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Effect of Exposure to Solar Radiation on Some Physiological and Hematological Parameters in Local and Crossbred Sheep

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A TOTAL of 34 ewes from Ossimi (O), Rahmani (R), 3/4 (O) + 1/4 Finish Landrace (F), 3/4 (R) + 1/4 (F) and 3/4 Barki (B) + 1/4 (F) were provided for this study. Half of the ewes in each group was given water ad libitum, while the other half was deprived of water for 96 hr. All ewes were exposed to solar radiation for 12 hr in summer. Measurements of respiration rate (RR), rectal (Tre) and skin temperatures (Tsk) were taken at 3 hr intervals, while plasma total protein (TP), albumin (AL), globulin (GL), hemoglobin (Hb), packed cell volume (PCV) and body weight (BW) were recorded at 6 hr intervals.

The prolonged exposure to solar radiation for 12 hr increased the loss in BW and increased PCV. Dehydrated ewes, when exposed to solar radiation for 9 hr increased Tre, Tsk and RR. An increase in TP or GL was observed after 9 hr post exposure. Periods of exposure to solar radiation appeared to be of greater effect than the dehydration on most of the studied traits.

Key words : Sheep, Solar radiation, Physiology, Hematology.

Sheep are domestic animals which have the ability to survive in a wide range of environmental conditions ranging from the hot dry or humid to severe cold climates. As ambient temperature increases, the body is able to adjust heat flow to prevent more than a slight or moderate rise in body temperature. Panting is the most important mechanism for heat loss in the sheep (Khalil, 1980 ; Shoukry, 1981 and Khalifa, 1982). During grazing in the open area or in desert, the sheep may be exposed to solar radiation, dehydration, exercise, starvation and changes in ambient temperature.

The present study was performed to deal with the exposure to solar radiation as one of the main constraints. Investigating the response of some physiological and hematological parameters to the exposure to solar radiation would be of great importance. The interaction of dehydration and exposure to solar radiation would also be of interest.

Material and Methods

The present study included 34 ewes located at Moustorod Experiment Station, Faculty of Agriculture, Al-Azhar University, Cairo. The ewes were Ossimi (O), Rahmani (R) as local breeds, as well as 3 crossbreds having 1/4 Finnish Landrace blood along with 3/4 (O), 3/4 (R) and 3/4 Barki (B). The number of the ewes taken from these five groups were 8, 8, 6, 6 and 6, respectively. The ewes were 2 - 2.5 years old. Three months before running the experiment, the ewes were shorn to avoid the effect of wool coat on the studied parameters. Feed requirements were given according to Morrison (1959).

Ewes of each group were divided randomly into two subgroups ; one was given water Ad libitum, (control) while the other was deprived of water (dehydrated) for 96 hr. The trial was performed during summer (July 1984) when both control and dehydrated ewes were exposed to direct solar radiation for 12 hr, from 7.00 a.m. to 19.00 pm. Respiration rate (RR), rectal temperature (Tre) and skin temperature (Tsk) were recorded before exposure and at 3 hr. intervals thereafter. However, body weight (BW) was measured and blood samples were collected before exposure and every 6 hr thereafter. Plasma were immediately separated and kept frozen at —20°C for further analyses. Hemoglobin concentration (Hb) was measured as described by Bauer (1970-a) and Packed cell volume (PCV) by the method of Bauer (1970-b). Total plasma proteins (TP) were determined by the Biuret method (Armstrong and Carr, 1964). Albumin (AL) was measured as a result of the reaction with bromocresol green at pH 4.2 (Doumas *et al.*, 1971). Globulin (GL) was calculated by difference of AL from TP, and A/G ratio was obtained by calculation. Rectal temperature (Tre) and skin temperature (Tsk) were measured using a Yellow Spring Telethermometer and RR was done by counting flank movement. Micrometeorological data were

collected at the site of the experiment at 7.00 am., 10.00, 13.00, 16.00 and 19.00. p.m. Ambient temperature (Ta) was 24.7°C, 28.0°C, 34.2°C, 36.6°C and 33.0°C, respectively. The corresponding values for soil temperature (Tsc were 28.0°C, 29.7°C, 38.7°C, 39.5°C and 37.4°C, respectively. Solar radiation temperature as indicated by the black body temperature (Tbb) were 44.0°C, 50.8°C and 48.8°C at 10.00 a.m., 13.00 and 16.00 pm., respectively.

