Heat Production of Newborn Lambs in Relation to Type of Birth Coat

G. ALEXANDER*

Summary

The heat production has been measured of Merino lambs, with the coat artificially dried, less than 7 hr old, in still air at 68°F, and of the same lambs in a wind at the same temperature, with the coat artificially wetted. Indirect calorimetry was used. When the coat was wet the heat production ranged from 18-137 per cent. higher than when it was dry. The water which evaporated from the coat absorbed a substantial proportion of latent heat from the atmosphere. In general, wet lambs with a long coarse coat showed a much smaller increase in heat production above that when the coat was dry than did wet lambs with a short fine coat. It is concluded that lambs with a long coarse coat would have a better chance of surviving in cold windy weather.

INTRODUCTION

It has become apparent in recent years that in at least some flocks in S.E. Australia, many newborn lambs that die have failed to obtain milk or have even failed to stand (Barrett, unpublished data). Bad weather conditions have been implicated in the death of some of these lambs (Alexander, Watson and Peterson, unpublished data). The findings of Moule (1954) suggest that a similar situation exists in some Queensland flocks.

In the latter two of these studies the rectal temperature of some lambs was observed to fall, often to below 90°F: within an hour after birth, suggesting that death had resulted from failure of the lamb to become homeothermic at the change of environment from an intrauterine to an extrauterine one. While it seems logical to associate this cooling with evaporation of amniotic fluid from the coat, as Moule (1954) has already done, no information has hitherto been published about (a) the response of newborn lambs to increased heat loss, such as through evaporation of amniotic fluid, (b) the relative contribution of the lamb and of the atmosphere to the latent heat of vaporization of the fluid that evaporates from the coat, and (c) the effect of type of birthcoat on these factors. The results presented below provide information on these points.

MATERIAL AND METHODS

(i) ***Nutrition of the Pregnant*** Ewes.-Ewes were maintained on pasture until about three weeks prior to lambing, from which time they were almost wholly maintained on a mixture of equal parts by weight of lucerne chaff and oats, at the rate of 2 lb/head/day. Ewes were in good condition at lambing.

(ii) Types of Lamb Used.-Lambs were Merinos either of pure South Australian strain, pure Medium Peppin strain or first cross between these two strains. The birth coats of lambs of the South Australian strain were predominantly long and coarse, those of the Peppin strain were predominantly short and fine; birth coats were classified by visual examination at birth as coarse, intermediate or fine. Only lambs possessing coarse or fine coats, and which were known not to have sucked, were used. Sixteen of the 17 lambs were singles; the other was a twin.

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*Division of Animal Health and Production, C.S.I.R.O., Sheep Biology Laboratory, Prospect, New South Wales.

(iii) ***Treatment of Lambs.***—The lambs were removed from their mothers within half an hour of birth; they were dried in front on an electric fan in a chamber at approx. 90°F, and then their heat production in relatively still air at 68 ± 2°F was measured over a period of 1 to 2 hr between 2 and 4½ hr after birth. Lambs were subsequently immersed in tap water which was rubbed well into the coat manually; they were allowed to drain for 5-10 min and excess water was squeezed from the legs. Their heat production, this time in a strong draught of air, also at 68 ± 2°F, was again determined, over a period of about 1 hr between 5 and 7 hr after birth.

(iv) ***Measurement of Heat*** Production.-Heat production was measured by indirect calorimetry ; a closed circuit system, similar to that described by Blaxter, Graham and Rook (1954), was used. Details of the apparatus will be described elsewhere, but the essential features, illustrated in Figure 1, are outlined below.

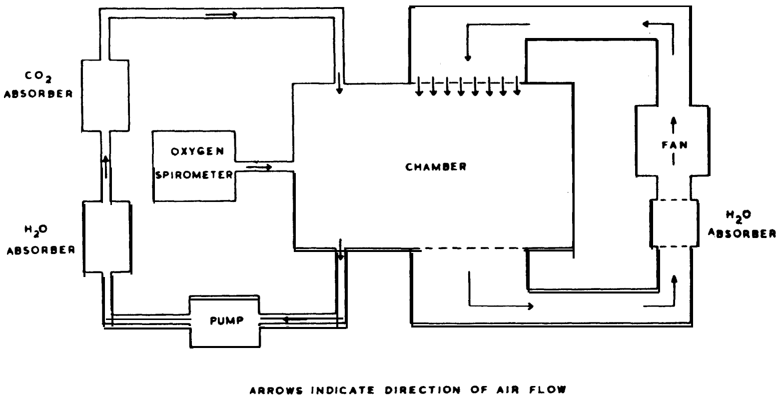

FIG. 1—Diagram of the closed circuit indirect calorimeter.

