J. Agric. Sci. Mansoura Univ., 29 (8): 4473 - 4486, 2004

THE ROLE OF HAIR COAT IN RESISTANCE TO WATER SALINITY AND HEAT STRESS IN GOATS

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ABSTRACT

This experiment was carried out at Maryout Research Station of the Desert Research Center, located 35km south west of Alexandria, to study the role of some hair coat characteristics of Baladi goats under stress of solar radiation and water salinity on some adaptive physiological parameters. The experimental period extended from the first of July to the middle of September 2000. Twenty adult Baladi bucks were randomly divided into four equal groups. Two groups were exposed to solar radiation and the two other groups were raised under shade. One of the two exposed groups was allowed to drink tap water (0.3g/L TDS) and the second group was offered saline seawater (13.1g/L TDS). The same respective order was done in the other shaded groups. Staple length (STL), fibre diameter (FD), medullated fibres percentage (C1,C2 and C3) were measured. Plasma total protein (TP), albumin (Al), globulin (Gl), A/G ratio, sodium (Na), urea (UR) and creatinine concentrations were determined.

Results revealed that each of drinking saline water and exposure to solar radiation caused a significantly decrease in body weight for all experimental groups. The lost in body weight was higher (4.03kg) in the shaded-saline watered group, while it was lower in control group (0.90 kg). TP, Al and Gl were significantly ($P<0.05$)decreased in response to drinking saline water and also exposure to sun rays, while A/G ratio, plasma Na, CRE and UR concentrations were significantly increased. A significant ($P<0.01$) correlation was found between both of CRE ($r= -0.88$) and Na ($r= - 0.81$) concentrations and fibre diameter, while the correlation between the all studied blood constituents and staple length was not significant. On the other hand, staple length and medullated fibre percentage diluted the effect of solar radiation on body weight loss

Keywords: salinity, seawater, goats, blood, and semi-arid conditions

INTRODUCTION

Increase and development of animal production in Egypt are obligatory choice due to the great demand of animal protein versus the progressive increases in Egyptian population. The north western coastal area of Egypt is a good example for arid and semi-arid conditions where drought, heat stress and salinity are main features during the long dry hot summer. In this area water, salinity refers to water scarcity as a result of a prolonged dry period which the average annual rainfall in winter months (September to March) is low and erratic and ranges from 150 to 180 ml (*Younis and Mokhtar*, 1999). Sheep and goats represent the main species of livestock, which exist in this area. Indeed these animals depend all year round on water obtained from traditional shallow wells with varying degrees of salinity which commonly increase during the dry seasons. Salt stress is considered one of the most critical factors limiting the productivity and has adverse effect on health and performance of animals. Goats are through to be less susceptible to ecosystem stresses than other ruminants as they are widely distributed under diverse environmental conditions (*Ibrahim*, 1999). In Egypt, *Atwa* (1979) determined that the content of total dissolved solids (TDS) in wells along the northern coastal region of the western desert varied from 360ppm to 10797ppm. Salt poisoning (which is apparently correlated with total saline load above tolerance level) are thirst, weakness, diarrhea, dehydration, emaciation and muscular spasm, which may lead to death (*Abdel Rahman et al*, 2000). The blood picture of grazing animals differs according to the concentration of salt in water received (*Hamdi et al*, 1982). The coat is of significant value to sheep and goats living in desert, it assists in the maintenance of body temperature, since the heavy wool and long hair act as a protective integument by decreasing heat gain in hot environments, while, shearing of sheep and goats removes much of the insulation against both hot and cold environments (*Macferlan et al,* 1958). It was concluded by *Acharya et al* (1995) that long haired goats tolerate radiant heat better than short haired goats.

