Biochemistry unit, New-Valley laboratory,
Animal Health Research Institute, ARC, Egypt.

THE INTERACTION BETWEEN TEMPERATURE HUMIDITY INDEX AND SOME HEALTH PARAMETERS OF SHEEP UNDER THE EGYPTIAN OASIS ENVIRONMENT

(With 9 Tables and 3 Figures)

By
M.A. SALEH; IBTISAM M. EL-MILEEGY* and A. ABOU EL-ELA
*Dept. of Physiology, Faculty of Medicine, Assiut University
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التداخل بين مُؤشر الحرارة والرطوبة وبعض مقاييس الصحة في الأغنام تحت بيئة الواحات المصرية

مصطفى أحمد صالح ، إيتسام محمد المليجي ، علي أبوالعلا محمد

تعتبر منطقة درب الأربعين من المناطق البكر وتمثل الحدود الجنوبية لسهول الواحات المصرية وهي تعتبر من أهم المناطق الواعدة للتوسع الزراعي في مصر. وقد استهدفت هذه الدراسة وضع بيانات تمهيدية لبعض مؤشرات الصحة شاملة الصورة الإكلينيكية والدموية والهرمونية بالإضافة إلى صورة التمثيل الغذائي في الأغنام الصحراوية (البرقي) وأغنام وادي النيل (الرحماني والأوسيمي) التي نقلت في الآونة الحديثة مع المربين إلى هذه المنطقة المستصلحة حديثا. كما استهدفت الدراسة أيضا الربط بين هذه المؤشرات ومعامل الحرارة والرطوبة كمحاولة لتقييم تأثير الإجهاد الحراري على مؤشرات الصحة في هذه الأغنام. للتقليل من تأثير العمر أثناء الدراسة التي تمتد ستة أشهر قد صممت هذه الدراسة باختيار ثلاثة مجموعات من الحملان الذكور (كل منها ١٥ حمل بمتوسط عمر ٧ أشهر ووزن تقريبي ٢٤ كجم). كل مجموعة منها مثلت شهرين، لذلك مثلت الثلاث مجموعات مدة متصلة مداها ستة أشهر تبدأ بشهر فبراير (المرحلة الأساسية للمقارنة) وتنتهي في يوليو (مرحلة الإجهاد الحراري). وكانت تتكون كل مجموعة من ثلاث مجموعات فرعية شاملة السلالات الثلاث (خمسة من كل من الرحماني والأوسيمي والبرقي). وقد تم إجراء الفحوص الإكلينيكية والدموية والبيوكيميائية شهريا خلال مدة الدراسة الستة أشهر. وأظهرت النتائج أن معدل الحرارة العظمى في نهاية شهر يوليو أكبر (١٥٤,٧ في المائة) والرطوبة أقل (١١٦,٨ في المائة) من مثيلتها في فبراير. وكان هناك اختلاف معنوي بين أنواع السلالات تحت تأثير معامل الحرارة والرطوبة في كل من درجة حرارة الجسم ومعدلات التنفس وحجم كريات الدم المصمت والبوتاسيوم والكورتيزول. وأظهرت النتائج تأرجح غير معنوي لكل القياسات في سلالتي البرقي والأوسيمي خلال فترة الدراسة ماعدا الارتفاع الواضح في

درجـــة حـــرارة الجسم ومعدلات التنفس عندما كان معدل الحرارة والرطوبة أعلى من ٩٠. وفـــي هذا السياق سبقت الأغنام الرحماني السلالات الأخرى في الارتفاع في درجة حرارة الجســم ومعـــدلات التنفس (عند معدل الحرارة والرطوبة ٨٥ و ٨٨ على الترتيب). ومن ناحـــية أخـــرى عندما وصل معدل الحرارة والرطوبة إلى ٩٢ قلت قيم كل من العدد الكلى لكـــرات الـــدم الحمراء والهيموجلوبين وحجم كريات الدم المصمت وتركيز البروتين الكلي والألبيوميـــن والبوتاسيوم والترايودوثيرونين في البلازما بينما زاد تركيز كل من الصوديوم والكورتيزول في البلازما في الأغنام الرحماني. وفي هذا السياق لم تتأثر قيم كل من حركة الكـــرش وتركيز كل من الجلوبيولين والكوليستيرول واليود و الثيروكثين في بلازما الدم في أي مـــن السلالات الثلاث بالتغير في معدل الحرارة والرطوبة. كما أوضح معامل الارتباط أن هـــناك ارتباط شديد بين معدل التنفس ومعامل الحرارة والرطوبة بينما كان هذا الارتباط أقل بالنسبة لدرجة حرارة الجسم. كما أوضحت النتائج أيضا وجود ارتباطا سلبيا بين معامل الحـــرارة والـــرطوبة وكل من العدد الكلى لكرات الدم الحمراء وحجم كريات الدم المصمت وتركـــيز البروتين الكلي والألبيومين والبوتاسيوم والترايودوثيرونين والثيروكثين في البلازما ووجود ارتباطا إيجابيا بين معامل الحرارة والرطوبة وتركيز الصوديوم في البلازما. وبذلك تخلص الدراسة بأن البيئة الصحراوية الجافة لم تؤثر على المؤشرات الصحية للأغنام البرقي والأوســـيمي التـــي تســـكن مـــنطقة درب الأربعيـــن وكانت القيم المقاسة داخل مدى القيم الفسيولوجية للأغنام. وبالرغم من ذلك أظهرت التغيرات الإكلينيكية والبيوكيميائية إن صحة الأغـــنام الرحماني كانت في خطر عندما كان معامل الحرارة والرطوبة أعلى من ٨٥ وليس ٨١ كمـــا سجل لسلالات المناطق المعتدلة. ومن هذه النتائج الإكلينيكية والبيوكيميائية تنصح هـــذه الدراسة بتصميم فئات جديدة لمعامل الحرارة والرطوبة مناسب للسلالات التي ترعى في المناطق الصحراوية.

