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Physiological Adaptation of Sheep to Sahara Desert

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CHANGES in respiration rate (RR), pulse rate (PR) and rectal temperature (RT) as a function of 4 hr exposure to heat accompanied with solar radiation and thirst were observed in 14 shorn and 15 non-shorn female Barky lambs.

Immediately before exposure, RR, PR and RT were not significantly different in both groups of animals. Exposure caused a significant increase in RR and a non-significant increase in RT above the pre-exposure levels in both groups. PR was significantly decreased. RR and RT were significantly higher in the shorn than in the non-shorn animals but PR was not significantly different in the two groups.

The data suggest that the evaporative cooling provided by the increase in RR was sufficient to prevent a significant increase in RT of the shorn and non-shorn lambs. The decrease in PR suggests a post-exposure depression of heat production and indicates a mid-summer heat-acclimatization of these animals. The data also indicate the beneficial effects of wool coat for heat balance under the heat stress of desert conditions.

Sheep and large mammals that live in the desert are frequently subjected to intense solar radiation that can be transferred to the animal as infrared heat. The heat stress imposed on the animals by the high solar load and high ambient temperature is such that considerable heat dissipation is required to maintain a thermal balance (Lee, 1972). This dissipation can be achieved by evaporation from the respiratory tract (panting) and by skin evaporation (sweating). In sheep, panting seems to play a more important part in general heat regulation than sweating (Hutchinson and Wodzicka-Tomaszewska, 1961).

Effects of heat accompanied with solar radiation and thirst on rectal temperatures and cardiorespiratory activities

The present experiments were designed to study some physiological responses of sheep to hot arid environments. The physiological responses measured were respiration rate (RR), pulse rate (PR) and rectal temperature (RT). RR was measured by counting flank movements, PR was measured by a clinical stethoscope and RT by a clinical thermometer.

All these parameters were recorded under shed (at 10.00 a.m.) just before the exposure of animals to direct sunlight. This was followed by immediate exposure of the animals and measurements of these parameters at hourly intervals (from 10.00 a.m. to 2.00 p.m.). The micro-meteorological data were also recorded at these intervals. These experiments were carried out during the summer, and animals were deprived of food and water during the time of exposure.

Results and Discussion

An experiment on shorn and non-shorn animals was carried out on July 1*st* and was repeated on July 9*th*. The mean values of both experiments for RR, PR and RT are presented in Table 1. The pooled results are presented in Fig. 1. At each exposure interval, the level of significance between the mean values of each parameter in the two groups of animals are plotted on the figure. It can be noted that there were no significant differences between the shorn and non-shorn animals in RR, PR and RT during the period of pre-exposure (Fig. 1). This observation was consistent in both experiments (Table 1).

Respiration rate (RR)

Following exposure, RR in both groups of animals increased with the progress of time to reach its maximum activity after 2 hr. This was followed by a decrease at 3 hr, and levelled off at the 4*th* hour. (Table 1 and Fig. 1). Using Duncan's multiple range "t" test, it was shown that, in the shorn animals, the increase in RR above the pre-exposure level was significant ($P < .05$) at any period of exposure. In the non-shorn animals, this increase was significant only at 2 hr post-exposure.

