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THE ROLE OF WOOL COAT IN RESISTANCE TO WATER SALINITY AND HEAT STRESS IN SHEEP

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ABSTRACT

This study was carried out at Maryout Research Station of the Desert Research Center, located 35km south west of Alexandria. The experimental period extended from the first of July to the middle of September 2000. Twenty adult Barki rams were equally divided into four groups. Two groups were exposed to solar radiation and the two other groups were under shade. One of the two exposed groups was offered tap water (0.3g/L TDS) and the second group was offered saline water (13.1g/L TDS). The same respective order was done in the other shaded groups. Staple length (STL), fibre diameter (FD), fibre type ratio (FTR), cotting score (CS), coat depth (CD) and number of crimps/cm (CRS) were measured. Plasma aspartate aminotransaminase (AST), alanine aminotransaminase (ALT), glucose (GLU) and haemoglobin (Hb) concentrations were determined.

The present study showed that drinking saline water significantly ($P<0.05$) declined both of animal BW and plasma GLU, while it caused an increment in both of plasma Hb and activity of liver enzymes (AST and ALT). Exposure to solar radiation tended to significantly increase BW and liver enzymes, while it decreased plasma Hb, but it had non significant effect on plasma GLU. Wool CD and FD could dilute the harmful impact of salt and heat stresses on sheep.

Keywords: sheep, wool traits, heat stress, salinity, blood constituents.

INTRODUCTION

High ambient temperatures, high direct and indirect solar radiation, humidity and water salinity are environmental stressing factors that impose strain on animals in arid and semi arid areas. Despite having well developed mechanisms of thermoregulation, ruminants do not maintain strict homeothermy under heat stress. Factors such as water salinity and solar radiation which existed in desert may exacerbate the impact of heat stress on animals (*Nissim, 2000*).

In the north-western costal desert of Egypt, animals may be forced to grow on drinking salty underground water. *Atwa (1979)* found that the total dissolved salts (TDS) in wells along the Northern coastal region of Western desert of Egypt varied from 360 to 10797ppm. The highest permitted salt concentration is 2.5% for sheep and goats, 2% for cattle and 1.5%for horses *(Schmidt-Nilsen, 1979)*. Sheep was stated to tolerate salt in water up to 13000ppm (*Peirce, 1966*). Body gain of sheep increased by drinking saline water up to 9100ppm concentration (*Ahmed et al., 1985*), while *Abdel Rahman et al (2000)* and *Fawzia and El-Sherif (2002)* found that the level of salinity up to 13100ppm reduced live body weight. *El-Sherif and El-Hassanien (1996)* stated that the long term administration of diluted seawater (13100ppm TDS) adversely affected the growth rate of growing lambs. *El-Hassanein* and *El-Sherif (1996)* found an evidence of some tissue inflammation due to the prolonged administration of salt water. Some wool fibre characteristics such as medullated fibres play an active role in protecting sheep from the extremes of climatic and environmental conditions (*Abd-El-Ghany, 1994*). The present study was conducted to study the influence of heat stress and water salinity on some physiological and haematological responses and the role-played by some wool characteristics of Barki sheep.