Analyses of variance of multifactor experiments having repeated measures on the same animal were conducted in each season according to Winer (1971).

Results and Discussion

Body Weight

Body weight loss increased significantly ($p < 0.01$) with prolonged exposure to solar radiation in both dehydrated and control groups (Fig. 1). Hafez (1968) attributed the loss of body weight during exposure to solar radiation to the increase in energy expended for heat dissipation through respiratory evaporation and subsequently to the reduction in the amount of water available for storage.

Temperature Patterns and Respiration Rate

As the animals were exposed to solar radiation, Tre, Tsk and RR increased significantly ($p < 0.01$) ; the rate of increase being higher in water deprived ewes (Fig. 2). This result may be explained by the fact that water deprived animals are not capable for increasing heat loss as the normal (El-Sherbiny *et al.*, 1983 and Khalil *et al.*, 1985). As the exposure to solar radiation increased to 9 hr, Tre tended to increase in the control group by 5.2% and 1.5% for locals and crossbreds, respectively. The corresponding values in the water deprived groups were 6.0% and 1.3%, respectively. After 12 hr of the exposure, Tre tended to decrease, the rate of decrease being much higher for locals in both control (3.8% versus 0.3%) and water deprived groups (4.5% versus 0.4%). Water deprived ewes showed significantly ($p < 0.05$) higher Tre compared with the control one after 9 hr (40.5 ± 0.2°C versus 40.0 ± 0.1°C) and 12 hr of the exposure (39.9 ± 0.3°C versus 39.4 ± 0.2°C) as shown in Fig. (2).

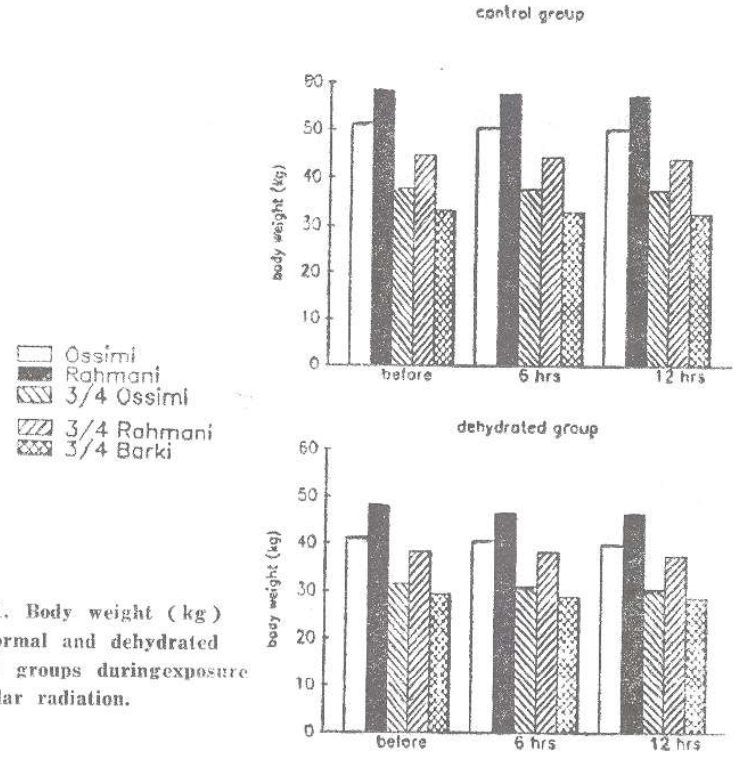
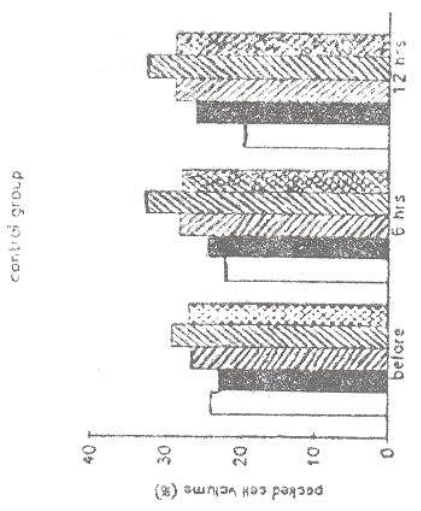
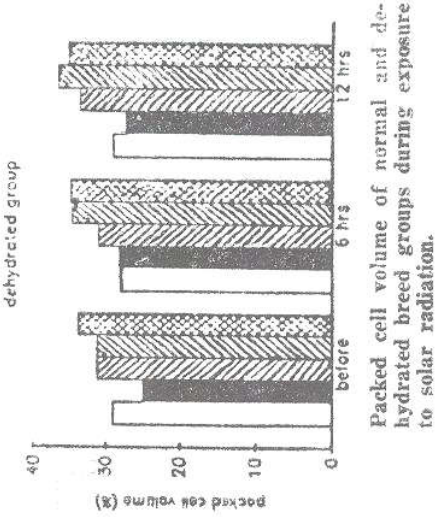


