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A STUDY ON SOME FACTORS AFFECTING HEAT TOLERANCE
AND PERFORMANCE OF SHEEP

BY

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THESIS

Submitted in Partial Fulfilment of the
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in
Animal Physiology

Faculty of Agriculture,
Ain Shams University

1984

APPROVAL SHEET

Title: A Study on Some Factors Affecting Heat Tolerance
and Performance of Sheep .

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1984



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I. INTRODUCTION

In Egypt, about one million out of a total of 3-million head of sheep are raised under the semi-arid conditions in the Western Desert with special reference to the North Western Coastal area. The fat-tailed Barki sheep are the native breed to this area which is well known to exhibit marked adaptability to the extreme prevailing conditions including heat, drought, water salinity, diseases and poor vegetation. As early as 1958, an attempt was made in the Animal Research Department of the Desert Institute to improve the productivity of Barki sheep through crossbreeding with exotic Hungarian Merino.

Although local ewes have the ability to show oestrus all the year round, mating is usually arranged during June-July and lambing occurs during November-December at the beginning of the grazing season. Thus, lambs are weaned at March-April. As a result, fattening the surplus male lambs occurs during a long hot dry summer season in which the animals are exposed to a high ambient temperature that may reach 45°C at midday. In addition, this period is characterized by shortage of feed supply owing to the limited available natural vegetation. Such harsh environmental conditions are believed to affect adversely the production and reproduction of the sheep raised in the desert. However, previous work in this department concerned with the impact of natural hot conditions and feeding regime on fertility of ewes (Mokhtar et al., 1984) and of young rams (Younis et al., 1984).

The present study was initiated to investigate the effect of some environmental factors, viz., shading, shearing and plane of nutrition as well as the breed type, on heat tolerance and performance of lambs under feedlot.

This study included three experiments over three successive years (1980 - 1982). The work was carried out at Maryout Experimental Station which belongs to the Desert Institute, and located some 30 kilometers southwest of Alexandria.

II. REVIEW OF LITERATURE

A. THERMOREGULATION IN SHEEP

1. Principles and Mechanisms :

Sheep as homeothermic animals, exhibit a considerable body temperature regulation against the acute changes in surrounding ambient temperature (Lee,1950; Johnson,1971 and Degen, 1977). Accordingly, sheep are able to maintain their rectal temperature within normal range of $39.0 \pm 1.5^{\circ}\text{C}$ irrespective of the severe fluctuations in ambient temperature throughout the daytime (Terrill,1968). For the fat-tailed sheep, such range was narrower, i.e., 1°C (Khalifa,1979; Mohamed,1980; Shoukry,1981 and Mokhtar,1982) .

The achievement of thermostability demands that the animal is in a dynamic thermal equilibrium. Heat gain of the animal (metabolic heat plus heat which may be absorbed from the environment) has to be counterbalanced by heat loss (Bianca,1968). Under tolerable heat load, the animal may adjust its heat production in order to facilitate maintaining its thermal balance (Blaxter,1962). Likewise, Degen and Shkolnik (1978) reported that heat production of Awassi sheep was found to be 18% less than values predicted

from metabolic rate equation. This reduction was attributed to the heat stress. Webster(1983), however, stated that sheep belong to the "homeotherms group" which maintain a constant body temperature primarily by regulating heat loss mechanisms with negligible metabolic heat cost except in extreme conditions under which the animals have to alter heat production by changing the metabolizable energy intake.

On the other hand, sheep dissipate heat to the environment via conduction, convection, radiation and evaporation when the ambient temperature is lower than that of the body (Bianca,1968; Bartholomew,1977 and Schmidt-Nielsen,1979). As the ambient temperature increases, the efficiency of the first three channels declines and may become reversed. Then, the animal depends only on the evaporative cooling to keep its body temperature fairly constant. Many workers have indicated that the respiratory tract of sheep is relatively important in water evaporation as compared to the skin(Brook and Short,1960; Alexander and Williams,1962; Brockway et al., 1965;Shafie and Abdelghany,1978 and Schmidt-Nielsen,1979). Shafie and Abdelghany(1978) attributed such phenomenon both to the low efficiency of the apocrine sweat glands and to the heavy wool coat of sheep. Practically,Degen and Shkolink (1978) found that Awassi sheep increased their total evaporative water loss as air temperature increased. At 40°C,

sheep dissipated about 91.8 - 93.4 % of their heat gain by evaporative cooling mechanism. Khalifa (1979) reported a very low sweating rate in Barki sheep. More recently, Webster (1983) showed that although sheep rely little on sweating under the fleece, but can sweat profusely over such temperature-sensitive areas as the scrotum. For the most part, however, they regulate evaporative heat loss by ventilating the very extensive and very vascular mucous membranes covering the turbinate bones in the nose .

