MOISTURE IN THE COATS OF SWEATING CATTLE

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I. INTRODUCTION

Yeates (1955) found heat tolerance of cattle with winter coats to be less than that of cattle with sleek summer coats in an environment of 105°F (40·6°C) dry bulb and 35 mm Hg water vapour pressure. He found that this was an attribute of the coat itself rather than a difference in physiology. In such an environment, the site of evaporation of sweat in coats of different depths could explain differences in performance as suggested by Allen (1962) and Turner and Schleger (1960). Moisture accumulating in the coat could be an indication that evaporation at the skin was not occurring or was incomplete.

The experiments described here were undertaken to measure the moisture content in a number of environments, since no work on this subject appears to have been published.

In October, 1963, a few preliminary measurements were made on winter coated animals in a shed and in a climate room. The main experiments in this progress report were made on summer coats in both natural and artificial environments in January, February and March, 1964.

II. METHODS

(a) Animals

The hair samples were taken from 17 Jersey and 11 Zebu cross heifers in the summer experiments and from 3 Jersey heifers in the spring experiment. The crossbreds were F1 and F2 Sindhi or Sahiwal x Jersey heifers in fair to good condition and had recently come off improved pasture. All animals were from 12 to 16 months old.

(b) Environments

The hair samples were clipped from the animals in four different environments; outdoors in the sun, outdoors in the shade, in a shed and in a hot room. For the outdoor experiments a set of four bails on a concrete base was used to hold the animals. In this and the other environments dry and wet bulb temperatures were measured with a sling psychrometer. Dry bulb temperatures ranged from 77 to 108°F (25 to 42°C) in the sun and from 68 to 94°F (20 to 34°C) in the shade while water vapour pressures ranged from 10 to 20 mm Hg in both

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situations. Air movement was measured with a cup anemometer near the bails and ranged from 130 to 630 ft/min (66-319 cm/sec). Measurement of air movement was continuous, but the estimate taken as relating to any moisture content of the hair was that over about ten minutes before clipping. Shade was provided either by cloud cover or by continuous artificial shading.

There were similar bails in a shed where dry bulb temperatures ranged from 65 to 98°F (18 to 37°C) and water vapour pressures from 5 to 17 mm Hg. Air movement, measured by thermoanemometer, was of the order of 25 to 50 ft/min (13 to 25 cm/sec).

The animals were put in the bails at about 8 a.m. and hair samples were clipped during the morning or afternoon or both.

In the hot room, in summer, hair was clipped under conditions of approximately 100°F (38°C) dry bulb and water vapour pressure 27 to 3 1 mm Hg; dry bulb 106°F (41°C) and water vapour pressure 30 to 34 mm Hg; dry bulb 109 to 111°F (43 to 44°C) and water vapour pressure 22 to 28 mm Hg; and dry bulb 120°F (49°C) and water vapour pressure 22 to 27 mm Hg. For the spring experiment in the hot room the dry bulb temperatures were 108 to 110°F (42 and 43°C) and water vapour pressures 18·4 to 18·0 mm Hg. On any one day, the temperature and water vapour pressure were held constant. The air movement in the hot room was about 20 ft/min (10 cm/sec). The animals were put into the hot room at 9 a.m. or 1 p.m. but hair was not clipped until at least two to three hours later. Equilibrium was achieved by this time as shown by supporting data.

(c) Procedure

Hair samples were taken from duplicate vertical strips extending from within a few inches of the vertebrae on each flank to the belly. Samples were taken by clipping close to the skin. A second operator collected the hair as rapidly as possible into a metal container. Both operators wore surgical gloves. To ensure that the hair was exposed for as short a time as possible after clipping, the collection was usually made in two portions using two containers. It was ascertained by exposure tests that moisture loss during collection was negligible. Shortly after clipping, hair and container were weighed, placed in an oven at 105°C and dried to constant weight. On many occasions the area of the clipped strip was measured in order to obtain the weight of hair per unit area. Measurements of coat depth were also made.