MATERIAL AND METHODS

The experiment was conducted 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 Baladi bucks of an average 1.9±0.33 years of age and 29.87±1.66kg body weight, were equally divided into four groups. Two groups were exposed to solar radiation and the two other groups were under natural shading by the use of shade trees. One of the exposed groups G3 was offered tap water (0.3g/L TDS) and the second group G4 was offered saline seawater (13.1g/L TDS) 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 7 salinity cycles were respected 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). Experimental animals were given the same ration (berseem hay and concentrate mixture) according to their body weight requirements (*Morrison,* 1959). Water was available to the animals to drink ad libitum and they were weighed at the beginning and every cycle there after during the experimental period and the weight changes were calculated. Some hair characteristics were measured such as staple length (STL), fibre diameter (FD), and medullated fibres percentage (C1-C2-C3 %). Blood samples were collected by jugular vein at the end of each cycle at (12:00m.d.) for determining plasma concentrations of total protein (TP), albumin (Al),globulin (Gl),Al to Gl ratio (A/G ratio), sodium (Na), urea(UR) and creatinine (CRE). Plasma was obtained for chemical analysis by centrifugation of blood at 3000 rpm then preserved at -20°c. Concentrations of TP was determined by Biuret-method (*Armstrong and Carr,* 1964). Albumin was measured as a result of reaction with Bromocresol Green at pH4.2 (*Doumas et al,* 1971). Globulin was calculated by subtraction of Al from TP, and A/G ratio was obtained by calculation. Plasma urea and creatinine were determined using commercial kits. Concentration of plasma sodium was estimated using flame photometry according to *Jacson*(1958). A hair sample of about 20gms was collected from the right mid-side position of each animal. A small greasy sub-sample of staples was taken at random from each mid-side sample and was used to measure staple length (STL) and fiber diameter (FD). In the greasy sub-sample, STL was the average of 10 staples and FD was measured from the greasy sub-staple on 300 fibers using a microscope and image captured by Image Analyzer (LEICAQ 500 MC). The whole sample was splitted into various types of medullated fibers percentage (C1, C2 and C3 %). 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). The meteorological (Table, 1) data were recorded every two hours throughout the study. Ambient temperature °c (AT), soil temperature °c (SOT) and percentage of relative humidity (RH%) were measured by a thermohygrograph located about 1.5 meters from the ground. Solar Radiation (SR) was measured by the degree of black ball temperature °c.

Table (1): Average 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	0.046	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: 8:00a.m.and Tm 2: 2:00p.m.

RESULTS AND DISCUSSION

1. Hair coat

Some hair characteristics of all studied groups of Baladi bucks (FD µm, C1% C2% C3% and STL cm) were shown in Fig. (1). Statistical analysis exhibited that the differences of all studied hair coat characteristics between groups were significant ($p<0.01$).