Fig. 1. Body weight (kg) of normal and dehydrated breed groups duringexposure to solar radiation.

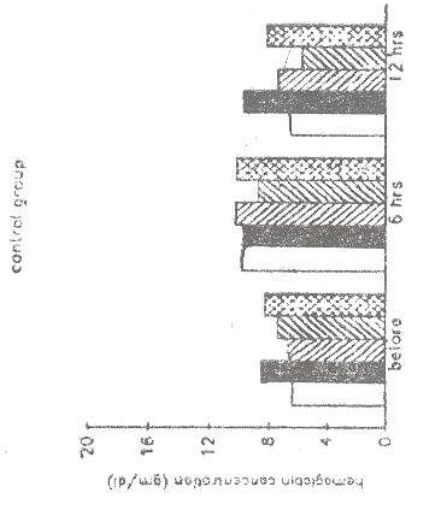
The maximum shift in Tre was wider in local breeds (2.0°C) than crossbreds (0.8°C). Macfarlane (1968) reported that tropical and subtropical sheep may be less thermostable and the diurnal changes in body temperature may occur within a wider range as compared to temperate breeds.

Skin temperature of the water deprived ewes was found to be significantly ($p < 0.05$) higher than the control ones after 9 hr (43.4 ± 0.5°C versus 42.5 ± 0.6°C) and 12 hr of the exposure to solar radiation (39.5 ± 0.4°C versus 38.5 ± 0.4°C). Fig. (2) reveals that prolonged exposure to solar radiation for 9 hr increased Tsk in local breeds, compared with crossbreds in the control (17.5% versus 9.5%) and water deprived groups (15.9% versus 11.1%). However, after 12 hr of exposure, Tsk tended to decrease. The rate of decrease was much higher for local breeds in both control (4.8% versus 0.7%) and water deprived groups (8.4% versus 0.8%).





Packed cell volume of normal and dehydrated breed groups during exposure to solar radiation.



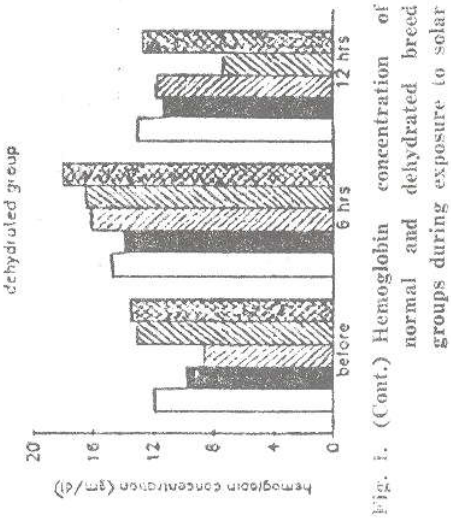


Fig. 1. (Cont.) Hemoglobin concentration of normal and dehydrated breed groups during exposure to solar radiation.