Skin temperatures were recorded on both sides of the animal by a thermistor apparatus. The mean of six readings taken vertically from belly to vertebrae, posterior to the mid-side, was calculated.

Estimates of sweating rates were made high on the mid-side by weight increase of duplicate calcium chloride capsules.

Duplicate hair samples from three Jersey and two Zebu cross heifers were placed in an accurately controlled climate room for periods of 24 hours at relative humidities from 25 to 97% and at a dry bulb temperature of 90°F (32°C), a temperature considered to approximate hair temperature in most of the experiments. The moisture contents observed are referred to as “regain values”.

III. RESULTS

(a) Characteristics of the coats

(i) Summer coats

The coats of the Zebu cross heifers were sleeker in appearance than those of the Jerseys whose coats appeared slightly rough due to the presence of guard hairs. Coats of both breed groups were approximately the same depth if the guard hairs were neglected; the mean depth for Jerseys was 4·0 mm and that for Zebu cross 3·5 mm. Coat scores (Turner and Schleger 1960) were similar for both breed groups and ranged from 3 to 4. The weight of hair per unit area was almost the same for the two breed groups; mean for Jerseys was 0.0091 g/cm^2 and the mean for Zebu cross 0·0088 g/cm^2. The weight per unit area was about 20% lower on the anterior part of the trunk than on the mid- and posterior regions.

(ii) Winter coats

The depth and weights per unit area of the three Jersey coats examined were considerably greater than those of summer coats.

(b) Moisture in the coats

Water content, found in the different environments, ranged from about 8 to 28% of the weight of the dry coat. All values in the hot room were above 15 % and those in other locations were below 17 % . The rate of sweating varied from less than 100 to over 600 $g/m^2.hr$.

(i) Position on the animals

The moisture content of the hair on the lower half of the flank was consistently higher than that on the upper half. Mean differences in percentage moisture for outdoor sun, shade and shed ranged from 0·71 to 0·77 while that for the hot room was 1·34. Moisture tended to be higher in the anterior position than in mid-side and posterior positions.

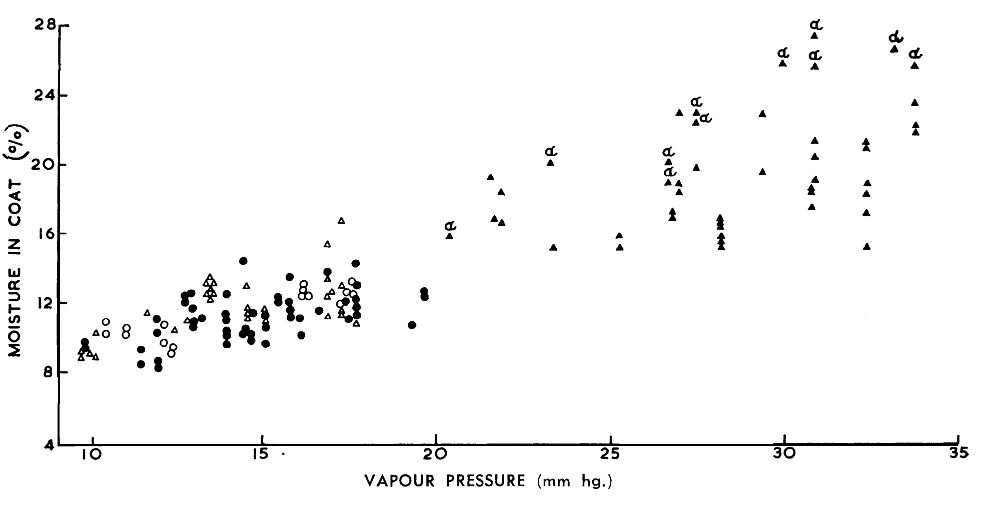

Fig. 1.—Percentage moisture in the coat related to atmospheric vapour pressure. ● outdoor sun, ○ outdoor shade, △ shed, ▲ hot room. Points in the hot room series marked "α" denote anterior samples taken just behind the shoulder.