SUMMARY

Darb Al-Arbain is a virgin area and represents the southern boundary of the Egyptian oasis depression. It considers one of the most promising areas for agricultural expansion in Egypt. This study aimed to setup a preliminary data on some health indices including clinical, haematological, hormonal and metabolic picture in desert (Barki) and Nile valley (Rahmani and Ossimi) sheep ‹which were recently transported with their owners to this newly reclaimed area. Also, to correlate between these indices and the temperature humidity index (THI) as a trial to evaluate the effect of heat stress on the health indices of these sheep. To nullify the effect of age throughout the study period (6 months), this work was designed to select 3 groups of male lambs (15 each; average 7 months and around 24 kg). Each group represented two months of the study period, so that the three groups represented a cycle of 6 consecutive months began by February (basal data) to July (intensified dry summer stress). Each group included three subgroups of Rahmani, Ossimi and Barki lambs (5/breed). Clinical, haematological and biochemical investigations were carried out monthly throughout 6 months study period. The average of maximum ambient temperatures at the end of July was 154.7% higher and the relative humidity was116.8 lower than the basal thermoneutral data. The effect of breed under the changes of THI was significant for rectal temperature, respiratory rate, PCV, potassium and cortisol. The patterns of estimated parameters were insignificantly fluctuated in Barki and Ossimi sheep except the significant elevation of rectal temperature and respiratory rate (at THI above 90). In Rahmani sheep, the magnitude of rectal temperature and respiratory rate (at THI 85 and 88 respectively) preceded those in other breeds. On the other hand the values of RBC, Hb, PCV, plasma total protein, albumin, K, T_3 were decreased and Na and cortisol values were increased in Rahmani sheep when THI reached 92. Correlation coefficient showed that respiration rate was highly correlated with increasing THI (r=0.738, *P*=0.0005), whereas rectal temperature was less responsive to THI (r = 0.561, P=0.015). It was noticed also that THI was negatively correlated with RBC, PCV, total protein, albumin, potassium, T_3, T_4 and positively correlated with Na. In conclusion, the hot arid and drought desert environment did not affect health indices in Barki and Ossimi sheep inhabiting Darb Al-Arbain area. The measured values were within the normal physiological ranges reported for sheep. In despite, the changes in clinical and biochemical indices showed that health of Rahmani breed was at risk only when THI was above 85 and not at 81 as reported for temperate breeds. From these results, this study recommends to establish suitable new THI categories for native breeds reared under tropical environment.

Key words: *Health parameters, sheep, Egyptian oasis,Environment*

INTRODUCTION

Animal health is a characteristic combination of quantitative and qualitative aspects of the conditions of an animal that can be measured in a scientific way (Scott *et al.,* 2000). Therefore, one of the health measurements should be based on environmental indices of heat stress and the animal's response in coping with difficulties (Silanikove, 2000 and Finocchiaro, *et al.* 2005).

Heat stress occurs when any combination of environmental conditions, such as air temperature, relative humidity, air movement and solar radiation cause the effective temperature of the environment to be higher than the animal's thermo-neutral zone (Finch, 1984; Armstrong, 1994 and Payne & Wilson, 1999). Temperature humidity index (THI) is commonly used as an indicator of the degree of climatic stress on animals. It was estimated that a THI of 72 and below is considered as no heat stress (cool), 73–77 as mild heat stress, 78–89 as moderate and above 90 as severe (Kibler, 1964; NOAA, 1976; Fuquay, 1981 and Ravagnolo *et al.* 2000).

Despite having well developed mechanisms of thermoregulation, ruminants do not maintain strict homeothermy under heat stress (NRC, 1986; St-Pierre, *et al.,* 2003 and Saleh *et al.,* 2003). Such stress is usually defined by the physiologists as a biological coast of adaptation against the stressor (Willmer *et al.,* 2000). On the other hand, there is an evidence of the deleterious effects of heat stress on animal health. These effects are manifested by clinical symptoms (hyperthermia, panting, reduced feed intake and interrupted rumination), in addition to hormonal (cortisol and thyroidal activity), metabolic and immune disorders (Nienaber, *et al.* 1999; Srikandakumar *et al.,* 2003; Hadjigeorgiou & Politis, 2004; Finocchiaro, *et al.* 2005 and Zamiri & Khodaei 2005). In view of the pathologists, these deleterious changes caused by thermal stress are deviation than normal levels so that thermal stress is considered as an environmental disease (Martin & Aitken, 2000 and Radostits *et al.,* 2000). In despite, mild heat stress does have some beneficial role via positively regulating cell proliferation and differentiation, and immune response in mammalian cells (Park, *et al.* 2005).

Sheep farming is a very important animal production activity in tropical countries (Baker & Gray, 2003 and Kosgey, *et al.,* 2006). In Egypt, most of the local sheep herds are of four local fat tailed, coarse-wool breeds, Rahmani, Ossimi, Saidi and Barki (Almahdy, *et al.* 2000a,b; El-Akram, 2001 and Ali, 2003).

The importance of heat stress to livestock industries is increasing with time because of the long-term trend shift in the location where animal agriculture is primarily located (St-Pierre, *et al.* 2003). Darb Al-Arbain is a virgin area and represents the southern boundary of the Egyptian oasis depression. It is considered one of the most promising areas for agricultural expansion in Egypt. In recent years, farmers from Nile delta and Upper Egypt had migrated to these newly reclaimed areas carrying their furniture and goods including sheep of various breeds to inhabit and cultivate these areas as a new living. In fact, veterinary studies on animals in this area are almost considered virgin. There are no published data on the indices of general health of normal sheep in such areas.

This study aimed to setup a preliminary data on some health indices including clinical, haematological, hormonal and metabolic picture in desert and Nile valley breeds of sheep reared at Darb Al-Arbain area. Also, to correlate between these indices and the climatic changes as represented by THI as a trial to evaluate the efficacy of Nile valley breeds (Rahmani and Ossimi) to tolerate heat stress compared to the local Barki sheep.

MATERIALS and METHODS

Study area: This study was carried out at Darb Al-Arbain area, about 130 km south of El-Kharga oasis, El-Wadi El-Gadid depression (Fig.1).