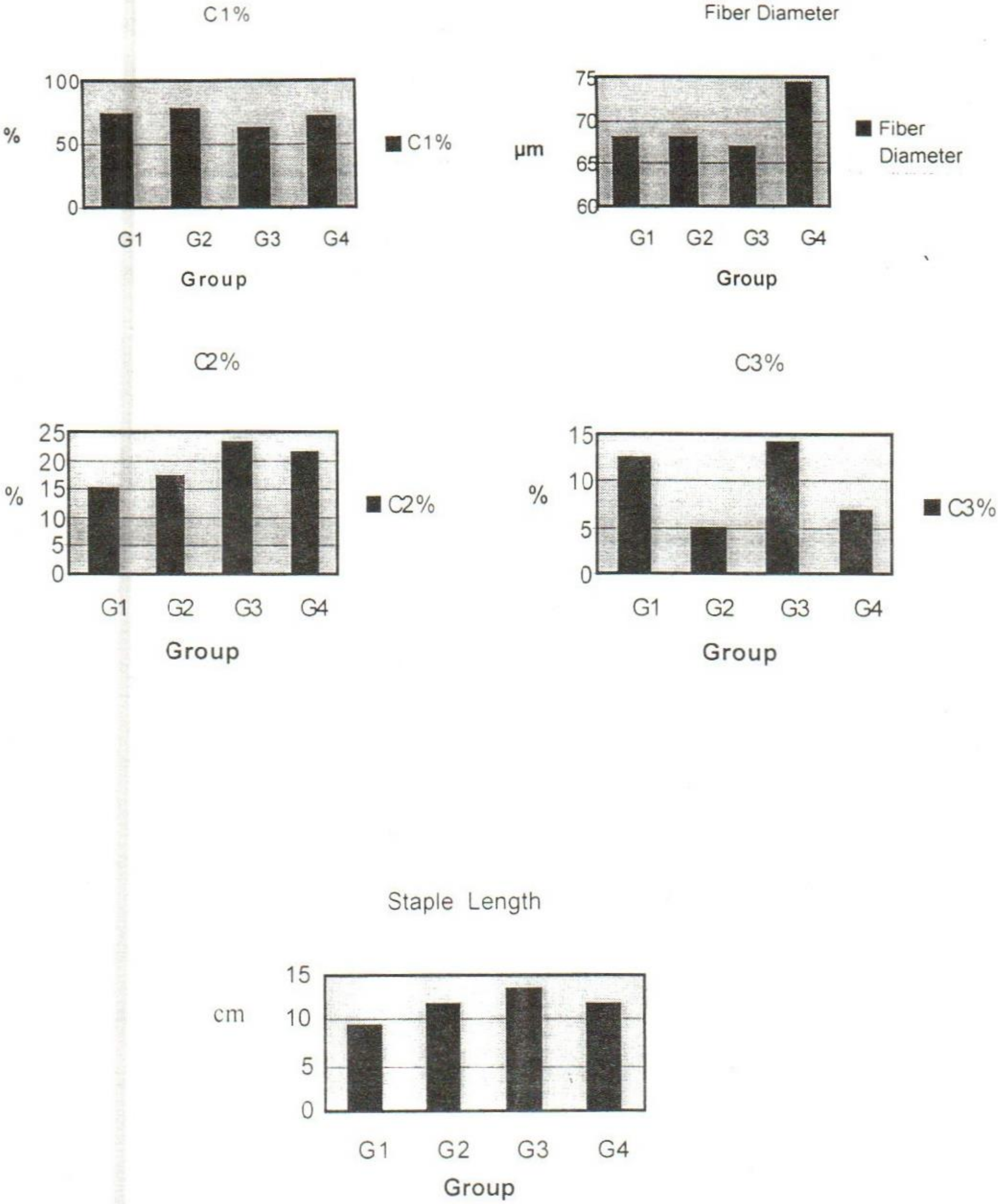

Fig. (1) Fibre diameter (FD), medullated fibres percentage (C1, C2 and C3) and staple length (STL) of the different experimental groups of Baladi goat bucks

The exposed–saline watered group G4 expressed the higher fibre diameter (FD) 74.38±1.338μm compared with the other experimental groups. Whereas the exposed-tap watered group G3 had the higher of both staple length (STL) 13.38±1.342cm and medullated fibre percentage (C3%) 14.14±4.759%. The same group G3 recorded the lowest (FD) 66.74±1.197μm. The shaded-tap watered group G1 had the lowest (STL) 9.27±1.225cm, while the bucks in shaded saline watered group G2 recorded the lowest medullated fibre percentage (C3%) 4.85±6.145%. These wide variations between animals within breed might be due to many factors partly to the environmental conditions. Climatic factors were reported to affect fiber diameter and length (*Gebremedhin*, 1987). Almost in the same geographical zone, differences between animals might be due to different factors such as nutrition, body size and individuality (*Aboul-Naga et al,*1985). *El-Ganaieny* (1996) reported 8.6 and 9.62cm for staple length and 58.33 and 55.46 for medullation index in Maryout and Kostal goats fleeces, respectively. It was suggested by *Abd-ElGhany* (1994)that a higher degree of medullated fibres in summer coat would help animals to be more heat tolerant. Summer coat contained more medullated fibers than winter coat (*Benjamin*, 1985). It was concluded by *Acharya et al.* (1995) that long haired goats tolerate radiant heat better than short haired goats.