MATERIALS AND METHODS

The study was carried out at Maryout Research Station of the Desert Research Center, located 35km south west of Alexandria (Latitude 31.02 N, Longitude 29.80 E). Twenty adult Barki rams of an average 2.1±0.1 years of age and 36.7±0.8kg body weight, were equally divided into four groups. Two groups were exposed to solar radiation and the two other groups were kept under natural shading by the use of shade trees. One of the two exposed groups was offered tap water (0.3g/L TDS); G3 and the second group was received saline water (13.1g/L TDS) ; G4 through 96 hours as long as 7 cycles with 24 hours interval drinking tap water in between cycles for all experimental animals. The same respective order was done in the other shaded groups; G1 and G2, respectively. The same former seven salinity cycles were repeated again after one week. The experimental period extended from the first of July to the middle of September 2000. Drinking saline water was prepared by daily dilution of seawater (39.3g/L TDS). All animals were given the same ration (berseem hay and concentrate mixture) according to their body weight requirements *(Morrison, 1959)*. Both tap and saline water were available to the animals to drink ad libitum and they were weighed at the beginning and every cycle thereafter during the experimental period and the weight changes were calculated. Some wool characteristics were measured such as staple length (STL), fibre diameter (FD), fibre type ratio (FTR); kemp (K), medullated (C1-C2-C3) and fine (F) fibres percentage (are counted 100%), cotting score (CS), coat depth (CD) and number of crimps/cm (CRS). Blood samples were collected by jugular vein at the end of each cycle at (12:00m.d.)for determining plasma concentrations of Aspartate aminotransaminase (AST), Alanine aminotransaminase (ALT), Glucose (GLU) and Haemoglobin (Hb).Plasma was obtained for chemical analysis by centrifugation of blood at 3000 rpm then preserved at -20°c. Concentrations of AST, ALT and GLU were determining using commercial Kits. Haemoglobin concentration was determined according to *(Crosby et al, 1954)*. A wool sample of about 20 gms was collected from the right mid-side position of each animal, a small greasy sub-sample of 10 staples was taken at random from each mid-side sample and was used to measure staple length (STL) and fibre diameter (FD). In the greasy sub-sample, STL was the average of 10 staples; measurements were made from the base to the dense part of the tip of the staple to the nearest 0.5cm.without applying any longitudinal tension. Fibre diameter (FD) was measured from the greasy sub-samples on 300 fibres using a microscope and image captured by Image Analyzer (LEICAQ 500 MC). The whole sample was splitted on a black velvet into various fibre types i.e., fine (non medullated)F, coarse (medullated)C and shed kemp fibres, K. Benzene test was used at times to distinguish between some fine and coarse fibres. The number of each fibre type was counted and presented as number of fine, number of coarse and number of kemp fibres. The meteorological data were recorded every two hours throughout the study. Ambient temperature (AT)°c, soil temperature (SOT)°c and percentage of relative humidity (RH)% were measured by a thermohygrograph located about 1.5 meters from the ground. Solar Radiation (SR)°c was measured by the degree of black ball temperature°c.

SAS software was used *(SAS, 1989)* for statistical analysis of the data according to 2X2 factorial design (fresh water, saline water, exposure to solar radiation and natural shading).

Table 1: Means ± standard errors (x ± SE) of meteorological data at the site of experiment during the course of measurements

Meteorological Parameters		Trial 1		Trial 2	
		Tm 1	Tm 2	Tm 1	Tm 2
AT °c	x	25.3	35.4	26.6	36.7
	±SE	0.042	0.077	0.034	0.015
SOT°c	x	24.6	34.3	25.3	36.2
	± SE	0.033	0.001	0.089	0.006
SR °c	x	28.1	44.8	33.1	46.9
	± SE	0.064	0.063	0.067	0.057
R.H.%	x	69.9	55.6	65.2	52.5
	± SE	0.055	0.010	0.185	0.001

AT: ambient temperature °c, SOT: soil temperature °c, SR: Solar radiation °c, R.H.% percentage of relative humidity, Trial 1: July (2000), Trial 2: August (2000), Tm 1 (8:00 am) and Tm 2(2:00)pm

RESULTS AND DISCUSSION

1- Coat Fibres

The studied wool traits of the four experimental groups are presented in Table (2). The differences of all coat characteristics between groups were significant (P<0.05). The exposed-tap watered group G3 recorded the higher values of K%, C3%, CRS/cm, CD cm and STL cm, whereas it had the lower values of F% and CS as compared with the other experimental groups. Table (2) showed also that the exposed saline-watered group G4 recorded the lower levels of K%, C3%, CRS/cm, CD cm and STL cm, while FD µm and F% marked the highest values as compared with other groups. The shaded tap-watered G1 and shaded saline–watered G2 groups showed different moderate values. *El-Sherbiny et al (1996)* recorded 30.91±1.5 µm for fiber diameter in Barki sheep and 28.42±1.7µm in ½ Barki x Finnish Landrace cross. The workers also reported 2.69±0.4 and 4.56±0.4 number of crimps /2 cm in the two breeds, respectively. *Khalil et al (1997)* estimated 6.46±0.4 cm for staple length, 35.5±1.7µm for fibre diameter, 256.9±24.6/cm^2 for number of coarse fibers, 532.5± 1.1/cm^2 for number of fine fibers and 69.4±15.6/cm^2

for number of Kemp fibres in Barki sheep. It is well known that wool coat is of significant value for sheep living in desert and could readily absorb a greater proportion of the solar radiation by the tip of wool staples, while the medulated fibers could make as an insulator factor preventing hot sun rays to penetrate wool coat inside *(Abdel-Ghany, 1994 and Khalil et al., 1997)*. Generally, the wool coat assists in the maintenance of body temperature, since the heavy wool acts as a protective integument by lowering heat loss in cold environment and by decreasing heat gain in hot environment.