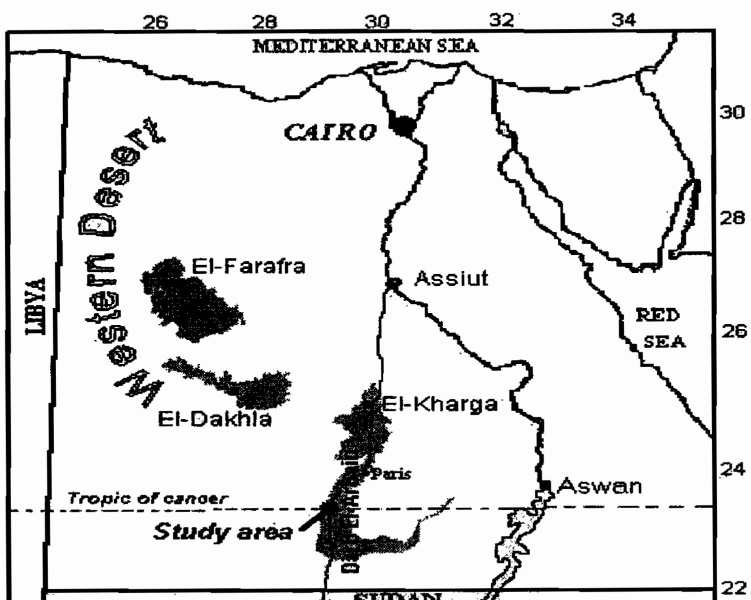

Fig. 1: Map of Egypt showing the western desert including the study area at Darb Al-Arbain region in the Egyptian oasis

This area is 77.8 m altitude and lies between 22° 30′ and 25° 40′ N latitudes and between 29° 42′ and 31° 20′ E longitudes. The climate is arid, essentially that of the desert. The temperature ranges from 49°C during summer days to 2°C in the chilly winter nights. Rainfall is almost negligible and the average precipitation is 0.3mm. Watering and irrigation depend absolutely on the ground wells.

Meteorological data:

This study was carried out during the period extended from February (thermoneutral period) to July (mid-summer), 2004. Weather data were available from an on-site weather station. These data included ambient air temperature, relative humidity, wind velocity and sunshine duration. Temperature (T) and relative humidity (RH) were used to calculate the temperature-humidity index (THI) according to the following formula: $THI = t_d - (0.55 - 0.55RH)(t_d - 14.4)$, where t_d is the dry bulb temperature (°C) and RH is expressed as a decimal (Kibler, 1964; NOAA. 1976 and Ravagnolo *et al.,* 2000).

Animals:

To nullify and negate the effect of age throughout the study period (6 months), this work was designed to select 3 groups of male lambs (15 each). Each group represented two months of the study period, so that the three groups represented a cycle of 6 consecutive months began by February (basal data) to July (intensified dry summer stress). Each group was consisted of three subgroups of Rahmani, Ossimi and Barki lambs (5/breed) as shown in table 1.

Table 1: No. of investigated lambs throughout a cycle of 6 consecutive months

Breed	Months			Total animals investigated through out 6 consecutive months
	Feb-Mar	Apr-May	Jun-Jul	
Barki	5	5	5	15
Ossimi	5	5	5	15
Rahmani	5	5	5	15
Total	15	15	15	45

The parents of both Rahmani and Ossimi sheep used in this study had been transported from their origin (Nile valley) to the new locations (Darb Al-Arbain) for approximately 2-3 years ago. The purity of breeds was identified by the shepherds and agricultural experts. Rahmani is the breed of choice in the Nile Delta. It is the largest breed, easily identifiable by its brown wool, large head, curved nose, very short or even absent ear and oval tail ended by a fine node extend below the Knee. Ossimi breed is distributed in mid Egypt. It is characterized by its white wool, convex brown head, long body, short neck and oval tail ended by a fine node not reach to the Knee. Barki sheep is the smallest breed, and can be identified by its white curly wool, small brownish head, straight nose, long neck, long limbs and triangular tail. Purebred Barki is the breed of choice for Bedouins in the desert.

Lambs were males of a nearly matching age (7±0.1 month) and weight (25.7±0.61 Kg for Rahmani and Ossimi and 23.2±0.53 Kg for Barki). Animals were apparently healthy and in good physical condition. These animals were located in neighboring areas. They were allowed to graze with their herds on the free range outdoors in their natural habitat. The grazing was mainly on perennial vegetation and supplemented indoors with Barseem Hegazi (Medicago sativa) at night all over the study period. Animals were shaded themselves during the summer midday times under the available trees, bushes, shrub, hedge or even under artificial shades made of palm leaves.

Clinical investigations and sampling:

These lambs were selected after they had been subjected to careful clinical examinations to prove their fitness and to reject any health abnormality. Standard methods were used for specific clinical investigations including measurement of respiratory rate, ruminal contractions using stethoscope and rectal temperature using a digital thermometer. These investigations were carried out at 1600 h, twice monthly at day 1 and 15 of each month for all groups. For tabulating, the readings were pooled as one value for each month (Tab. 2 and Fig. 2).

The selected lambs were bled once monthly (at day 15 of each month) by Jugular vein puncture directly after clinical examination (at 1600 h). Blood was collected from the jugular vein (10-ml) into heparinized sterile vacuum tubes (Venoject®, Sterile Terumo Europe, Leuven, Belgium). One ml of each blood sample was separated for haematological studies, and the remainder was centrifuged to obtain plasma, which was kept at –20°C until be used for biochemical assay.

Haematological and biochemical investigations:

Haematological studies including red blood cell (RBC) count, haemoglobin (Hb) and packed cell volume (PCV) were carried out using standard techniques of haematology after Feldman *et al.* (2000). Plasma protein, albumin and cholesterol were carried out by using commercial test kits (Sclavo diagnostics, 53100 Sienna, Italy). Plasma sodium and potassium were measured by using flame photometer. Iodine concentration in the plasma was measured by using iodine selective electrode model 94-53, according to method of selective electrode attached to expandable ion analyzer EA 92C after the methods described by Palleta and Panzenbeck (1969) and Wheeler *et al.* (1980). Plasma T_3, T_4 and cortisol were analyzed by standard ELISA techniques using test kits (Bio-Merieux, 69280 Marcy, L'Etoile, France) according to manufacture instructions.