For sheep, Bianca(1970) proposed the range of -3 to 20°C as a thermal indifference zone within which the heat balance is to be maintained with minimal chemical or physical adjustment by the animal. Also, Hahn(1976) expected an acceptable average daily temperature of 4 to 24°C for nominal loss in the efficiency of sheep production. Within such relatively wide thermoneutral zone, the metabolic heat production is independent of air temperature. Above the upper critical temperature the animal cannot comfortably sustain homeothermy by evaporative heat loss alone and so has to reduce the heat production (Webster, 1983) .

2. Heat Tolerance Responses in Relation to Adaptability :

It is well recognized that the ability to maintain the normal body temperature under hot conditions, is probably

the most important adaptive feature of sheep (Terrill, 1968). Within the normal range of body temperature, the animal may conserve its physiological functions and, consequently, perform effectively. Accordingly, in heat tolerance tests (based on exposure of the animal to a standard conditions of thermal stress) a shift in core temperature is taken as an indicator for inability to establish thermal equilibrium by the physiological means. Such tests assume that while animals may vary in thermostability mechanisms, the tolerated degree of thermolability is invariable (Johnson, 1971) .

Since some species may alter their body temperature according to changes in the environmental temperature within a wider range without any symptoms of stress, Bligh (1970) suggested a new concept of thermolability as an adaptive response to heat stress. Accordingly, the heat-tolerant animals may be classified into two categories: those which are able to maintain a constant body temperature through the activation of adequate heat loss process, and those which elevate passively their deep body temperature without showing symptoms of heat stress. Theoretically, thermolability allows conservation of energy in cold and famine conditions by avoiding the necessity of increasing heat production, and conservation of water in hot and arid conditions by avoiding the necessity for increasing evaporative heat loss (Schmidt-Nielsen, 1979 and Bligh, 1970). In addition, such passive thermolability

permits to decrease the difference between air and body temperatures which controls the heat exchange between them. Thus, the amount of absorbed heat to the stressed animal becomes of low magnitude. However, Johnson(1971) did not observe such phenomenon among the individuals of sheep and goats studied as an adaptive response to either cold or thermal stress. Though passive lability of body temperature was observed in sheep by Blexter et al.(1959) and Alexander and Williams (1962), it seems that the thermolability mechanism may be confined to certain species such as camel and donkey (Bligh and Harthoorn, 1965 and Bligh et al.,1965) .

B. FACTORS AFFECTING THERMOREGULATION IN SHEEP

There are many factors involving the heat regulatory mechanisms in sheep. Some of those factors are external such as climate, plane of nutrition, water availability and diseases. Another type of factors which are related to the animal itself such as internal environment, type and nature of fleece, physiological status of the animal, age, sex...etc. Figure 1 summarizes factors affecting homeothermy of sheep (adapted from Esmay, 1978). Factors discussed there after are those most related to the theme of the present study .

