahme des Lebendmassezuwachses. Daher kann jene nicht zur Vorhersage der Hitzeverträglichkeit in dieser Studie genutzt werden.

Während des feucht-heißen Sommers (Temperatur-Feuchtigkeits-Index = 80,7 ± 8,9 °) waren der tägliche Körpermasse- und Feststoffzuwachs, die Trockenmasseaufnahme, die Schilddrüsen-, Leber- und Nierenfunktionen reduziert. Demgegenüber waren das Gesamtkörperwasser, die Wasseraufnahme, die Rektaltemperatur und die Atemfrequenz erhöht. Die Behandlung hitzegestreßter Ziegen mit gekühltem Trinkwasser verbesserte signifikant den Zuwachs an Lebendmasse und Feststoffen und reduzierte die Hitzestreßeffekte auf die Wärme- und Wasserbilanzen sowie die Schilddrüsen-, Leber- und Nierenfunktion. Das Bespritzen mit Leitungswasser trug signifikant nicht zum Abbau der nachteiligen durch Hitzestreß verursachten Effekte bei.

Capacidad de adaptación al calor de chivos crecientes de la raza Bedouin en Egipto

Resumen

Treinta y cuatro chivos crecientes estaban en uso para un ensayo de establecer un índice útil de tolerancia al calor utilizando diferentes cambios fisiológicos y bioquímicos causados por exposición a la radiación solar. Los cambios en temperatura del cuerpo, hemoglobina, hematocrito, agua corporal total, triiodotronina y cortisol no estaban correlacionados con la disminución de ganancia de peso corporal provocada por el estrés termal. Por lo tanto, esta no ha podido usado en este trabajo para predecir la capacidad de adaptación al calor.

Durante el verano caliente húmedo (índice de temperatura y humedad = 80.7 ± 8.9°) las ganancias diarias en peso corporal y sólidos, el consumo de materia seca, las funciones de la glándula tiroidea, del hígado y de los riñones estaban reducidos. Por otro lado, el contenido del agua corporal total, el consumo de agua, la temperatura rectal y la frecuencia respiratoria estaban elevados. El tratamiento de los chivos en estrés por calor con agua potable enfriada mejoraba de forma significativa las ganancias en peso corporal y sólidos y redujo los impactos del estrés calórico sobre las balances térmicos y de agua así como a las funciones de la glándula tiroidea, del hígado y de los riñones. Rociar los chivos con agua de tubería no dio resultados de forma significativa en la reducción de los impactos del estrés por calor.

L'adaption à la chaleur des boucs en croissance en Egypte

Résumé

34 boucs en croissance ont été soumis à un essai au cours duquel un index de tolérance à la chaleur était à estimer, recherche au moyen de quelques changements physio biologiques causés par l'influence de la radiation solaire. Les changements observés au niveau de la température du corps, la quantité d'hémoglobine, d'hématocrites, de l'eau totale du corps (inter-et extracellulaire), de thyronine triodique et de cortisone ne montraient aucune corrélation avec la diminution de la croissance causée par le stress résultant de la chaleur. De ce fait, celle-là (la diminution...) ne saurait constituer un facteur prédisant la compatibilité à la chaleur dans cette étude.

L'augmentation journalière du poids du corps et de matière solide, l'ingestion de matière sèche, la fonction des glandes thyroïdes, du foie et des reins étaient réduites. Par-contre, l'eau totale du corps, la quantité d'eau bue, la température au niveau du rectum, la fréquence respiratoire avaient augmenté. Traités à un bain d'eau fraiche, on remarque une importante augmentation du poids chez les boucs stressés par la chaleur. Le bain contribue favorablement à diminuer les effets du stress à la chaleur face aux bilans de la chaleur et de l'eau ainsi que des fonctions des glandess thyroïdes, du foie et des reins. Il est toutefois à noter que ce traitement n'ait aucunement contribué à réduire les effets négatifs causés par le stress dû à la chaleur

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