Table 2. Least square means and standard errors (X±SE) of some wool fine characteristics of the experimental groups of Barki sheep

Wool characteristics		G1	G2	G3	G4
FDμm	$\overline{x}$	32.950	31.175	32.60	33.960
	± SE	0.521	0.521	0.466	0.521
K%	$\overline{x}$	1.750	3.20	3.25	1.60
	± SE	0.41	0.41	0.37	0.41
C1%	$\overline{x}$	13.7	9.85	11.38	11.50
	± SE	2.15	2.14	1.92	2.15
C2%	$\overline{x}$	8.15	11.60	10.98	10.38
	± SE	2.08	2.08	1.86	2.08
C3%	$\overline{x}$	8.28	10.63	10.92	4.45
	± SE	1.63	1.63	1.46	1.63
F %	$\overline{x}$	68.12	64.72	63.47	71.77
	± SE	1.32	1.32	1.18	1.32
CRS/cm	$\overline{x}$	2.60	2.85	3.90	2.24
	± SE	0.43	0.43	0.39	0.43
CD cm	$\overline{x}$	8.13	8.00	8.60	7.13
	± SE	0.36	0.36	0.32	0.36
STL cm	$\overline{x}$	6.88	7.38	8.06	6.63
	± SE	0.25	0.25	0.22	0.25
CS	$\overline{x}$	1.00	1.00	0.20	0.50
	± SE	0.19	0.19	0.17	0.19

FD: fibre diameter, K: kemp fibres %, C1-C2-C3: different degrees of medullated fibres %, F: fine fibres %, CRS: number of crimps/cm, CD: coat depth, STL: staple length, and CS: cotting score

2- Live Body Weight (BW)

Tables 3 and 4 show the average live body weights at the onset and end of the study for the experimental groups. The differences between groups of the BW at the end of the two stages (Trial 1 and Trial 2) of the study were significant (P<0.001). Live BW significantly (P<0.01) decreased as time progress in both G2 and G4; the two treated saline groups. At the end of the experiment, animals lost 5.91,4.07,5.53 and 4.78%of their initial live BW for G2 and G4 for (Trial 1) and (Trial 2), respectively. *Fawzia and El-Sherif (2002)* reached to the same result on sheep used different levels of saline water up to 13100ppm. The decrease in BW of G2 and G4 may be due to an increase in osmotic pressure of body fluids and /or a reduction of digestibility, absorption and efficiency of utilization of nutrients fed *(Hemsely et al, 1975)*. In the contrary, *Ahmed et al. (1985)* found that body gain of rams increased by drinking saline water up to 9100ppm concentration. However, this contradiction may due to the low concentration of saline drinking water (9100ppm) compared with the level used in the present study (13100ppm). Peirce (1966) recorded that the tolerable salt concentration for sheep to range from 11000 to 13000ppm in sodium chloride tap water.

Table (3): Least square means and standard errors (X±SE) of live body weight at the onset (W1) and the end (W2) of the experiment in Trail 1

Group	W1(kg)	W2 (kg)	Weight change in kg	Weight change %
G1 $\overline{x}$	48.30	53.25	+4.95**	10.25
±SE	3.805	3.816		
G2 $\overline{x}$	49.60	46.67	-2.93**	5.91
±SE	3.715	4.406		
G3 $\overline{x}$	51.00	56.88	+5.88**	11.53
±SE	3.001	3.564		
G4 $\overline{x}$	51.60	49.50	-2.10**	4.07
±SE	3.828	3.726		

+: Weight gain, -: weight loss, Trial 1:July (2000), G1: shaded tap watered, G2: shaded – treated, G3: exposed-tap watered, G4: exposed-treated, weight-change in the live body weights as kg and % were calculated from the initial weight
** Significant at level (P<0.01)

A high significant (P<0.001) correlation (0.78) was found between the wool coat depth (CD) and BW in all experimental groups. The exposed-saline watered group G4 lost of their BW less than the shaded-saline watered group G2 along the two trails of study (Tables 3 and 4). *Abd-ElGhany (1994)* stated that dense wool coat acts as a protective integument under exposure to solar radiation by decreasing heat gain, whereas it considered a heavy burden for animals under shade. Accordingly, the exposed-tap watered group G3 tended to increase BW than the shaded tap-watered group (G1; control group) in the two trails. So the wool coat played a significant role to make animal welfare. Therefore, it is clearly shown that wool coat in terms of long staples and medullated fibers may lighten the accumulative effect of solar radiation. *Abd-El Ghany (1994)* confirmed that medullated fibers could be considered as insulated fibers in hot climates in desert.