Statistical analysis:

Firstly, linear model Analysis of Variance (ANOVA) was performed on pooled data using SPSS 10 software package (SPSS, Chicago, IL). The Least Squares Means (LSM) were compared with comparison-wise standard error rate after significant F-tests. The fixed factors included the effect of weather changes (within effects) and the effect of breed (between effects). The interactions between the three breeds were included in the model using pair-wise multiple comparison procedures (Duncan's new multiple range test). Pearson Product Moment Correlation (PPMC) was performed between THI and the arranged all-raw data of clinical, haematological and plasma metabolites regardless any effect, and represented by its degree of correlation (r) and significance level (p).

RESULTS

Table 2: Values ±SE of the meteorological data and THI during study period at Darb Al-Arbain area.

Month	Ambient Temperature (°C)	Relative humidity (%)	Wind speed (m/sec)	Sunshine duration (h)	Calculated THI*	
					Value	Category
February	18.1	41.5	2.2	10.6	63.7	Safe
March	26.8	36.0	1.8	11.1	73.2	Alert
April	31.2	32.5	2.1	11.5	76.4	Alert
May	36.3	27.5	1.6	12.2	82.6	Dangerous
June	41.0	22.5	1.4	12.7	85.1	Dangerous
July	46.1	19.0	1.4	13.4	90.2	Emergent risk

*THI was calculated and categorized after the formula and scales cited by Kibler (1964), NOAA (1976) and Ravagnolo *et al.* (2000). Values are the pool of two readings monthly at day 1 and 15 for all groups.

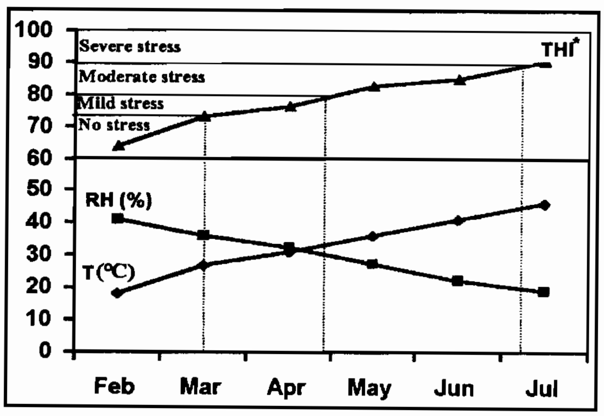

Fig. 2: The mean values of the meteorological data and THI during study period (February to July 2004) at Darb Al-Arbain area. *THI categories were designed after the formula and scales cited by Kibler (1964), NOAA (1976) and Ravagnolo *et al.* (2000).

Table 3: Pooled least square means (LSM), range, standard error of means (SEM) and F value of clinical, haematological and plasma parameters under the effect of THI and breed of sheep.

	Unit	LSM[a]	Range		SEM	F- value	
			Min.	Max.		Effect of THI	Effect of Breed
Rectal temperature	°C	39.28	38.4	39.9	0.04	*	*
Respiratory rate	Breath/min	40.88	29	71	1.31	*	*
Ruminal contraction	Cont./2min	4.08	3	5	0.03	NS	NS
RBC	$x10^6$/ul	9.01	6.94	11.56	0.25	*	NS
Hb	g/dl	10.97	7.51	13.11	0.20	*	NS
PCV	%	32.2	24	36	0.92	*	*
Plasma total protein	g/dl	6.31	4.99	8.84	0.19	*	NS
Plasma albumin	g/dl	3.28	2.46	4.51	0.19	*	NS
Plasma globulin	g/dl	3.03	2.53	4.33	0.11	NS	NS
Plasma cholesterol	g/dl	63.1	49.5	91.1	1.54	NS	NS
Plasma sodium	mmol/l	139.4	129	157	2.45	*	NS
Plasma potassium	mmol/l	4.78	3.4	6.1	0.10	*	*
Plasma iodine	μg/dl	1.98	1.54	3.41	0.15	NS	NS
Plasma T_3	ng/ml	0.94	0.61	1.44	0.09	*	NS
Plasma T_4	ug/dl	3.88	2.98	5.21	0.14	NS	NS
Plasma cortisol	ug/dl	1.24	0.89	2.05	0.11	*	*

[a]: Based on 90 samples representing 5 individuals of each of the 3 breeds throughout 6 replicates (months).
*significant at P<5%; NS, non-significant.

Table 4: Monthly variations (mean values ±SE) of clinical indices of sheep during the study period from Feb. (2) to July (7).

M	Rectal temperature (°C)			Respiration rate (breathes/min)			Ruminal contractions (/2min)		
	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani
2	38.9±0.13	39.1±0.09	39.3±0.10	33.4±1.5	34.9±2.0	37.0±1.3	4.2±0.012	3.8±0.009	4.2±0.014
3	39.0±0.11	39.1±0.11	39.3±0.09	32.2±1.2	35.1±1.6	36.2±1.9	4.2±0.014	4.2±0.012	4.2±0.014
4	39.0±0.11	39.2±0.10	39.4±0.11	33.0±2.1	35.6±1.3	38.3±2.1	4.2±0.011	4.2±0.009	4.0±0.016
5	39.1±0.09	39.2±0.08	39.4±0.09	35.3±1.4	39.4±1.8	48.1±1.4	4.1±0.010	4.0±0.017	4.0±0.012
6	39.2±0.12	39.3±0.11	39.6±0.08	39.5±2.1	41.5±1.9	53.5±1.6	3.8±0.009	4.2±0.021	4.2±0.011
7	39.6±0.11	39.7±0.12	39.8±0.08	50.4±1.7	54.5±1.4	64.3±1.5	4.2±0.018	4.0±0.014	3.8±0.009

Values are the pool of two monthly readings at day 1 and 15 for all groups.

Table 5: Monthly variations (mean values ±SE) of haematological indices of sheep during the study period from Feb. (2) to July (7).