Respiration rate was significantly ($p < 0.05$) higher in the water deprived sheep compared with the control after 9 hr of exposure. The data of local breeds indicates lower RR than crossbreds in both control (117.5 $\pm$ 8.8 r.p.m. versus 181 $\pm$ 6.4 r.p.m) and water deprived groups (210 $\pm$ 16.4 rpm versus 233.1 $\pm$ 12.8 rpm). Fig. (2) indicates that RR tended to increase as the exposure to solar radiation increased up to 9 hr after which RR decreased. The exposed sheep tended to increase their RR in order to increase their heat loss. It seems that the rapid panting which was observed early after the exposure might be as efficient as the slow panting noticed at later periods of exposure. Mount (1979) revealed that early after exposure the panting may be of shallow type while it may be slower and deeper later in exposure.

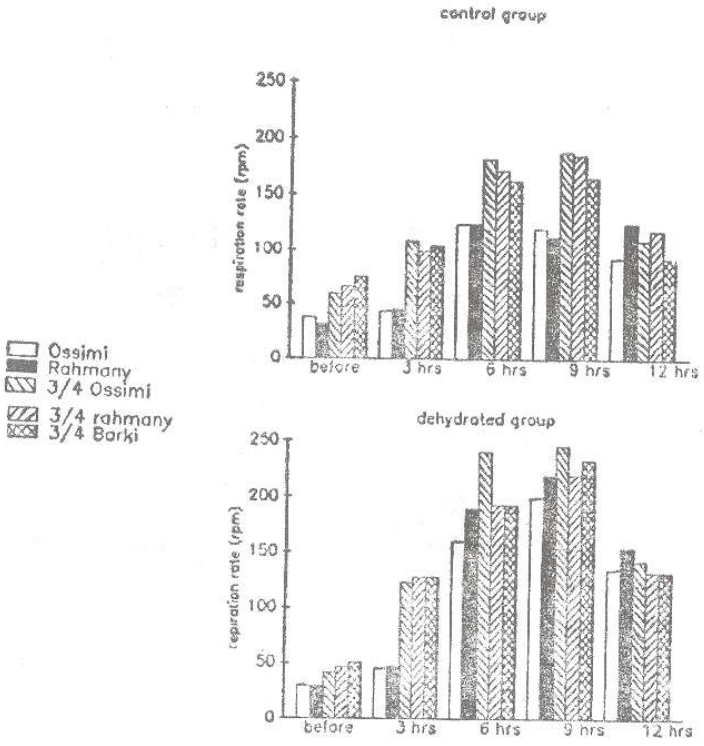


Fig. 2. Respiration rate of normal and dehydrated breed groups during exposure to solar radiation.