In the extended Trial 2, it seamed that sheep lost more of their BW under salinity stress in G2 (-3.49kg) and G3 (-2.34kg) as compared with G2 (-2.93kg) and G4 (-2.10kg) of (Trial 1), Tables (3 and 4). These differences were significant (P<0.05). This finding may be due to the decrease in nutrient intake that was taken by saline treated groups with prolonged stress of water salinity.

Table (4): Least square means and standard errors (X±SE) of live body weight at the onset (W1) and the end (W2) of the experiment in Trail 2

Group		W1	W2	Weight change in kg	Weight change %
G1	x̄	52.63	54.01	+1.38**	2.62
	±SE	3.073	3.416		
G2	x̄	46.03	42.54	-3.49**	5.53
	±SE	4.413	4.309		
G3	x̄	54.17	56.47	+2.30**	4.25
	±SE	3.023	4.621		
G4	x̄	49.00	46.66	-2.34**	4.78
	±SE	3.675	3.384		

+: Weight gain, -: weight loss, Trial 2:August G1: shaded tap watered, G2: shaded – treated, G3: exposed-tap watered, G4: exposed-treated, weight-change in the live body weights as kg and % were calculated from the initial weight
**** Significant at level (P<0.01)**

3- Blood glucose level (GLU)

Plasma glucose concentrations were significantly affected by both of period (P<0.01) (Trial 1 and Trial 2) and groups (P<0.001). Blood glucose levels tended to decrease in the treated saline groups G2 and G4 compared with tap-watered groups G1 and G3 in the two trails as shown in Table (5). However, the overall means of plasma glucose for G4 was higher (3.110mmol/l) than G2 (2.964mmpl/l) which means that the exposure to solar radiation in the hot season may emphasize the effect of drinking saline water on the animal. *Coles,(1986)* stated that exposure to solar radiation and drinking saline water could increase of adrenocorticotrophic hormone (ACTH) which stimulates the adrenal cortex to secrete glucocorticoids which, in turn, increase gluconeogenesis. Shading is an effective way of lowering the natural heat stress of sheep (Younis and Mokhtar, 1999). *Fawzia and El-Sherif (2002)* revealed an insignificant declined levels of plasma glucose in sheep with increasing saline concentration in water. The observed decline in plasma glucose in sheep by increasing water salinity may be due to the long period of administration of saline in addition to using diluted seawater that contained different minerals and not only sodium chloride. *Fawzia et al (1997)* found that blood glucose levels tended to decrease in rams given saline water. On the other hand, *Assad et al (1994)* found non significant increase in blood glucose of ewes that received 7.7 and 13.5 ppm /TDS of diluted seawater. However, the exposed-saline watered group G4 had a low blood glucose level (3.110 mmol/l) than the exposed-tap watered group G4 (3.532 mmol/l).

The heavy wool coat (i.e. more coat depth, long staple length, compact fleece and large diameter with increasing in medullated fibres) assists in the maintenance of body temperature and it also acts as a protective integument by decreasing heat gain in hot environments *(Khalil et al, 1997)*. In the present study, a significant (P<0.01) correlation (r=-0.51) was found between plasma glucose concentrations and fibre diameter (FD). This result means that FD could help animals to reduce heat production via reducing plasma glucose levels under stress of both exposure to solar radiation G1 and G3 and drinking saline water G3 and G4, Table (5).

4- Blood haemoglobin level (Hb)