The lamb was placed in an air-tight chamber in which a stream of air could be directed over the lamb at about 10 m.p.h. Carbon dioxide and water given off by the lamb were absorbed in external containers, through which the air from the chamber was circulated. Oxygen entered the chamber from a graduated spirometer. The amounts of water and carbon dioxide given off were determined by weighing, and the amount of oxygen consumed was determined from changes in volume of the spirometer. The relative humidity in the chamber varied in different runs, between 30 and 70 per cent. when the lamb was dry, and between 66 and 85 per cent. when the lamb was wet. Lambs in the chamber usually stood or lay quietly.

From the oxygen consumption and respiratory quotient (vol. CO_2 produced/vol. O_2 absorbed) the heat production per unit time was calculated from tables of Lusk (1928), assuming that the amount of protein used for energy production by the lamb was small; unpublished data of the author indicate that this assumption introduces no serious error. Where the heat production is expressed as kcal/sq.m. of surface area/hr, the formula of Peirce (1934) has been used to convert body weight to surface area:—

$$A = 0.121\ W^{0.59}$$

where A = surface area in sq.m.
W = body weight in kg.

Results

(i) ***Effect of Wetting the Coat on Heat Production.-The*** heat production of each lamb in a wind with the coat wet was substantially greater than in still air when the coat was dry (Fig. 2), by amounts which ranged from 5-32 kcal per hr, (18-137 per cent. of that when the coat was dry). Lambs were observed to shiver after wet-

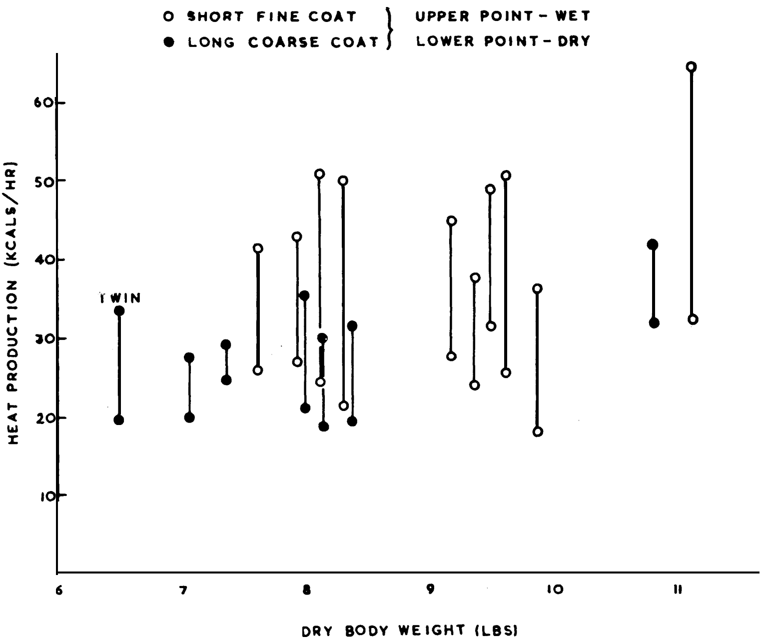

FIG. 2—Heat production of lambs with different types of birth coat in relation to body weight.

ting. Changes in rectal temperature during the measurements were slight (between +2 and —2°F); they were usually negative during dry runs and positive during wet runs. Skin temperature was not measured.