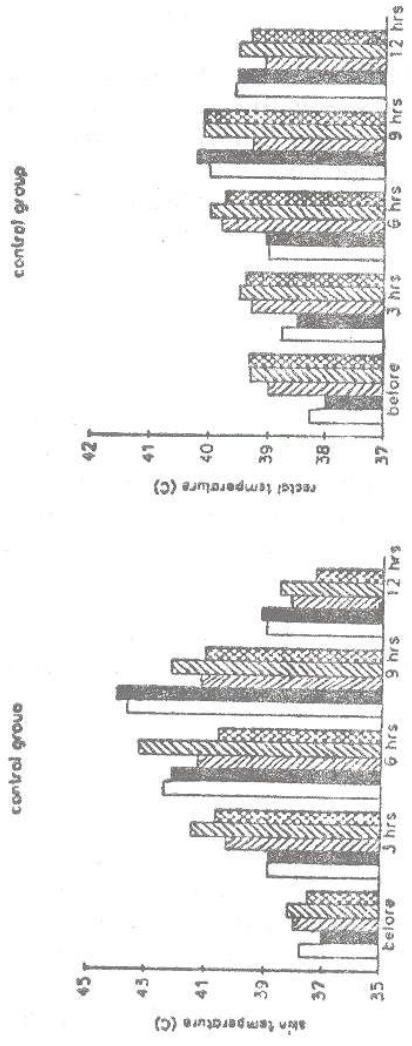
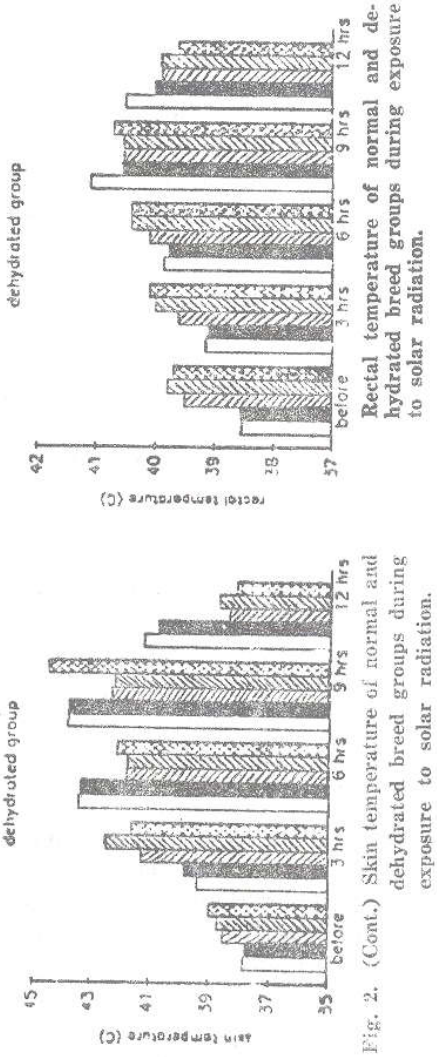


Fig. 2. (Cont.) Skin temperature of normal and dehydrated breed groups during exposure to solar radiation.



Rectal temperature of normal and dehydrated breed groups during exposure to solar radiation.

Shoukry (1981) found that Egyptian local breeds had lower RR compared with crossbreds when exposed to solar radiation for 2.5 hr. He also proposed that breed differences in Tre and RR may indicate differences in heat acclimatization among breed groups. Macfarlane *et al.* (1957) revealed that RR of the adapted sheep in subtropical areas were lower than that of the foreign breeds. When these animals were exposed to solar radiation, the foreign breeds indicated more increase in RR compared with the adapted ones. Khalil (1980) and Khalifa (1982) suggested that, local breeds might attain higher body temperature during exposure to heat to reduce the difference between body temperature and Ta which might be a means to conserve water by decreasing the need for evaporative cooling.

A significant increase in Tre, Tsk and RR was observed when the Egyptian fat-tailed sheep were exposed to solar radiation up to 8 hr (Khalil, 1980 ; and Shoukry, 1981). As the environmental temperature increase the stressed animal may increasingly require high amount of water to compensate for evaporative water expenditure (Bailey *et al.*, 1962). Hence, Khalil (1980) postulated that, the increase in sheep body temperature will reduce the difference between body and ambient temperatures which reduces water utilization for evaporative cooling.

It may be concluded that, the duration of exposure to solar radiation seems to have more effect on most studied traits rather than the effect of dehydration alone.

Blood and Plasma Components

Hemoglobin (Hb) and PCV tended to increase significantly ($p < 0.01$) as the exposure to solar radiation increased up to 6 hr. Between 6 and 12 hr of exposure, PCV continued to increase while Hb declined Fig. (1). This trend might suggest the ability of the animals to form new cells in order to maintain the PCV as replacement for the damaged red blood corpuscles caused by exposure to heat stress. These newly-formed cells are immature and contain low Hb (Bass and Henschel, 1956 ; and Whittow, 1968). The addition of red cells to the circulating blood from reservoirs occurs during exceptional circumstances such as hyperthermia. It

was also suggested that the changes in the rate of production of blood cellular component may have a role in the regulation of blood volume (Whittow, 1968).