Haemoglobin (Hb) concentrations were significantly affected by salinity ($P<0.05$) and by solar radiation ($P<0.01$). An elevation in Hb concentration was recorded in the two treated saline groups G2 and G4 rather than the others through the two trials (Table,5). The higher plasma concentration of Hb was recorded by G4 (10.457 g/dl). This result might reflect a phase of haemoconcentration which means animals could keep the concentration of Hb relatively high due to its increased concentration within the cells. Elevation in Hb concentration was reported by *(Kawashti et al, 1983 and Hussein et al,1990)* in sheep given saline water containing 2% and 1.3% sodium chloride, respectively. *El-Hassanein and El-Sherif (1996)* recorded a slightly higher concentration of Hb in saline-treated rams given 13.1 g/l TDS in water. This increase in Hb concentration was achieved by increasing mean corpuscular haemoglobin (MCH) (picogram) and mean corpuscular haemoglobin concentrations (MCHC) (g/dl) values, keeping higher Hb levels which seemed to be of physiological importance for the treated saline rams. *Georrgieu (1988)* found that poisoning with sodium chloride may cause an elevation in Hb concentration, reduction of oxyhaemoglobin in tissues and increase in venous blood. *Weeth et al (1960)* found that drinking water containing 1% and 2% salt caused varying degrees of anhydremia resulting in an elevation of specific gravity and haematocrit values in the blood of heifers. On the other hand, a non significant fall in Hb concentration was noticed in a group of goats given high saline water *(Ibrahim, 1995)* which came in agreement with observation made by *Hussein et al(1990)* on rams that received saline water (1.3%). Therefore, this result may due to water retention; a sequence of the salt load. Factors such as water deprivation and water salinity may exacerbate the impact of heat stress under exposure to solar radiation *(Nissim,2000)*. The lower value of Hb concentration was (9.632 g/dl) in exposed-tap watered group G3, while it was (9.819 g/dl) in shaded-tap watered group G1 (control). The difference ($P<0.01$) between the two former groups revealed that Hb concentration decreased by exposure to solar radiation, Table (5). This finding may suggest incidence of haemodilution resulted from excessive water intake by sheep under heat stress, as well as to reduce oxygen consumption. Increased water intake is a primary response of animals to heat exposure *(Younis and Mokhtar, 1999)*. It was concluded by *Acharya et al (1995)* that sheep have long staples get more tolerance against solar radiation than short ones. It is shown in Table (2) that G4 had less of STL (6.63 cm) than the other treated groups. The present result is accordance with the finding of *Georgieu (1988)* in hens, *Hussein et al (1990)* in sheep and *Ibrahim (1995)* in goats.

5- Liver transaminase enzymes (AST and ALT)

The changes of aspartate aminotransaminase AST and alanine aminotransaminase ALT levels were significantly affected by each of salinity ($P<0.01$) and exposure to solar radiation ($P<0.05$). The differences of two enzymes between the experimental groups were significantly ($P<0.01$) for AST and ($P<0.001$) for ALT. The levels of AST and ALT had approximately the same values in the control group of both Trial 1 and Trial 2, Table (5). The levels of AST and ALT significantly (P<0.05) increased with time increase from Trial 1 to Trial 2 recording their highest levels in exposed-saline watered group G4 (54.598 IU/l) for AST and (16.090 IU/l) for ALT. *Fawzia and El-Sherif (2002)* recorded an increase in AST and ALT with increasing saline water intake (13.1 ppm/TDS) to reach (53.00 IU/l) for the high saline group of sheep. *Fawzia et al(1997)* found a highly significant correlation between saline water intake and the liver enzymes activity AST and ALT. Similar results were reported by *Weeth and Haverland (1961)*who reported that AST was 480 u/ml in heifers receiving 1.75% NaCl compared to 66u/ml of the control animals. *Ibrahim (1995)* observed an increase in serum GOT and GPT in sheep, but a non significant increase in GOT was found in goats received dilute seawater containing 9.2 and 13.8ppm /TDS . It seemed that saline load affected AST release in the blood of sheep. It can be concluded that the increase of ALT due to the increase in salinity of drinking water indicates liver hyperfunction. In addition, glucose levels decreased with saline administration (Table,5). This indicated the incidence of energy expenditure by sheep for coping with saline load, which exerted a stress on the liver function *(Boyd and Ford, 1967)*. On the other hand, *Assad et al(1994)* found a non significant difference in serum transaminase enzymes SGOT and SGPT in sheep receiving diluted seawater containing 7650ppm and 13535ppm/TDS. *Assad et al(1989)* observed cloudy swelling in the liver cells, widening of the sinusoids and oedema of the hepatic tissues in ewes and their lambs that received 1.3% TDS of diluted seawater. In the present study, the comparison between G2 and G4 exhibited the harmful impact of heat stress on liver enzymes.