2. Body weight

The present results revealed that drinking saline water (13100 ppm TDS) was found to affect ($p<0.05$) adversely the body weight of bucks in the two saline treated groups; (-4.03±0.057kg as 13.57% from the initial body weight) and (-2.05±0.064 kg as 6.35% from the initial body weight) in G2 and G3, respectively, (Table,2 and Fig,2). *El-Sherif and El-Hassanein* (1996) in sheep and *Abdel Rahman et al,* (2000) in California rabbits reached to the same result. On the other hand, *Ahmed et al* (1985) found an increase in body weight as a result of drinking saline well water containing 9100 ppm TDS, in rams. However, this result was found in a short-term experiment and a lower salt concentration than that used in the present study, while *Abdel Samee and El Masry* (1992) did not found effect of drinking natural saline well water on California and New Zealand white rabbits. This conflicting may be due to differences in breed and source and level of water salinity. Regardless of the effect of salinity, the exposed animals to solar radiation G3 and G4 significantly ($p<0.01$) lost about (0.90±0.053kg as 3.01% from the initial body weight) and (2.05±0.064kg as 6.35% from the initial body weight), respectively. The exposed–saline group G4 exceeded the exposed-tap watered group G3 with (-1.15kg in body weight loss. It means that the saline water up to 13100ppm TDS may magnify the harmful effect of solar radiation on animals in the desert. The relatively low body weight lost in G3 may be also explained by the higher staple length (13.38cm) and medullated fibres percentage (14.14%) than the other experimental groups (Fig 1). Short haired black goats had lowest tolerance of radiant heat (*Acharya et al*, 1995). The medulla which is composed of large loosely connected keratinized cells filled with a gas (probably air) was found to be thickness in summer season than in winter (*El-Ganaieny et al*, 1998). These medullated fibres in the fleece might increase animal heat tolerance and they are related to animal thermoregulation, especially in hot weather (*Benjamin*, 1985). This result might be indicate the important role and the biological function of the fleece in the welfare of the animal. Therefore, it will be important to select fleeces with long hair and high percent of medullated fibres for goats raised in the hot environment for demand thermostability through a higher degree of insulating factors of coat fibres. *Acharya et al* (1995) concluded that selection for long haired goats for breeding and rearing in the hot tropics may increase productivity during summer months. *Khalil et al.* (1997) stated that coarse fibres and its distribution over the body seemed to be of efficient insulating properties for tolerating heat compared with fine fibres. The shaded-saline group G2 lost about 4.03±0.022kg (13.57%) from the initial weight. This percentage was the highest one compared with other experimental groups (Table, 2). This result might be attributed to the animal coat existed under shade. Compact fleece may be considered a heavy burden for animals under shade; it may prevent heat dissipation (*Abd El-Ghany,* 1994). Generally, drinking saline water depressed the thyroid activity (*Ayyat et al*, 1991) and such a depression may adversely affect the hepatic synthesis of RNA (*Tata and Widnell*, 1966). This may explain the reduction of live body weight in response to drinking saline water.

Fig. (2) Average of live body weight at the onset (W1) and the end (W2) of the experiment in Trail 1