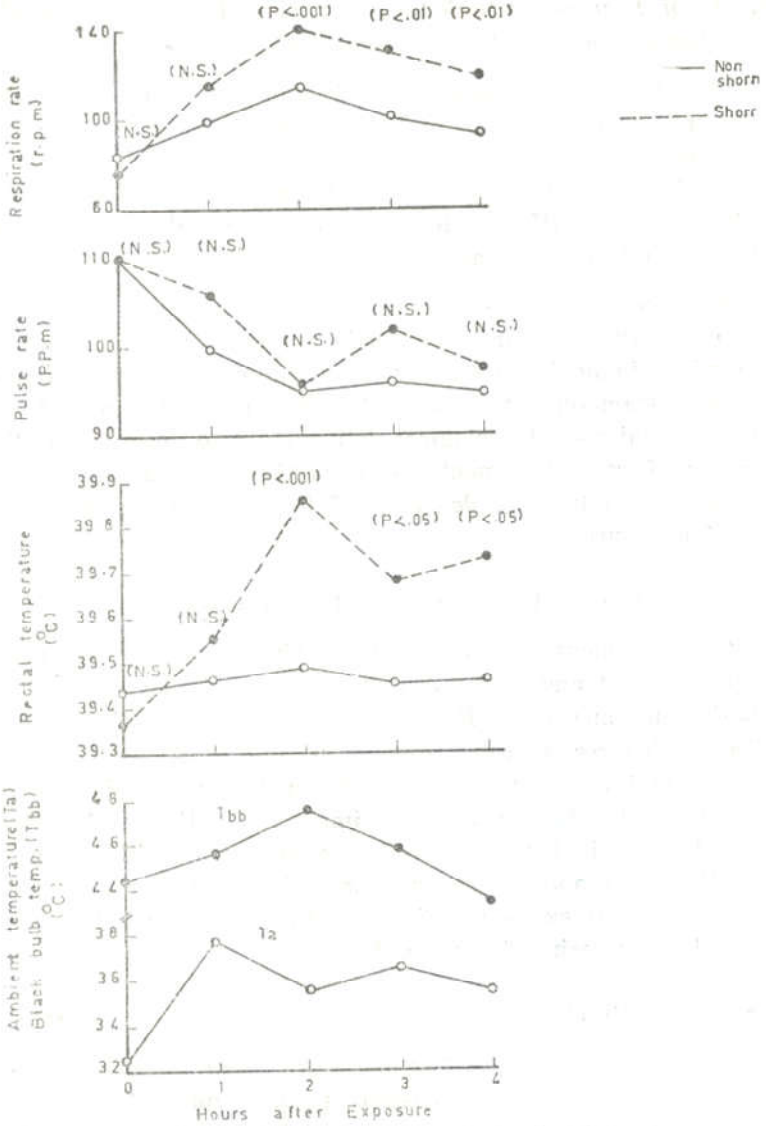

Fig. 1 Effect of heat accompanied with solar radiation and thirst on rectal temperature and cardiorespiratory activities of female lambs

TABLE 1. Effect of heat accompanied with solar radiation and thirst on rectal temperature and cardiorespiratory activities of female lambs.

Hours of exposure	Experiment (1)			Experiment (2)		
	Non-Shorn	Shorn	P	Non-Shorn	Shorn	P
1. Respiration rate:						
Before exposure	92.7 ± 7.0	81.1 ± 8.4	NS	73.3 ± 6.8	70.4 ± 6.8	NS
1 hour	106.9 ± 6.5	107.0 ± 6.5	NS	91.2 ± 8.3	122.4 ± 8.9	<.05
2 hours	119.6 ± 6.1	130.1 ± 4.8	NS	107.8 ± 6.3	148.9 ± 6.0	<.001
3 hours	102.5 ± 7.6	121.7 ± 8.0	NS	97.8 ± 9.0	138.1 ± 3.9	<.01
4 hours	100.8 ± 7.7	113.7 ± 5.3	NS	86.7 ± 9.2	122.3 ± 7.9	<.01
2. Pulse rate:						
Before exposure	118.0 ± 4.4	109.9 ± 3.8	NS	99.7 ± 4.8	107.4 ± 5.9	NS
1 hour	103.1 ± 2.8	110.9 ± 3.9	NS	95.7 ± 4.5	99.7 ± 3.0	NS
2 hours	101.7 ± 3.7	101.3 ± 3.4	NS	87.9 ± 2.9	89.3 ± 2.6	NS
3 hours	100.4 ± 2.3	104.4 ± 3.3	NS	91.9 ± 2.8	99.1 ± 3.0	NS
4 hours	102.4 ± 2.9	107.3 ± 2.5	NS	87.3 ± 2.1	87.7 ± 2.3	NS
3. Rectal temperature:						
Before exposure	39.58 ± 0.06	39.61 ± 0.05	NS	39.28 ± 0.06	39.10 ± 0.06	NS
1 hour	39.58 ± 0.07	39.75 ± 0.06	NS	39.27 ± 0.07	39.34 ± 0.01	NS
2 hours	39.58 ± 0.07	40.06 ± 0.07	<.001	39.40 ± 0.10	39.66 ± 0.08	NS
3 hours	39.47 ± 0.08	39.94 ± 0.11	<.01	39.42 ± 0.06	39.41 ± 0.09	NS
4 hours	39.44 ± 0.08	39.80 ± 0.12	<.05	39.49 ± 0.08	39.65 ± 0.07	NS