Water deprived ewes had higher Hb compared with control ones after 6 hr (15.9 ± 1.10 gm./dl versus 9.8 ± 0.88 gm./dl) and 12 hr of exposure to solar radiation (11.3 ± 0.74 gm./dl versus 7.5 ± 0.86 gm./dl). The same trend was found in PCV % after 6 hr (31.8 ± 1.06% versus 27.6 ± 0.94%) and 12 hr of exposure (33.8 ± 1.22% versus 29.0 ± 1.22%). However, crossbreds of the water deprived group had higher Hb value after 6 hr (17.0 ± 1.10 gm./dl versus 14.4 ± 0.88 gm./dl) and lower value after 12 hr of the exposure to solar radiation (10.7 ± 0.74 gm./dl versus 12.3 ± 0.86 gm./dl). Meanwhile, crossbreds of the water deprived group had higher PCV % than locals after 6 hr (33.6 ± 1.1% versus 29.7 ± 1.00%) and 12 hr of exposure to solar radiation (35.2 ± 1.00% versus 30.2 ± 1.55%). As a result, the effect of exposure to solar radiation was more pronounced in the crossbreds than in the local.

The increase in PCV % may suggest the suffering of these animals when exposed to solar radiation for 12 hr. Higher PCV % was found in the thermal stressed animals (Roman *et al.*, 1978). It is also known that more erythrocytes are needed at higher Ta in order to increase the oxygen required for increased respiration.

The present data indicated that higher Ta with water deprivation increased Hb content and PCV % in the water deprived sheep. This trend was supported by earlier work in sheep (Khalifa, 1982).

Figure (3) suggests that the increase in plasma total proteins might be due mainly to the increase in GL while A/G ratio followed the same trend of AL concentration. As the exposure to solar radiation increased to 6 hrs., water deprived ewes increased significantly ($p < 0.05$) their TP (9.0 ± 0.34 gm./dl versus 7.5 ± 0.30 gm./dl), GL (7.3 ± 0.40 gm./dl versus 5.7 ± 0.34 gm./dl) and decreased their A/G ratio (0.29 ± 0.06 versus 0.4 ± 0.04) compared with the control group. The same trend was also found after 12 hr of the exposure for TP (9.7 ± 0.28 gm./dl versus 7.1 ± 0.14 gm./dl), GL (7.9 ± 0.32 gm./dl versus 5.1 ± 0.21 gm./