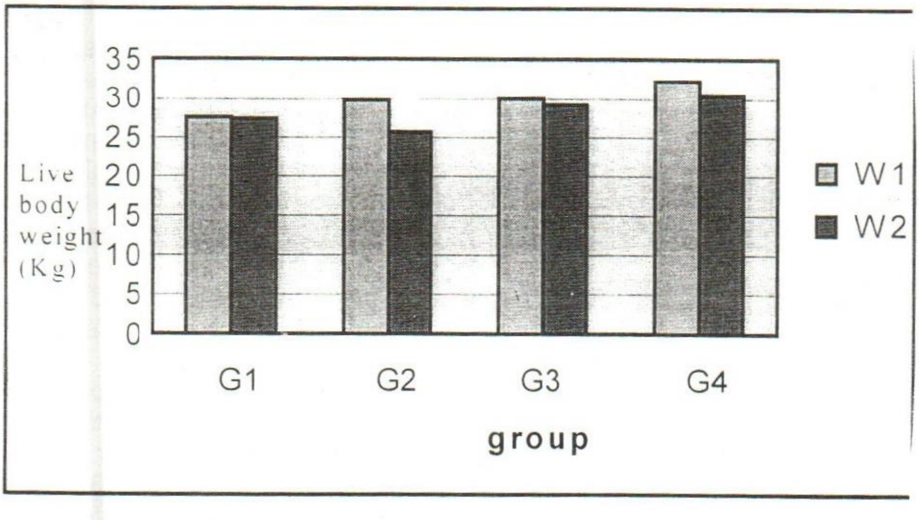

Table (2). Changes in live body weight as kg and % of different experimental groups of Baladi bucks

Group	Weight change kg	Weight change %
G1	-0.43	1.56
G2	-4.03	13.57
G3	-0.90	3.01
G4	-2.05	6.35

+: Weight gain, -:weight loss, Trial 1:July, Trial 2:August, G1: shaded tap watered. G2: shaded –treated, G3: exposed-tap watered, G4: exposed-treated, weight-change in the live body weight as kg and % from the weight at the onset of the experiment.

3. Plasma proteins

Statistical analysis showed a significant effect of salinity ($p<0.05$) and exposure to the sun ($p<0.01$) on plasma total proteins in the experimental groups. The differences of plasma TP between groups were significant ($p<0.01$). A decline in TP due to treatment was detected in the experimental groups as affected by salinity and exposure to solar radiation (Fig.3). The average TP of the two trials 1 and 2 in the control group G1 was 7.83±0.587 g/dl while it was 5.14±0.164g/dl in the exposed-saline watered group G4. Regardless of exposure to solar radiation, TP decreased from 7.21±1.842g/dl in G3 to 5.14±0.164g/dl in G4. In addition, the fall in TP as affected by solar radiation was markedly shown in the exposed-tap watered group G3; 7.21±1.842g/dl as compared with the shaded-tap watered groups (G1; control); 7.83±0.587g/dl. Albumin (Al) and globulin (Gl) significantly ($p<0.05$) declined in response to drinking saline water and exposure to sun rays, but the ratio of albumin to globulin (A/G ratio) was significantly ($P<0.05$) increased (Fig 3). The forgoing results of TP, Al and Gl concentrations suggest that the depression in total plasma protein was due to depletion of plasma albumin rather than plasma globulin with except of G4 which albumin (2.77 g/dl) exceeded globulin (2.37g/dl) resulted in higher A/G ratio (1.169) than G1 (0.851), G2 (0.897) and G3 (0.878). The increase in A/G ratio caused an increase in plasma colloid osmotic pressure, which may help the animal to conserve water in the desert environment (*Khalil et al*, 1990). A significant increase in A/G ratio of exposed ewes to solar radiation. This enables the sun-exposed ewes to keep higher blood volume than sheltered ones (*El-Sherif et al*, 1996). Under hot condition, keeping blood volume is essential, either for high specific heat of water or the need of evaporative cooling of body temperature (*Roubincek*, 1969 and *Swenson,* 1977) Fluids are known to be drawn into the circulation from the extra vascular space, which cause a decrease in plasma proteins concentration (*Sodhi*, 1983 and *Khalil et al*, 1985) In acclimatized animals the body can manufacture the proteins rapidly to restore blood osmotic pressure (*Davson* and *Eggleton*,1962). Albumin is the important factor in maintaining osmotic equilibrium between blood and the tissue fluids due to its hydrophilic properties (*Bell et al*, 1961; *Davson* and *Eggleton*, 1962 and Swenson, 1977). Accordingly the exposed-saline watered group G4 had a higher degree of fibre diameter (74.38±1.338μm) Fig.(1). Fibre diameter might be indicate the important role of coat fibre quality on the welfare of animal by decreasing heat gain during the environmental extremes in summer (*El-Ganainey et al*, 1998). Globulin was reported to be higher in summer (*Doxey*, 1977).، The decrease in TP during exposure to solar radiation in summer could partly attained through the increase in Gl than Al concentration as a response to drink saline water. Other