The shorn animals manifested higher RR than the non-shorn at any exposure interval. In the first experiment, this increase was not statistically significant. In the second experiment, a significant increase was obtained at all exposure intervals (Table 1). The pooled results showed a significant increase in RR of shorn animals than that of the non-shorn at 2, 3 and 4 hr after exposure. At 2 hr of exposure (maximum increase in RR), the increase above pre-exposure levels were 37% and 86% in the non-short and shorn lambs, respectively (Fig. 1).

Pulse rate (PR)

Following exposure, the PR of the shorn animals was consistently higher than that of the non-shorn. However, these differences in PR between the two groups of animals were not statistically significant (Table 1 and Fig. 1).

There was a considerable decrease in PR in the two groups of animals after exposure, reaching its lowest levels in 2 hr (Table 1 and Fig. 1). In the non-shorn animals, the decrease below the pre-exposure level was significant ($P < .05$) at any period of exposure. In the shorn animals, this decrease was significant only at 2 and 4 hr post-exposure.

Rectal temperature (RT)

Following exposure, both groups of animals manifested a gradual increase in RT, reaching its peak in about 2 hr (Fig. 1). The maximum increases above the pre-exposure levels were 0.17 and 0.07° in the shorn and non-shorn lambs, respectively. Although in either group this increase was not significant, the increase was more pronounced in the case of the shorn animals. Thus, at 2, 3 and 4 hr post-exposure, the shorn animals showed significantly higher RT than those of the non-shorn (Fig. 1).

The above results show that RT and cardiorespiratory functions are influenced by thirst and environmental heat load of solar radiation. Thus at 350 and above (Table 2), all the measured physiological parameters had changed (Fig. 1).

TABLE 2. Micro-meteorological data recorded during the period of experimentation.

	Exp. (1)	Exp. (2)	Average
1 Ambient temperatures, Ta (°):			
Before exposure	34.0	31.0	32.5
1 hour exposure	38.5	37.5	37.75
2 hours exposure	35.0	36.0	35.5
3 hours exposure	36.0	37.0	36.5
4 hours exposure	35.5	-	35.5
2 Black-bulb temperatures, Tbb (°):			
Before exposure	44.17	44.44	44.31
1 hour exposure	44.44	46.93	45.69
2 hours exposure	47.22	47.78	47.50
3 hours exposure	45.56	46.11	45.84
4 hours exposure	43.33	-	43.33

In both groups of animals, exposure to solar radiation caused a significant increase in RR and a non-significant increase in RT above the pre-exposure levels. The lack of a significant increase in RT under heat stress indicates that thermal polypnoea represents an adequate mechanism for evaporative cooling in shorn and non-shorn sheep. The increase in RR under these conditions enables the animals to dissipate heat by vaporizing the high moisture content of respired air. But the excessive respiratory activity that occurred in the shorn lambs (Fig. 1) is not always desirable, since the animals may develop respiratory alkalosis as a result of excessive loss of CO_2 and, consequently, loss of blood alkali reserve (Kamal, 1965).