M	RBC ($x10^6$/ul)			Hb (g/dl)			PCV (%)		
	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani
2	9.2±0.42	8.9±0.41	9.2±0.31	10.8±0.43	11.1±0.44	11.2±0.33	32.2±0.9	33.1±1.1	33.7±1.2
3	9.5±0.73	9.1±0.49	9.0±0.43	11.1±0.56	11.4±0.41	11.2±0.43	33.1±1.1	34.4±0.9	33.6±1.1
4	8.9±0.60	9.4±0.54	9.2±0.42	10.9±0.33	10.8±0.31	10.9±0.54	31.1±0.9	32.0±1.0	32.8±1.1
5	9.3±0.76	9.3±0.63	8.9±0.52	11.3±0.49	11.2±0.45	11.3±0.42	32.8±1.2	33.2±0.8	34.3±1.4
6	9.1±0.62	9.1±0.48	8.8±0.60	11.0±0.51	10.9±0.63	10.8±0.45	31.1±1.0	32.1±0.9	33.1±1.0
7	8.6±0.49	8.5±0.36	8.1±0.29	10.6±0.53	10.7±0.42	10.1±0.28	30.3±1.1	29.4±1.3	26.6±0.8

Table 6: Monthly variations (mean values ±SE) of plasma proteins of sheep during the study period from Feb. (2) to July (7).

M	Total protein g/dl			Albumin (g/dl)			Globulin (g/dl)		
	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani
2	6.4±0.51	6.33±0.41	6.30±0.37	3.41±0.34	3.22±0.34	3.34±0.21	2.99±0.28	3.11±0.31	2.96±0.34
3	6.51±0.42	6.38±0.39	6.53±0.61	3.50±0.31	3.31±0.28	3.42±0.35	3.01±0.54	3.07±0.29	3.11±0.31
4	6.37±0.61	6.28±0.54	6.69±0.57	3.43±0.29	3.29±0.61	3.51±0.41	2.94±0.34	2.99±0.44	3.18±0.33
5	6.50±0.44	6.52±0.52	6.63±0.73	3.38±0.33	3.38±0.42	3.39±0.51	3.12±0.41	3.14±0.28	3.24±0.43
6	6.35±0.81	6.13±0.61	6.35±0.66	3.31±0.42	3.22±0.33	3.24±0.38	3.04±0.25	2.91±0.33	3.11±0.29
7	5.93±0.57	5.86±0.49	5.55±0.41	3.01±0.29	2.98±0.27	2.74±0.18	2.92±0.31	2.88±0.41	2.81±0.31

Table 7: Monthly variations (mean values ±SE) of plasma minerals of sheep during the study period from Feb. (2) to July (7).

M	Sodium mmol/l			Potassium mmol/l			Iodine (μg/dl)		
	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani
2	137±1.8	138±1.6	136±2.1	4.9±0.22	4.7±0.28	5.1±0.33	2.1±0.12	2.2±0.11	1.9±0.09
3	139±1.6	137±1.2	138±1.3	5.1±0.31	4.9±0.31	4.9±0.28	1.9±0.11	2.3±0.014	1.9±0.11
4	137±1.6	138±0.9	137±1.5	4.8±0.25	4.9±0.19	5.2±0.31	1.9±0.09	2.1±0.12	1.9±0.11
5	140±1.1	141±1.6	143±1.8	4.7±0.19	5.1±0.27	4.7±0.26	2.0±0.10	1.9±0.10	2.1±0.13
6	139±1.6	140±1.4	142±1.9	4.8±0.24	4.8±0.22	4.4±0.34	2.1±0.13	2.1±0.11	1.8±0.10
7	140±1.7	142±1.9	145±1.7	4.7±0.34	4.5±0.29	3.9±0.31*	1.8±0.10	1.9±0.13	1.8±0.13

Table 8: Monthly variations (mean values ±SE) of plasma hormones of sheep during the study period from Feb. (2) to July (7).

M	T_3 (ng/ml)			T_4 (ug/dl)			Cortisol (ug/dl)		
	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani	Barki	Ossimi	Rahmani
2	0.91±0.02	1.04±0.03	1.11±0.03	3.9±0.22	4.1±0.17	3.8±0.20	1.22±0.08	1.17±0.06	1.24±0.07
3	0.97±0.02	0.94±0.02	1.12±0.03	4.1±0.19	4.0±0.16	3.9±0.22	1.18±0.08	1.21±0.06	1.16±0.07
4	0.89±0.03	0.99±0.02	0.97±0.02	4.0±0.24	4.1±0.24	3.9±0.25	1.24±0.09	1.16±0.07	1.22±0.07
5	0.88±0.02	1.01±0.02	0.89±0.03	3.9±0.18	3.9±0.19	3.7±0.18	1.19±0.06	1.20±0.07	1.27±0.06
6	0.94±0.01	0.89±0.03	0.87±0.03	3.8±0.12	3.7±0.25	3.8±0.15	1.11±0.07	1.19±0.06	1.48±0.10
7	0.82±0.03	0.88±0.03	0.79±0.02	3.7±0.21	3.8±0.23	3.7±0.24	1.07±0.08	1.24±0.07	1.71±0.09

Table 9: Pearson Product Moment Correlation (r) and level of significance (p) between THI and the clinical, haematological and plasma parameters.

Item	Rectal temp.	Respiratory rate	Ruminal contraction	RBC	Hb	PCV	Total protein	Albumin
R	0.561	0.738	-0.260	-0.530	-0.478	-0.568	-0.491	-0.569
P	0.015	0.0005	0.298	0.024	0.049	0.014	0.039	0.0136
Item	Globulin	Cholesterol	Sodium	potassium	Iodine	T3	T4	Cortisol
r	-0.247	-0.244	0.774	-0.557	-0.411	-0.7	-0.616	0.279
p	0.324	0.330	0.0002	0.016	0.089	0.0012	0.0065	0.261