workers recorded a decrease in the total plasma protein concentration, in Bedouin goats that received (0.9%) saline water (*Chosniak et al*, 1987);in pregnant ewes that had (1.3%)diluted seawater (*Assad et al*,1989) and in California rabbits that watered 4840ppm TDS (*Abdel Rahman et al*,2000). It is well known that plasma albumin is formed only in liver (*Miller et al*, 1954), so that its reduction in response to drinking diluted seawater may reflect reasonable impairment of hepatic function. Other possibility, that excess dissolved salts in seawater mixtures may affect active transport of amino acids needed for intracellular albumin synthesis in hepatic tissue (*Bullock et al*,1991). The decrease of both TP and Al could be considered as a physiological accommodation to prevent excessive passage of fluids into interstitial tissues in response to the high water salinity levels (*Hussein et al*, 1990). On the other hand, an elevation of total plasma protein was reported by *Baker* (1989) in adult goats after saline water administration. However, no changes in serum albumin of pregnant ewes after ingestion of sodium chloride (0.5%, 4.8%, 9.1% and 13.1%) were reported by *Mayer and Weir* (1954).

4. **Kidney function**

Both drinking water salinity and exposure to solar radiation caused a significant ($p<0.01$) increase in plasma urea (UR), creatinine (CRE) and sodium (Na) concentrations Fig. (3). The differences between groups were significant ($p<0.01$). The effect of salinity on plasma UR, CRE and Na concentrations is markedly noticed between the shaded-tap watered group G1; 18.52±0.159mg/dl, 1.07±0.033mg/dl and 140.97±1.027meq/l, respectively, and the shaded-saline watered group (G2; 25.46±0.074mg/dl, 1.59±0.036mg/dl and 162.74±1.125meq/l), respectively. This result may reflect insufficiency of renal glomerular filtration and impairment of kidney functions (*Kaneko*, 1989). The increase of plasma Na concentration with drinking saline water suggested a close positive association between aldosterone and sodium /sodium + potassium ratio in the blood (*Hamdi et al*, 1982). Moreover, under stress of drinking saline water kidneys have to increase their function to keep body homeostasis by increasing urine excretion in animals that more adapted than others (*Sturkie*, 1976). Although there were some changes in biochemical constituents as plasma total proteins, urea, creatinine and sodium concentration, bucks were in a good health condition and they could tolerate saline water that contained salts up to 13100ppm/TDS throughout the study. This tolerance was an adaptation to ingest saline water and is due to physiological changes in kidney function (*Assad et al*, 1994). However, the total water saline load above tolerance level may cause "salt poisoning". Symptoms of salt poisoning are thirst, weakness, diarrhea, dehydration, emaciation, and muscular spasm, which may lead to death. Death in such a case may appear due to a severe upset in the tissue-water balance resulting in the inability of kidneys and intestinal tract to remove excess water from the blood stream (*Ibrahim*, 1999). The study results confirmed those of *Assad et al.* (1989), *Fawzia et al,* (1997) and *Abdel Rahman et al,* (2000). The statistical analysis of the present data showed a significant ($p<0.01$) correlation between both of CRE ($r=-0.88$) and Na ($r=-0.81$) with fiber diameter while the rest of hair characteristics had no significant correlation with studied blood traits. The exposed-saline watered group G4 had a higher fiber diameter (74.38µm) Fig. (1). This result means that FD may reduce the exceeded rise in plasma CRE and Na concentrations under stress of salinity and in turn modify kidney function. Fiber diameter might be indicate the important role of coat fibre quality on the welfare of animal during summer (*El-Ganaieny et al*, 1998). A higher degree of medullated fibers that associated with fiber diameter in summer coat would helps animals to be more heat tolerant (*Schleger and Turner*, 1960 and *Abdel-Ghany*, 1994). Regardless of saline water effect, the exposure to solar radiation caused a significant ($p<0.05$) increase in plasma UR, CRE and Na concentrations of the exposed-tap watered group G3; 19.78±0.174mg/dl, 1.21±0.026mg/dl and 151.46±1.088meq/l, respectively, compared with the corresponding values of the shaded-tap watered group G1;18.52±0.159mg/dl,1.07±0.033mg/dl and 140.97±1.027meq/l, respectively, Fig.(3). These differences were significant ($p<0.01$). These finding indicated that drinking diluted seawater up to 13100 ppm/TDS enhanced some biochemical changes as in plasma total proteins and kidney function than that of the effect of exposure to solar radiation. *Srikandakumar et al*, (2003) reported that exposure to solar radiation (dry bulb temperature of 35.6-43.9°C and relative humidity 95-35% during the hotter month of July in Oman) caused a significant ($p<0.01$) increase in both plasma creatinine and blood urea nitrogen in Omani sheep. The exposed-tap watered group G3 recorded a higher staple length (STL); 13.38±1.342cm than the shaded-tap watered group G1; 9.27 ±1.225cm (Fig 1). Although the correlation between the studied blood constituents and STL was not significant, previous studies ensured that STL is one of the important coat characteristics which protects animals exposed to the sun via decreasing heat gain. For instance, *Acherya et al* (1995) concluded that long haired goats tolerate radiant heat better that short haired goats. Moreover, *Schmidit –Nielsen* (1979) reported that sheep with fleece of 4cm thick sustained temperature gradient of 45°c between the tip and skin, and fleeces longer than 2cm produce a useful insulation. It was also proved by (*Macfarlane et al*, 1958) that fleece helps in protecting animals from radiant energy when it was more than 3cm.