(ii) ***Contribution of the Lamb to the Latent Heat of Fluid Evaporating from the Coat***.-The weight of water that evaporated from the coat of each wet lamb was estimated by subtracting the weight of water collected during each "dry" run (insensible loss) from that collected during the corresponding "wet" run. The difference was multiplied by the latent heat of vaporization of water at an estimated skin temperature of about 86°F (0.58 kcal per g), to provide an estimate of the energy required to evaporate the water if all the latent heat were supplied by the lamb, and if no heat debt were incurred i.e., if the "average" temperature of the "whole" lamb remained constant as has been nearly true in more recent observations. In every instance the observed additional heat production of the lamb was less than the heat required to evaporate the water from the coat even though the wind alone, by decreasing the insulation round the lamb, would increase the heat lost by at least 25 per cent., as shown in more recent unpublished studies. The range of the observed increase in heat production, expressed as a percentage of this maximum possible increase, due to evaporation of water from the coat, was 23-89 per cent., average 53 per cent. The method of calculation is shown in Table I.

TABLE I.

Calculation of Observed/Expected Increase in Heat Production of Wetted Lambs.

Coat Condition	Water Given Off (g)	Heat Production (kcal/hr)
Wet	63	33.6
Dry	23	19.6
Difference	40	14.0

Heat absorbed by evaporating water = 40 x 0.58 kcal.
= 23.2 kcal.

% observed/expected increase in heat production =(14.0/23.2)100.
= 60.

(iii) *Effect* ***of Type of Birth Coat.-The*** mean increase in heat production per sq.m. of surface area ("wet" minus "dry") and the range are shown in Table II in relation to the type of birth coat. In general, independently of birth weight (Fig. 2), lambs with a short fine coat showed a much greater increase in heat production than did lambs with a long coarse coat; the difference between the means was highly significant.

TABLE II.

Differences in Heat Production between Wet and Dry Lambs,

Type of Coat	No. of Lambs	Range (kcal/sq.m./hr)	Mean±S.E.M. (kcal/sq.m./hr)	Significance of Difference between Means
Short Fine	10	48.6-108.8	75.5±6.9	0.01>P>0.001
Long Coarse	7*	18.2-61.2	41.6±5.7	

*Includes one twin (61.2 kcal/sq.m./hr).

The mean rate at which water was evaporated from the short fine coats was 58 g/hr and from the long coarse coats 49 g/hr. The difference was not significant.

Discussion

The data show that newborn lambs losing heat in a wind through evaporation of water from the coat are able to increase their heat production to maintain body temperature; shivering produces at least some of the extra heat. It is also apparent that the type of birth coat has a marked influence on the heat drain imposed by wetting the lamb.

It is clear that a substantial amount of heat must be absorbed from the atmosphere by water evaporating from the coat; it is not clear from the data how much the nature of the coat determines the proportion of heat absorbed from the lamb and from the atmosphere, because the effect of wind alone would differ in coats of different types. However, if the point at which evaporation occurs is towards the tip of the fibre, lambs with a long birth coat would be better insulated by trapped air between the skin and the point of evaporation than those with a short coat, and it would be expected that the lamb would supply a smaller proportion of the latent heat in the former than in the latter instance.

It is not surprising that when differences in heat production ("wet" minus "dry") were classified according to type of birth coat there was an overlap in the ranges, because density of coat which would affect insulation was not considered; a short dense coat could be more effective than a long sparse coat.

These findings show that Moule (1954) was unduly pessimistic when he estimated theoretically that the temperature of lambs must fall because the evaporation of an estimated 6 oz of fluid from the coat in one hour would require 100 kcal, and because the lamb's heat production, which he obtained from the figures of Peirce (1934) for basal heat production, would be only 20 kcal/hr. In the present study the heat production of some lambs was more than doubled by wetting the coat, and in other unpublished data it was more than trebled, a finding which is in accordance with the effect of cold stress on homeotherms generally. Further, a high proportion of the 100 kcal would be absorbed from the atmosphere and not from the lamb.

The relative saving of energy by wet newborn lambs with a long birthcoat under such mild conditions as existed in the chamber would be of doubtful practical significance; however under certain conditions of cold and wind, heat loss would exceed heat production with resulting hypothermia in lambs with a short coat, but not in lambs with a long coat, i.e. a long birthcoat would be a decided advantage for survival in conditions of rapid heat loss.

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