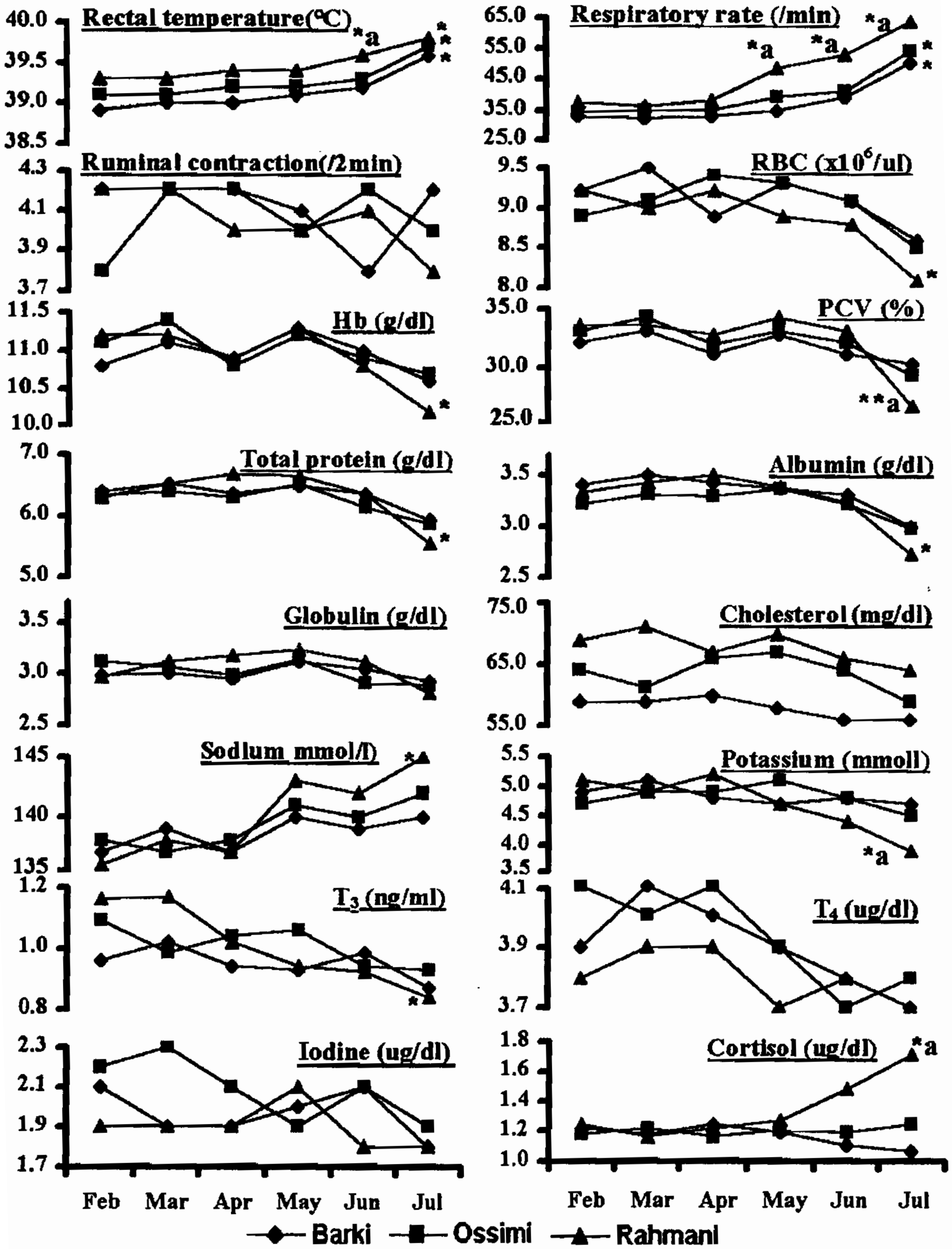

Fig. 3: Mean values of monthly variations of clinical, haematological and biochemical indices in sheep. The values of rectal temperature and respiratory rate are the pool of 2 readings monthly during the period between Feb. and June, and 3 readings in July for each animal. *Values are differing at P<5% than basal data (February). a, breed differences at the same month.

In the studied area, the average of maximum ambient temperatures at the end of July was 154.7% higher and the relative humidity was116.8 lower than the basal thermoneutral data (Tab. 2 and Fig. 2). By applying the scales of THI it was noticed that the period extended throughout Feb. to mid March was non-stressor, but the stress was mild in the second period extended from mid March to the end of April. The moderate stress was shown throughout May, June and the first week of July, while severe stress began by the second week of July.

The overall pooled least square means (LSM), range, standard error of means (SEM) and F value of clinical, haematological and plasma parameters under the effect of THI and breed of sheep are presented in table (3). Under the effect of THI the statistical F-value of pooled data was significant for rectal temperature, respiratory rate, RBC, Hb, PCV, plasma total protein, albumin, Na, K, T_3 and cortisol. The interaction of breeds of sheep under the THI changes was significant for rectal temperature, respiratory rate, PCV, potassium and cortisol.

Table (4-8) and Fig. (3) explain the source of variations in the estimated F value by using ANOVA and Duncan's new multiple range test of clinical, haematological and biochemical parameters under the effect of THI and breed of sheep.

By the application of THI scales, it was noticed that there were breed differences in rectal temperature when THI value was 88 but the breed differences in respiration rate occurred at THI value of 85. Rectal temperature of Rahmani sheep began to increase significantly when THI was 88, but for Barki and Ossimi breeds the significant increase in rectal temperature was reached when THI was above 90. The magnitude of the increase in respiratory rate of Rahmani sheep preceded the rectal temperature where it was significant at THI 85. Both Barki and Ossimi breeds showed an increase in respiration rate when the THI was above 90. Under these circumstances, ruminal contractions were not affected in all breeds under all THI categories.

RBC counts, Hb concentrations and PCV values were decreased significantly when THI was above 90 in Rahmani sheep without significant breed differences from both Barki and Ossimi sheep for RBC count and Hb concentration. Breed differences appeared in PCV when THI exceeded 90 where it was lower in Rahmani than both other breeds.

The effects of THI and breed on the changes in blood chemistry were set out in Tab. 6-8 and Fig. 3. There was no breed difference in the response of increase in THI up to a value of 88 but at THI value above 90 the breeds showed a considerable variations. The mean values of plasma total protein, albumin and potassium, T_3 were significantly decreased in Rahmani sheep when THI reached its maximal value (above 90) if compared with basal thermoneutral data. There was no breed difference in the estimated parameters all over the period of the study except for potassium, which was significantly lower in Rahmani breed in comparison with Barki and Ossimi sheep. In contrast, the mean values of plasma sodium and cortisol were significantly increased in Rahmani sheep when THI was above 90. The breed difference appeared in plasma cortisol, which was higher in Rahmani sheep if compared with Ossimi and Barki sheep when THI exceeded 90.