On the other hand, PR was decreased during thirst and exposure to solar radiation (Fig. 1). This condition is known to cause hemo-concentration and an increase in viscosity of blood in many species (Dill *et al.*, 1973), that may lead to an increase in PR to maintain blood circulation. Therefore, the lack of increase in PR in the present experiments on sheep could be related to the maintenance of body fluid levels.

A close correlation between PR heat production has been generally known for a long time (Kibler and Brody, 1949). Exposure of cattle to a hot environment was shown to cause a decrease in PR and a similar decrease in heat production (Yousef

and Johnson, 1966). This is not surprising, considering that the blood pumped by the heart supplies oxygen and nutrients for heat production, and also carries heat from the interior to the surface of the body for dissipation. Thus, in present experiments, it is more likely that the observed post-exposure decrease in PR is an indication of the depression of heat production in these animals. Moreover, the results could indicate that the animals are relatively heat tolerant due to a mid-summer (July) acclimatization (Hutchinson and Wodzicka-Tomaszewska, 1961; Findlay, 1963).

In conclusion, the non-shorn female lambs endured solar radiation and water deprivation better than the shorn animals (Fig. 1). This indicates the beneficial effects of heavy wool coat for heat balance of sheep under hot dry conditions. One reason is that the insulation of the wool protects sheep from the inward passage of the heat of solar radiation (Hutchinson and Wodzicka-Tomaszewska, 1961; Lee, 1972). In addition, wool may play a significant part in heat dissipation; it is hygroscopic and absorbs moisture, both on the surface and within the fibres. In semi-arid conditions, solar radiation may raise the wool tips to a high temperature and the drying out of the wool would aid heat dissipation, roughly equivalent to the latent heat of vaporization (Hutchinson and Wodzicka-Tomaszewska, 1961).

This study adds to our knowledge of the physiological characteristics of Barky sheep, and of their responses to the environmental stress of the Sahara during deprivation of food and water.

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التاقلم الفسيولوجى للاغنام تحت ظروف البيئة الصحراوية

احمد سعيد الشيخ ، ابراهيم عيسى ابراهيم ، محمد حلمى سالم ، على عباس محمد ومحمد خليل يوسف

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اجريت هذه التجارب على مجموعتين من اناث الحملان البرقى (١٤ مجزوزة ، ١٥ غير مجزوزة) وذلك لقياس أثر الحرارة والتعريض لمدة ٤ ساعات لاشعة الشمس بجانب العطش على معدلات التنفس والنبض ودرجة حرارة الجسم . وقد وجد ان :

١ ـ كلا المجموعتين لاتختلف معنويا بالنسبة لهذه القياسات قبل التعريض لاشعة الشمس مباشرة (أى تحت الظل) ..

٢ ـ وجد بعد التعريض زيادة معنوية فى معدلات التنفس وزيادة غير معنوية فى درجة حرارة الجسم . اما معدلات النبض فقد حدث فيها نقص معنوى فى كلتا المجموعتين .

٣ ـ معدلات التنفس ودرجة حرارة الجسم بعد التعريض كانت زائدة زيادة معنوية فى الحيوانات المجزوزة عن الغير مجزوزة . اما معدلات النبض فلم تكن مختلفة معنويا بين المجموعتين وتشير النتائج الى ان التبخير لناتج عن زيادة معدلات التنفس كان كافيا لتبريد الجسم لدرجة منعت اى زيادة معنوية فى درجة حرارة الجسم فى كلا المجموعتين من الحملان ويشير النقص فى معدلات النبض الى نقص فى الانتاج الحرارى لهذه الحيوانات بعد التعريض مما يدل على تاقلم هذهالحيوانات للحرارة الذى يحدث عادة بعد منتصف الصيف . وتشير النتائج كذلك الى الاثار المفيدة للصوف على الاتزان الحرارى للاغنام تحت الظروف الصحراوية الحارة .