(ii) Effect ***of*** *vapour* ***pressure***

There was no obvious relation between moisture content and relative humidity of the atmosphere, but there was a significant regression of moisture in the coat on atmospheric vapour pressure (Figure 1).

Since the experiments in the hot room covered a different range of vapour pressures from those in the other environments, two regressions were calculated. The regression coefficient for the outdoor sun, outdoor shade and shed was 0·33% moisture per mm Hg vapour pressure, while that for the hot room was 0·36% per mm. Both coefficients were significant ($P<0{\cdot}001$).

When moisture contents, which were recorded in the outdoor and shed environments, were corrected to a common vapour pressure by means of the regression equation, no significant differences were found between the means for the two breed groups (Table 1). Treatment differences, on the whole, were small but significant ($P<0{\cdot}05$); values in outdoor sun were lower than in the shed ($P<0{\cdot}001$).

TABLE 1

Mean percentage moisture in coat (corrected for water vapour pressure)†
According to treatment and breed group

Treatment	Breed Group	No. of Duplicate Strips	Mean and Standard Error (%)
Outdoor Sun	Jersey	30	11·14 ± 0·20
Outdoor Sun	Zebu Cross	22	11·03 ± 0·23
Outdoor Shade	Jersey	8	11·69 ± 0·43
Outdoor Shade	Zebu Cross	18	11·29 ± 0·43
Shed	Jersey	18	12·28 ± 0·29
Shed	Zebu Cross	14	11·60 ± 0·32
Hot Room	Jersey	25	18·47 ± 0·52
Hot Room	Zebu Cross	12	19·83 ± 0·91

†Hot Room data corrected (see text) to VP. of 28·7 mm Hg; all other treatment data corrected to VP. of 14·5 mm Hg.

Results in the hot room have not been compared with the rest, as the different range of vapour pressures would require large corrections. However, there was no obvious breed difference (Table 1).

(iii) Regain value of ***the coats***

Figure 2 shows the mean regain values of samples of hair from three Zebu cross and two Jersey heifers.

There was little difference in regain values between the different animals. There was some hysteresis and the relationship was roughly linear between 25 and 77% relative humidity. Figure 2 also shows that there is no general relation between moisture content of the unclipped coats and relative humidity. Superimposition of the regain value line on the plot shows that the moisture in coats in the hot room considerably exceeded the regain values. Outdoors in the sun the moisture values were, in general, close to or slightly above the regain values. The moisture content in outdoor and shed environments tended to be slightly higher than regain values at low relative humidities and slightly lower at high relative humidities. At the high relative humidities the environmental temperature was low.