Correlation coefficient (Tab. 9) showed that respiration rate was highly correlated with increasing THI (r=0.738, P=0.0005), whereas rectal temperature was less responsive to THI (r = 0.561, P=0.015). Plasma sodium concentrations showed strong correlation with THI (r=-0.774, P=0.0002). It was noticed also that THI was negatively correlated with RBC (r=-0.530, P=0.024), PCV (r=-0.568, P=0.014), total protein (r=-0.491, P=0.039), albumin (r=-0.569, P=0.014), potassium (r=-0.577, P=0.016), T_3 (r=-0.7, P=0.001), T_4 (r=-0.616, P=0.007). Other parameters as ruminal contraction, Hb, plasma globulin, cholesterol, iodine and cortisol were not correlated with THI.

DISCUSSION

Extensively managed animals, such as desert sheep, often live in harsh and unfavourable environments where they need to be able to cope with variable weather conditions and availability of forage. An additional challenge to the animal health kept in extensive systems is the lack of supervision (Dwyer and Lawrence, 2005). The current study was a trial to give an attention on the general sheep health in the western Egyptian desert and to study the effect of harsh desert environment on health indices.

The obtained least square means and ranges of clinical, haematological and plasma parameters of sheep in this study concur with the normal ranges of temperate and tropical breeds of sheep cited by Oladimeji, *et al.* (1996); Kramer (2000); Antunović, *et al* (2002); Duncan and Prasse (2003); Srikandakumar, *et al.* (2003) and Can, *et al.* (2005). The values were also comparable with those of sheep reared under the Nile-Valley and the Egyptian Northern Coast conditions (Shetaewi *et al.*, 1991; Salem *et al.*, 1999; El-Sherif & Assad, 2001 and Kobeisy *et al.*, 2001).

An increase in body temperature and respiration rate can be expected when sheep are exposed to environmental temperatures above the thermoneutral zone (Kamal, 1975; Reece, 1997 and Hindson & Winter, 2002). Hyperpnoea develop when heat production exceeds heat loss or when the evaporative heat loss mechanisms becomes impaired due to excessive loss of body fluids and reduced blood volume. This response is in part due to direct stimulation of peripheral temperature receptors that transmit nervous impulses to the heat and respiratory centers in the hypothalamus (Habeeb *et al.,* 1992).

According to the formula and scales cited by Kibler (1964), NOAA (1976) and Ravagnolo *et al.* (2000), the supposition of THI categories in this study was safe until mid March. It was mild stressor and alert on the second half of March until the end of April. During the period extended throughout May, June and the beginning of July, the THI was categorized as moderate stressor anticipating danger forecast. By the beginning of the second week of July, the THI was classed as severe stress with an emergent risk.

Threshold or critical temperature and humidity for health of temperate sheep is 30°C air temperature and 70% relative humidity, which accounted for THI value of 81 (Bhattacharya and Uwayjan, 1975). Exposure to solar radiation under ambient temperatures over 35°C prevented sheep from maintaining their thermal balance (Anderson, 1989). At this point rectal temperature may reach 40°C and open mouth panting begins. (Casamassima *et al,* 1991 and Sevi *et al.,* 2001). In the current study, the response of rectal temperature and respiratory rate had not occurred until THI reached above 90. Rectal temperature in individual sheep had not reached 40°C and no mouth breathing had been occurred even when THI was above 90 (at ambient temperature 46°C and RH 19%). It appeared that the stressor period in the cited scales for temperate breeds was not correlated for tropical breeds used in the current study.

It was noticed that the magnitude of respiration rate preceded the rise in rectal temperature. Also, respiration rate was highly correlated with increasing THI ($r=0.738$, $P=0.0005$), whereas rectal temperature was less responsive to THI ($r = 0.561$, $P=0.015$). These results are confirmed by the fact that respiration rate is a good and sensitive indicator for thermal stress than rectal temperature (Lemerle and Goddard, 1986; Saleh, 1996, Schmidt-Nielsen, 1997 and Alamer & Al-hozab, 2004). The increase in rectal temperature occurred in Rahmani sheep when THI was 85, but for Barki and Ossimi breeds the magnitude of rectal temperature was reached when THI was above 90. These results differ than and go beyond the THI value of 73-79 reported for temperate breeds by Fuquay, (1981), Lemerle and Goddard (1986) and Ravagnolo *et al.* (2000). This means that the breeds in the current study were well adapted to heat stress and overcame the cited THI for temperate sheep. The lower magnitude of increase in rectal temperature and respiratory rate in the Barki and Ossimi sheep suggests that these animals were less stressed with increasing heat stress and the Rahmani sheep were still undergoing thermotolerance.

Haematological indices including RBC count, Hb and PCV were negatively correlated with THI (r=-0.530, -0.478 & -0.568 and P=0.024, 0.049 & 0.014 respectively). However, ANOVA showed that they were stable in all sheep along with the increase in THI until a point above value of 90, at which these haematological indices decreased. During hot-dry climatic exposure, water intake increased between 37% and 45%. (Guerrini, 1981). So that this reduction in haematological indices is concordant with the haemodiulution occurred in stressed sheep when they lied in the severe stress zone (Kuselo, *et al.* 2005). The reduction in oxygen requirements to minimize the metabolic heat load, the depression of haematopoiesis, and the sequestration of erythrocytes in the capillary beds (Habeeb *et al.,* 1992 and Igbokwe, 1997) might be additional factors responsible for reduction in haematological indices.

The present investigation showed that total plasma protein and albumin were negatively correlated with THI (r=-0.491 & -0.569 and P=0.039 & 0.0136 respectively) but the calculated plasma globulin was not correlated (r=-0.247, P=0.324). In this concern, ANOVA revealed that these proteins were fluctuated within narrow and insignificant pattern in all investigated sheep except in Rahmani sheep. In the severe stress zone, plasma albumin was decreased in Rahmani sheep with a consequent reduction in total protein levels without breed difference.