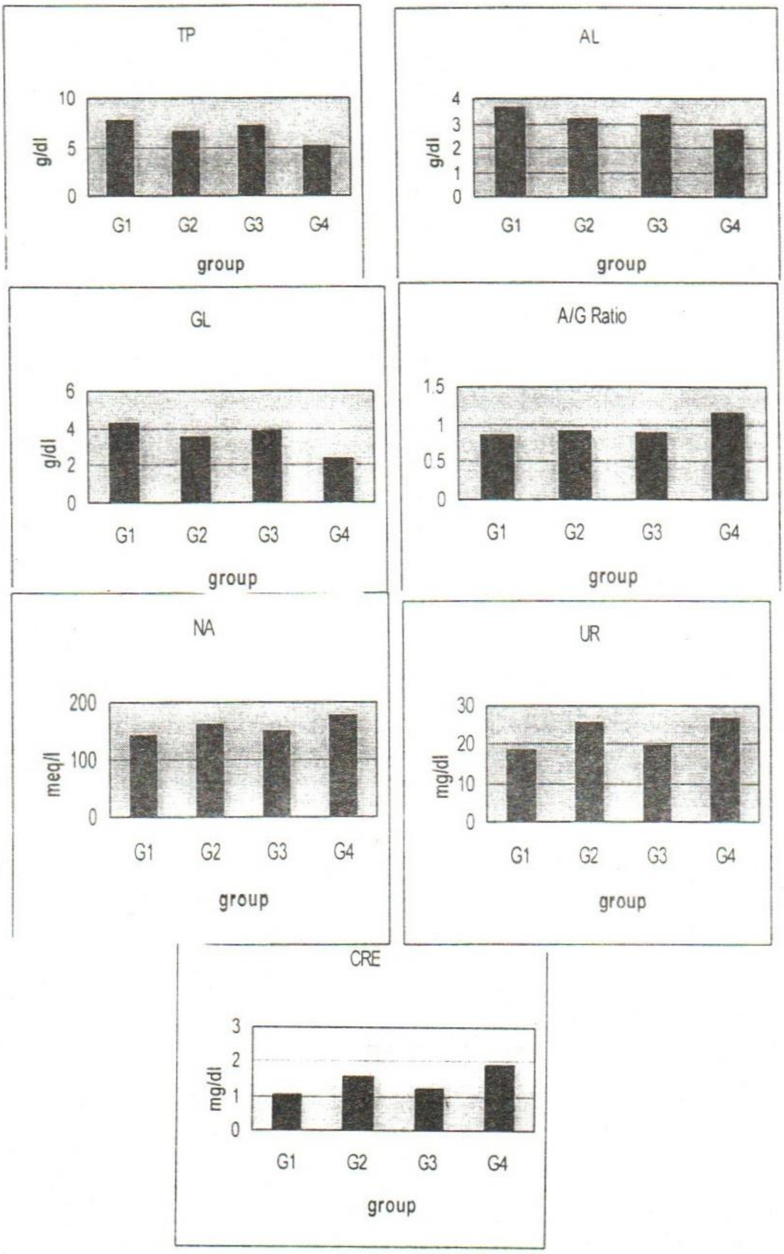

Fig. (3) Plasma total protein (TP). albumin (Al). globulin (Gl). A/G ratio. sodium (Na). urea (UR) and creatinine (CRE) concentrations of the different experimental groups of Baladi bucks

CONCLUSION

Although the present study on Baladi goats recorded some changes in body weight, blood constituents and kidney function under stress of both solar radiation and drinking diluted seawater up to 13100 ppm/TDS, animals still alive without any serious effect which means that Egyptian Baladi goats have a high ability to withstand the severe environmental conditions in desert. In addition, fibre diameter could play a major role for protecting goats under water salinity stress whereas, staple length could provide animals with a good insulation under heat stress.

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دور غطاء الشعر فى مقاومة ملوحة المياه والإجهاد الحرارى فى الماعز

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مركز بحوث الصحراء- شعبة الإنتاج الحيوانى والدواجن- قسم إنتاج وتكنولوجيا الصوف