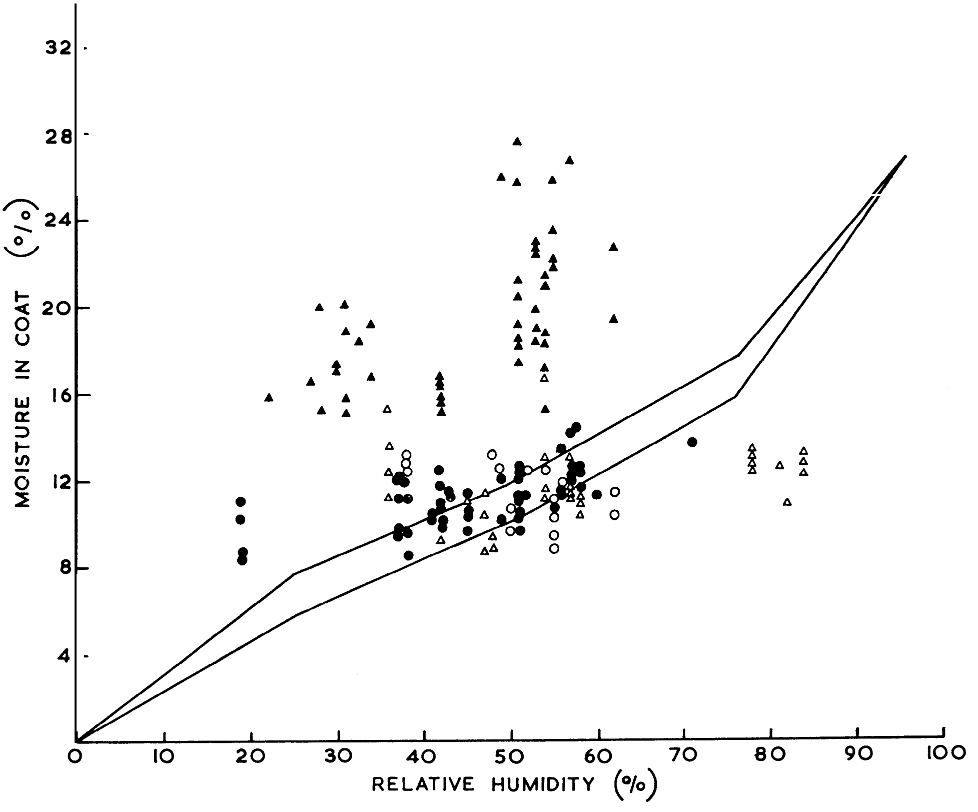

Fig. 2.—Percentage moisture in the coat related to atmospheric relative humidity and regain curve of the clipped hair placed at 90°F (32°C) in various humidities. ● outdoor sun, ○ outdoor shade, △ shed, ▲ hot room.

(iv) Winter coats

At equal vapour pressures, moisture in the winter coats was higher than in summer coats by 3 and by 5% of moisture in the shed and hot room respectively. The moisture contents in the two types of coats were similar at corresponding relative humidities.

(v) Other variables

There was no obvious relationship of sweating rate or wind speed with coat moisture either corrected or uncorrected for vapour pressure. However, as discussed below, further calculation showed an apparent effect of rate of sweating in a comparison between results from the shed and hot room.

IV. DISCUSSION

In general, the moisture contents of summer coats were surprisingly low in all environments, particularly in the natural environments where the amount of moisture in the hair corresponded to the amount produced during only about 1½ min of sweating at a rate of, say, 400 g/m^2 hr. Even so, much of it could be explained as moisture of equilibration with the atmosphere (Fig. 2). Further, it appears that when skin temperature exceeds air temperature (shed and outdoor shade), warming of the hair next to the skin can be effective in reducing the moisture of the coat to less than that of clipped hair in equilibrium with the atmosphere (Fig. 2). A likely reason why moisture was relatively independent of sweating at a given vapour pressure (section (v) above) is that a high environmental temperature or solar radiation, while increasing sweating, also warms the skin and hair thus facilitating evaporation and preventing accumulation of moisture. These results suggest that in natural environments summer coats do not seriously hinder evaporation of sweat and also that evaporation takes place at the skin; but this remains to be confirmed by more refined techniques.

In the hot room the moisture contents of the coats were considerably above the regain value at the relative humidity of the atmosphere (Fig. 2). The values were also considerably above those found in the shed with its similar radiant environment (air temperature close to radiant temperature) and air movement, but lower dry bulb temperatures. In the shed, the skin temperature was higher than the air temperature which would reduce the relative humidity close to the hair so reducing its regain value. In the hot room the reverse was true due to high ambient temperature. The effect of skin temperature on the regain value may be roughly calculated from a knowledge of the thermal insulation of the coat, which has been determined by Bennett (1964). The adjustment of regain value for skin temperature accounts for roughly 40% of the difference in moisture content between the hair of animals in the shed and hot room. There remains about 5% of moisture in the coat which appears to be related to the wide difference in rate of sweating (mean, 398 $g/m^2.hr$ in the hot room and 108 $g/m^2.hr$ in the shed).

Some of the values in the hot room were close to the maximum possible regain which suggests that near the skin there may have been some free moisture. However, the coats of cattle do not appear to accumulate sweat so easily as light human clothing (Macpherson 1960).

V. ACKNOWLEDGMENTS

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