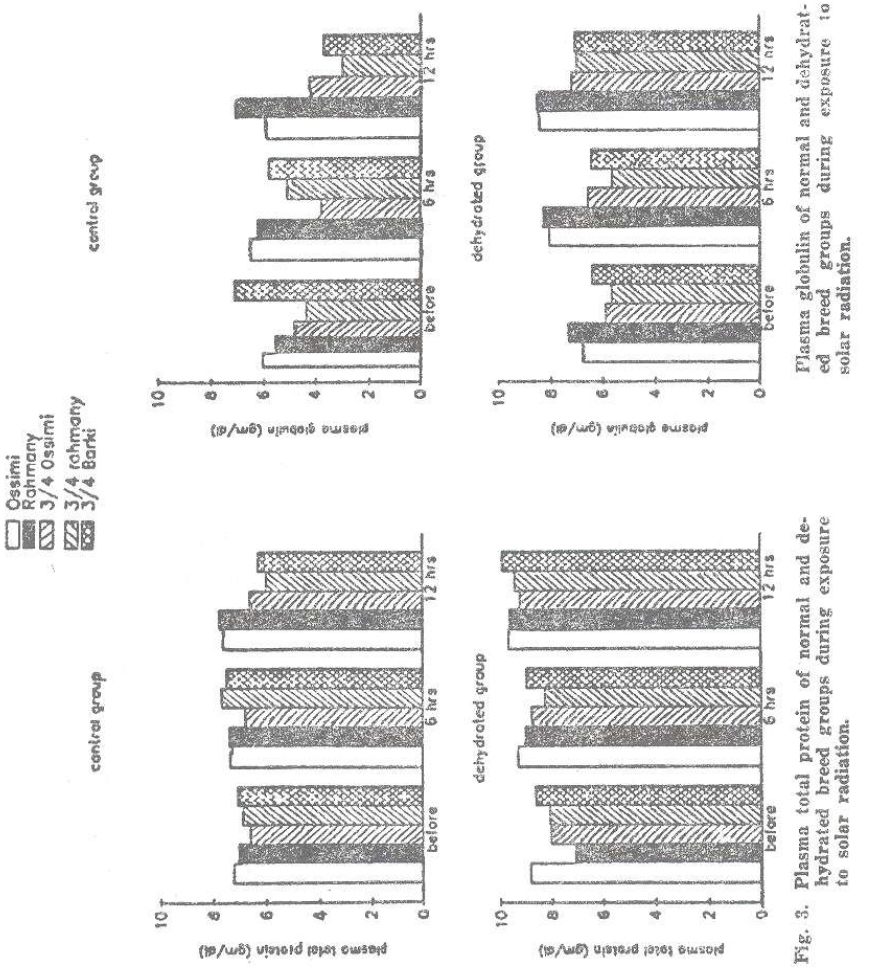


Fig. 3. Plasma total protein of normal and dehydrated breed groups during exposure to solar radiation.

Plasma globulin of normal and dehydrated breed groups during exposure to solar radiation.