HEAT GAIN = HEAT LOSS

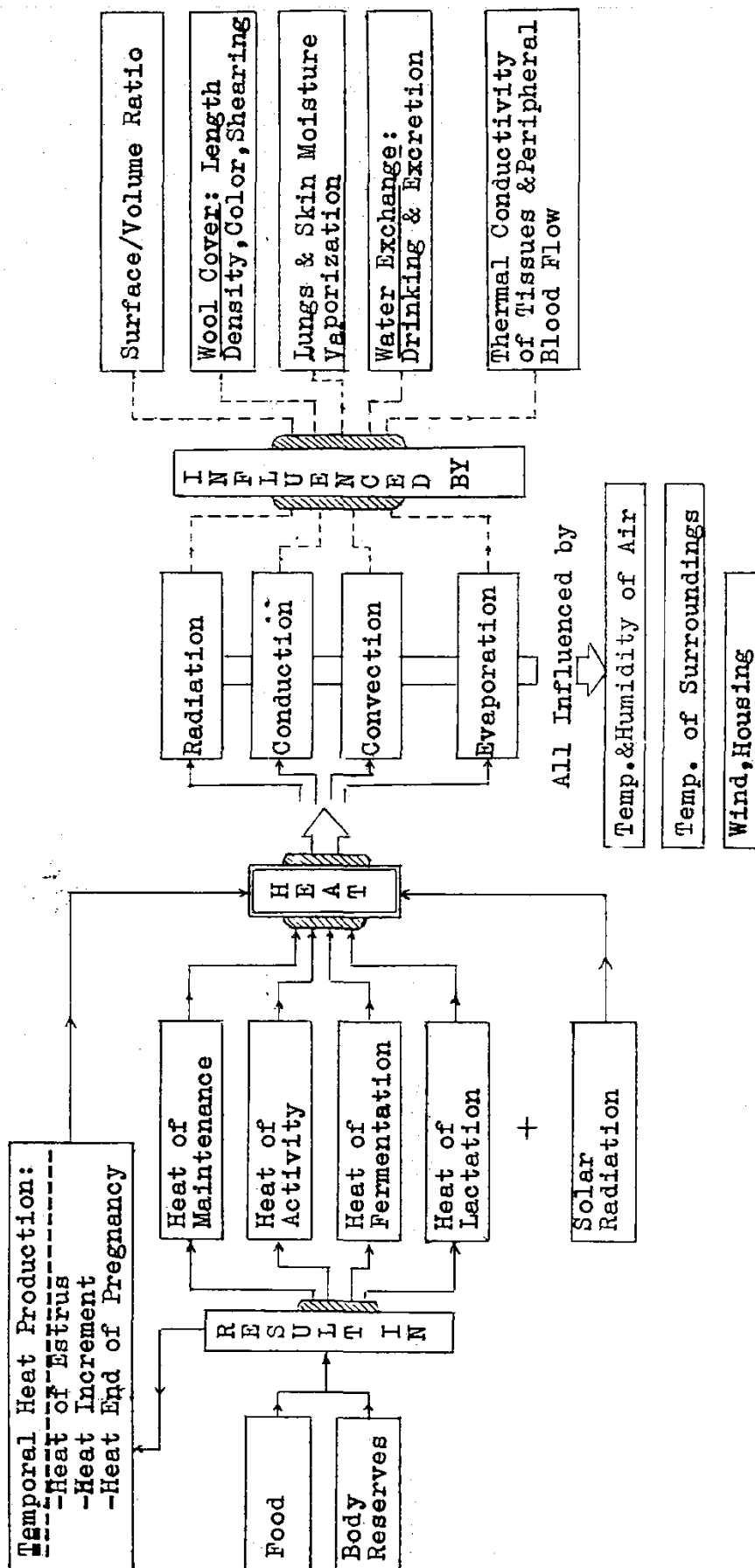


Fig. (1): Schematic Diagram of the Factors Affecting the Homeothermy of Sheep.
(Adapted from Esmeay, 1978)

1. Factors Related to the Environment :

i. Climatic variables :

Generally, climatic elements such as air temperature, solar radiation, relative humidity, wind velocity and rain are well known to influence the physiological function of sheep, e.g., the heat regulating mechanisms (Bianca, 1968 and Bayley, 1974).

Ambient temperature is the most important meteorological factor affecting the body temperature of sheep. When the mean daily temperature falls within the thermoneutral zone, sheep would not be likely placed under thermal stress (Bianca, 1970 and Hahn, 1976). Within this comfort zone, sheep dissipate their heat production primarily through sensible means (conduction, convection and radiation) over which the animal has only little control (Bianca, 1968). As ambient temperature increases toward outside the thermoneutral range, such sensible heat loss gradually decreases, and the evaporative ways tend to increase steadily to a point that the evaporation becomes the inevitable pathway of heat dissipation. This is definitely realized at the equality of air and body temperatures (Alexander and Williams, 1962 and Schmidt-Nielsen, 1979). Alexander and Williams (1962) reported that the efficiency of evaporation in cooling the lambs was