The significant reduction in these proteins in Rahmani sheep seems to be due to dilution of these proteins, decrease protein synthesis as a result of the depression of anabolic hormonal secretion and the increase in the catabolic hormones as glucocorticoids and catecholamins (Habeeb *et al,* 1992). Also, albumin might be filtered and redistributed into the extravascular spaces during thermal stress due to its high osmotic sensitivity and its relatively lower molecular mass and size than other protein fractions, (Kerr, 2002) resulting in reduction in the circulating portion. The re-absorption and recycling of circulating urea from the blood to the rumen in tropical ruminants which utilized by the microflora for protein synthesis might be an additional factor (Igbokwe, 1997 and Pugh, 2002).

Plasma electrolytes including sodium and potassium were fluctuated in a diverse behaviour in the current study. Correlation coefficient denoted that THI was positively correlated with plasma sodium and negatively correlated with plasma potassium concentrations (r=0.774 & -0.557 and P=0.0002 & 0.016 respectively). Insignificantly, plasma sodium tended to increase and plasma potassium tended to decrease until THI value reached above 90, a point at which these changes were significant in Rahmani sheep only. The increase in plasma sodium might be a functional compensatory mechanism for retention of body water to insure efficient evaporative cooling because plasma osmolality and blood volume depend mainly on sodium concentration than other osmotic ingredients (Collier *et al.* 1982). The contrary reduction in plasma potassium concentration in heat stressed Rahmani sheep might reflect the higher loss of potassium from the skin during sweating for evaporative cooling (Collier *et al.* 1982). Respiratory alkalosis might be enhanced as a result of hyperpnoea (in Rahmani sheep it was 64 breaths/min in stressed sheep vs. 37 in basal data). Under these circumstances cells tend to uptake potassium ions to release hydrogen ions resulting in reduction in extracellular potassium but intracellular concentrations increased (Duncan and Prasse, 2003).

Correlation coefficient revealed that both thyroid hormones T_3 and T_4 were negatively correlated with THI values but plasma iodine was not correlated (r=-0.7, -0.616 & -0.411 and P=0.0012, 0.0065 and 0.09 respectively). Despite of their essential role in thermogenesis (Schmidt-Nielsen, 1997), both thyroid hormones T_3 and T_4 tend to insignificantly decrease with increasing THI. In this concern, ANOVA revealed a non perceptible changes in heat stressed sheep than the basal values until the THI value above 90, a point at which the decline in plasma T_3 value in Rahmani sheep was significant. The insignificant fluctuations of these hormones in Barki and Ossimi sheep differ than those reported by Collier *et al.* (1982), Beede and Collier (1986) and Silanikove (2000) in which thyroid hormones were markedly decreased with increasing thermal stress. However, our results agree with the findings of Guerrini and Bertchinger (1983) on sheep stressed under hot dry environment and Saleh, *et al.* (2003) on camels reared under the environment of the Egyptian oasis. It seems that the low iodine contents in the Egyptian oasis (UNICEF, 1993 and Saleh, 2000) might have a role in damping the effects of stress on thyroid hormones. Furthermore, Aceves *et al.* (1987) found that chronic heat stress had no direct effect on the thyroid gland activity, but peripheral monoiodination (to convert T_3 to T_4) or monodeiodination (to convert T_4 to T_3) may occur as a trial of economic adjustment of the internal metabolism. The significant reduction of T_3 in heat stressed Rahmani sheep concur with the results of Gambert (1991) and Zamiri & Khodaei (2005) that T_3 levels are more sensitive to changes in environmental temperature than are T_4 levels. On the other hand, The reduction in T_3 might be a trial to decrease the basal metabolic rate to decrease heat production (Habeeb *et al.* 1992; Kerr, 2002 and Pugh, 2002).

Activation of the hypothalamic-pituitary-adrinal axis and the consequent increase in plasma glucocorticoid concentrations are perhaps the most important responses of animals to stressful conditions (Habeeb, *et al.,* 1992). Under severe heat stress the hyperglycemic action of cortisol is most likely required to provide the expected increase in glucose utilization. However, plasma cortisol in the current work was not correlated to THI values (r=0.279 and P=0.261). ANOVA revealed that plasma cortisol concentrations in heat stressed Barki and Ossimi sheep tend to decrease (non-significantly) when compared with basal values. On the other hand, plasma cortisol was significantly increased in Rahmani sheep with significant breed difference during the period of severe thermal stress ((THI above 90). Hashizume *et al.* (1994); Mears & Brown (1997); Sevi *et al.* (1999) and Zamiri & Khodaei (2005) concluded that the decline in plasma cortisol activity under chronic heat stress indicates adaptation to the stress, whereas an increase in the cortisol concentration over the basal level in animals that are chronically exposed to heat load is an indication that the animal became distressed.

In general, our results concur with the reports of Silanikove (2000) and Sevi, *et al.* (2002) that sheep are one of the most heat-resistant species among farmed animals. Some of Barki and Ossimi sheep in this study showed their superior heat tolerance by grazing and ruminating happily in the sun. Such peculiarities may contribute to minimize the impact of high summer temperatures on sheep health. Similar results were obtained for Bos indicus cattle reared under tropical summer in the United Arab Emirates (Ansell, 1976). There are recent evidences that ruminants that evolved in hot climates have acquired thermotolerance genes that protect cells from the deleterious actions of elevated temperature. (Paula-Lopes *et al.,* 2003; Hansen, 2004 and Hernández-Cerón *et al.,* 2004).

In conclusion, this study had setup a preliminary data on some health parameters of sheep reared under the Egyptian oasis conditions. The hot, arid and drought desert environment did not affect health indices in Barki and Ossimi sheep inhabiting Darb Al Arbain area. However, the health of Rahmani breed was at risk and still having a thermoregulatory mechanism only when THI was above 85 and not at 81 which reported as stress threshold for temperate breeds. From these aforementioned results, this study recommends to establish suitable new THI categories for native breeds reared under tropical environment differ than those cited for temperate and high producing ruminant.

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