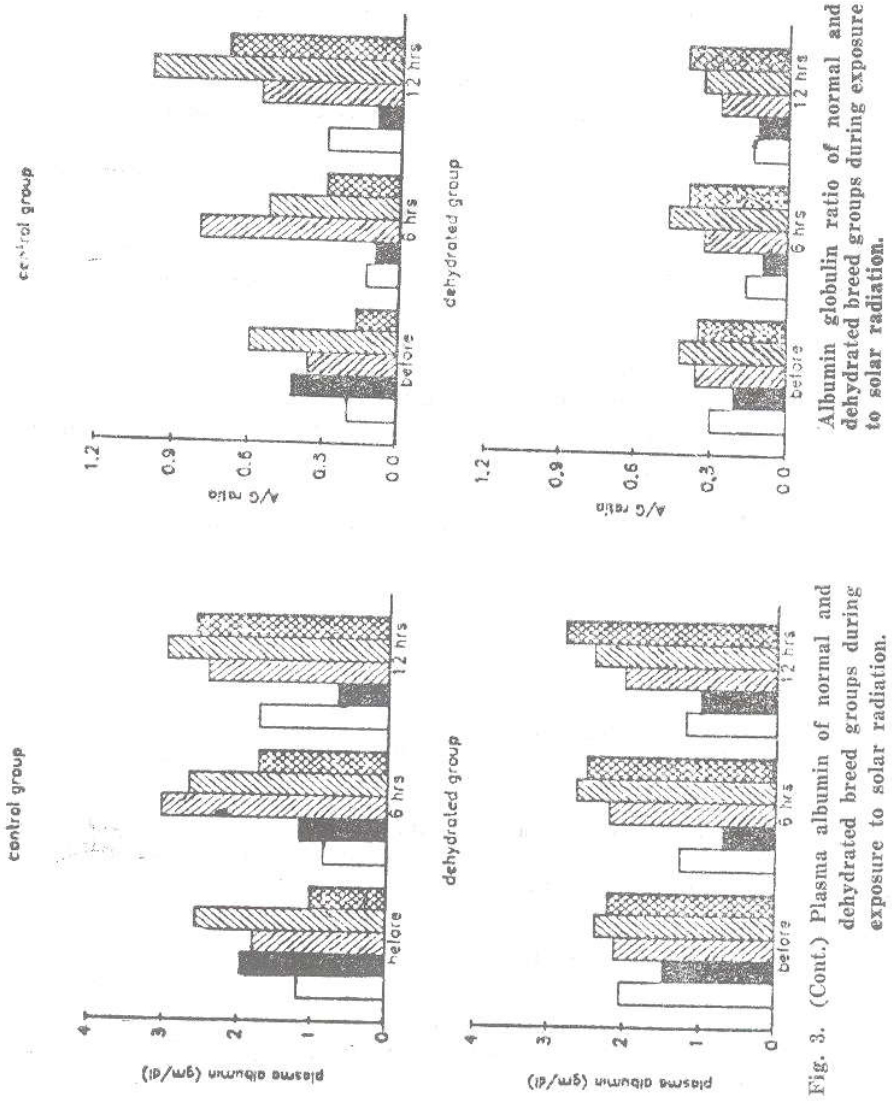


Fig. 3. (Cont.) Plasma albumin of normal and dehydrated breed groups during exposure to solar radiation.

Albumin globulin ratio of normal and dehydrated breed groups during exposure to solar radiation.

dl), AL (1.7 ± 0.26 gm./dl versus 2.0 ± 0.15 gm./dl) as well as A/G (0.26 ± 0.04 versus 0.55 ± 0.05). In other words the percent changes after 12 hr of exposure to solar radiation were increased by 13.1% for TP and 19.8% for GL, while AL and A/G ratio decreased by 10.1% and 25.0%, respectively in the water deprived ewes. As the exposure to solar radiation increased to 12 hrs., local breeds of the water deprived groups showed higher GL (8.6 ± 0.40 gm./dl versus 7.1 ± 0.40 gm./dl) and lower AL (1.1 ± 0.20 gm./dl versus 2.4 ± 0.30 gm./dl) and A/G ratio (0.14 ± 0.07 versus 0.34 ± 0.02) compared with their crossbreds counterparts. TP was found to be nearly the same for local and crossbred groups (9.7 ± 0.45 gm./dl versus 9.6 ± 0.27 gm./dl).

There was an indication that plasma TP and GL tended to increase by exposure to solar radiation. Most of the increase in plasma TP appeared to happen mainly via an increase in the plasma GL. However, the increase might occur through mobilization of proteins from the lymphatics.

Similar findings were reported by Bass and Henschel (1956) and Shoukry (1981).

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أثر التعريض لاشعة الشمس وعلاقته ببعض مكونات الدم والقياسات الفسيولوجية فى بعض الاغنام المحلية والخليطة

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استخدمت فى هذه الدراسة ٣٤ نعجة من خمس سلالات (اوسيمى – رحمانى – ٣/٤ أوسيمى + ١/٤ فينش لاندريس – ٣/٤ رحمانى + ١/٤ فينش لاندريس – ٣/٤ برقى + ١/٤ فينش لاندريس) قسمت النعاج المماثلة لكل سلاله الى نصفين – ترك النصف الاول ليأخذ حاجته الطبيعية من الماء والغذاء بينما تم تعطيش النصف الاخر لمدة ٩٦ ساعة – ثم عرضت كل النعاج لحرارة الاشعاع الشمسى لمدة ١٢ ساعة خلال الصيف . تم قياس معدل التنفس ودرجة حرارة كلا من الجلد والمستقيم كل ٣ ساعات بينما تم تقدير تركيزات البروتين الكلية – الالبيومين الجلوبيولين – الهيموجلوبين – الهيماتوكريت (نسبة حجم كرات الدم) كما تم حساب نسبة الالبيومين الى الجلوبيولين وكذلك تم وزن الجسم كل ٦ ساعات .

اوضحت النتائج ان تعريض الاغنام لحرارة الاشعاع الشمسى لمدة ١٢ ساعة يزيد من النقص فى وزن الجسم وكذلك ادى الى زيادة الهيماتوكريت (نسبة حجم كرات الدم) .

عندما تعرضت النعاج المعطشة للاشعاع الشمسى لمدة ٩ ساعات لوحظ ارتفاع حرارة كلا من الجلد والمستقيم وكذلك معدل التنفس ومن جهة اخرى فقد زادت البروتينات الكلية والجلوبيولين بعد ١٢ ساعة من التعريض للاشعاع الشمسى .

مدة التعريض لحرارة الاشعاع الشمسى كان لها تأثير اوضح من تأثير التعطيش على معظم الصفات المدروسة .