Table (5): Least square means and standard errors (X ±SE) of plasma constituents of trial groups as affected by exposure to solar radiation and water salinity in Barki sheep

Parameter	Group	Trial 1	Trial 2	Overall mean ±SE
AST IU/l	G1	43.940	43.310	43.625±2.969
	G2	52.048	53.822	52.935±3.313
	G3	50.664	52.054	51.359±2.667
	G4	53.158	56.038	54.598±2.684
ALT IU/l	G1	10.362	10.470	10.419±0.997
	G2	13.884	14.482	14.183±1.116
	G3	11.300	11.882	11.591±1.200
	G4	15.756	16.424	16.090±1.086
Glucose (GLU) mmol/l	G1	4.056	3.498	3.778±0.150
	G2	3.042	2.886	2.964±1.090
	G3	3.594	3.470	3.532±0.203
	G4	3.290	2.970	3.110±0.175
Haemoglobin (Hb) g/dl	G1	9.730	9.908	9.819±1.300
	G2	9.965	10.017	9.991±1.217
	G3	9.700	9.925	9.813±1.265
	G4	10.583	10.331	10.457±1.117

Trial 1:July(2000), Trial 2:August (2000), G1: shaded tap watered, G2: shaded –treated, G3: exposed-tap watered, G4: exposed-treated, AST: asprtate aminotransaminase IU/l, ALT: alanine aminotransaminase IU/l.

It markedly shown from Table (5) that the exposure to solar radiation increased the enzymes activity of liver. Other stress such as high environmental temperatures was found to increase the level of both liver enzymes by inducing an increase in gluconeogenesis, stimulated by higher secretion of the glucocorticoids *(Madian, 1989 and Badawy, 1999).* On the other hand, *Abdel Rahman et al (2000)* recorded insignificantly decrease for both GPT and GOT of California rabbits under salt stress (4840ppm/TDS). The elevation of both transaminases may reflect malfunctioning of liver, supporting the previous suggestion concerning the mechanisms responsible for albumin decrease after drinking diluted seawater. Statistical analysis revealed an insignificant correlation between the studied wool characteristics and the liver enzymes.

Conclusion

In Conclusion, the results of the present study stated that Barki sheep are able to withstand harsh environmental conditions in desert where drought, heat stress and salinity are main features during the long dry hot summer in the north western coastal area of Egypt which it is a good example for arid and semi-arid conditions. Wool coat depth plays an important role in order to protect animals exposed to solar radiation. Fibre diameter also could be considered the most important factor of the wool coat characteristics which protects sheep against both of heat and saline stress. In addition, despite having such conditions, sheep did not reach to *"aversive stage"* or to *"noxious stage"* throughout the experiment.

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دور غطاء الصوف فى مقاومة ملوحة المياه والإجهاد الحرارى فى الأغنام

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أجريت هذه الدراسة بمحطة بحوث مريوط التابعة لمركز بحوث الصحراء والتى تبعد ٣٥ كم عن محافظة الاسكندرية . وقد بدأت الدراسة فى الاول من شهر يوليو وحتى منتصف شهر سبتمبر عام ٢٠٠٠ م. استخدم فى هذا البحث عدد ٢٠ كبش برقى ناضج قسمت الى ٤ مجاميع متساوية. عرضت مجموعتان إلى أشعة الشمس المباشرة ووضعت مجموعتان تحت الظل. شربت إحدى المجموعتين المعرضتين ماء الصنبور (٠،٣ جم/لتر أملاح ذائبة كلية) بينما شربت المجموعة الثانية ماء مالح (١٣،١ جم/لتر أملاح ذائبة كلية) وأجريت نفس المعاملة السابقة على المجموعتين المظللتين.

تم قياس طول الخصلة، قطر الليفة، التلبد، عمق غطاء الصوف وعدد التموجات فى السنتيمتر الطولى ، وتم حساب النسب المئوية للألياف المختلفة وتم تقدير أنزيمات الكبد (AST و ALT) والجلوكوز والهيموجلوبين فى بلازما الدم.

أظهرت الدراسة أن شرب الماء المالح أدى إلى انخفاض معنوى فى كلا من وزن الجسم وتركيز الجلوكوز فى البلازما بينما سبب زيادة فى كل من تركيز الهيموجلوبين ونشاط إنزيمات الكبد. أدى تعريض الكباش لحرارة الإشعاع الشمسى إلى زيادة معنوية فى وزن الجسم وإنزيمات الكبد بينما أدى إلى نقص فى هيموجلوبين البلازما ، لكن لم يظهر التعريض لأشعة الشمس تأثيرا معنويا على مستوى جلوكوز الدم. أظهرت الدراسة أيضا أن عمق غطاء الصوف وقطر الألياف قد يؤديان إلى تخفيف حدة التأثير الضار الناجم من شرب الماء المالح والإجهاد الحرارى الناتج من التعرض لأشعة الشمس المباشرة على الأغنام.