أجريت التجربة بمحطة بحوث مريوط التابعة لمركز بحوث الصحراء والتى تبعد عن محافظة الإسكندرية ٣٥ كم لدراسة دور بعض صفات غطاء الشعر فى الماعز البلدى المعرضة للإشعاع الشمسى وشرب الماء المالح على بعض صفات التأقلم الفسيولوجية. امتدت التجربة من أول يوليو وحتى منتصف سبتمبر ٢٠٠٠م. قسم عدد ٢٠ تيس بلدى ناضج إلى 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، النسب المئوية للألياف ذات النخاع كما تم تقدير تركيزات كلا من البروتين الكلى والالبيومين والجلوبيولين ونسبة الالبيومين الى الجلوبيولين و الصوديوم واليوريا والكرياتينين فى بلازما الدم.

أوضحت النتائج أن كلا من شرب الماء المالح والتعرض لأشعة الشمس المباشرة قد سببا نقصا معنويا فى وزن الجسم فى كل مجموعات الدراسة. كانت المجموعة المظللة التى تشرب ماء مالحا أكثر المجموعات انخفاضا فى وزن الجسم (٤،٠٣ كجم) بينما كانت المجموعة المقارنة أقل مجموعات التجربة انخفاضا فى وزن الجسم (٠،٩ كجم). سجلت تركيزات البروتين الكلى والالبيومين والجلوبيولين انخفاضا معنويا كاستجابة لشرب الماء المالح وكذلك التعريض لأشعة الشمس، بينما ارتفعت نسبة الالبيومين الى الجلوبيولين و الصوديوم واليوريا والكرياتينين فى بلازما الدم ارتفاعا معنويا. أوضحت النتائج وجود ارتباطا معنويا بين كلا من الكرياتينين و الصوديوم مع قطر الليفة بينما لم تظهر النتائج ارتباطا معنويا بين كل من صفات الدم المدروسة وطول الخصلة. من ناحية اخرى كان لطول الخصلة والنسب المئوية للألياف ذات النخاع دورا هاما فى تقليل انخفاض وزن الجسم الناتج من تعرض الماعز لأشعة الشمس المباشرة.