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The shelter requirements of the new-born lamb

A. R. SYKES

Lincoln College, Canterbury

ABSTRACT

Surveys of peri-natal mortality attribute 25 to 30% of lamb deaths to starvation/exposure, based on exhaustion of visible fat reserves. The ability of the new-born lamb to prevent this loss of body reserves depends on a complex series of relationships involving capacity for thermogenesis in relation to heat loss and ability to secure adequate further sources of energy in milk. Heat production and loss in lambs are described and values for the lower critical temperatures of lambs derived. The immediate peri-natal responses and differences between breeds are discussed in relation to survival. The derivation of effective ambient temperature and its use in assessing shelter requirements of lambs are discussed. Animal behaviour and practical matters are considered.

Peri-natal mortality, defined here as death within one week of birth, is a significant source of loss of farm income. Estimates of its extent vary between years but have ranged from 14 to 34% in hill flocks in New Zealand (Dalton *et al.,* 1980). In other situations short-term losses of up to 54 and 91% have been recorded in Corriedale and Merino sheep respectively (Obst and Day, 1968). Even within a supposedly hardy breed—Welsh Mountain sheep in Britain—mortality rates of up to 27% have been recorded (Purser and Karam, 1967). Surveys of pre-natal mortality invariably attribute 25 to 50% of lamb deaths to starvation exposure, usually based on exhaustion of visible fat reserves in the body (Houston and Maddox, 1974; Meyer and Clark, 1978; Dalton *et al.,* 1980; Johnstone *et al.,* 1980).

Factors Influencing Heat Loss

The new-born lamb, if it is to maintain homeothermy, must adjust rapidly at birth to a change in the temperature gradient between itself and its environment from about − *1 °C in utero* to one of up to 45°C *post partum* by increasing heat production or reducing heat loss. Within certain climatic limits, defined as thermoneutral, animals maintain body temperature without increase in heat production. At environmental temperatures below this range, heat production must increase. The lower limit of the range, the critical temperature, is determined by the total insulation and metabolic heat production of the animal, the latter being largely determined by feed intake. It is reduced by high feed intake and greater total insulation. Heat loss at temperatures below the critical increases linearly at a rate which is inversely proportional to total insulation.

Heat loss from the body surface occurs by conduction, radiation and convection at rates determined by the conductance of tissues between deep body and the skin (I_t), the conductance of external insulation (I_f), and the insulation of the interface between the fleece and air (I_s). The rate of air movement over the surface of the coat is particularly important in determining the value of these latter two. Body heat is also lost to water which flows over the body or is vaporised from the surface. The natural effects of the latter two, wind and rain, are notoriously difficult to quantify.

The values for the insulation of the tissues and pelage of lambs and of adult sheep are given in Table 1. These do not show major differences between

TABLE 1 Tissue and external insulation of newborn lambs and mature sheep at ambient temperature below the critical.

Tissue insulation	°Cm²/W	Adult	0.07 to 0.18	Webster and Blaxter (1966)
		Lamb	0.15	Alexander (1974)
Fleece insulation	°Cm²/W/mm	Adult	0.015 to 0.023	Joyce et al. (1966)
				Bennett and Hutchinson (1964)
Fleece depth	°Cm²/W	Lamb		
		long coat	0.15	Alexander (1974)
		short coat	0.05	

adult and neonate. The insulations of the short- and long-birth coated lambs of Alexander were equivalent (/m^2 surface area) to fleeces of 3 and 10 mm, respectively, in adult sheep. The greater insulation of the adult is generally brought about by its longer fleece. Because the insulating value of the fleece depends on its ability to trap still air, it is markedly influenced by wind which disturbs the fleece. Joyce *et al.* (1966) determined the effect of wind on total fleece insulation as $I_f = 0.0122 - 0.0028\ V^{0.5}$, where V is windspeed (m/s). Thus an increase of windspeed from 0.1 m/s to 2 m/s would decrease I_f by 30%.

Wind Chill—Effective Environmental Temperature

The heat losses of sheep exposed to combinations of temperature and windspeed were measured by G. Ames (pers. comm. to J. Slee). Wind chill was described in terms of effective ambient temperature as a depression of the temperature of the environment (Fig. 1). The rate of decrement of effective temperature with increase in windspeed appears to differ between sheep with long and short fleeces. Care should be exercised in interpreting these data because fleece type and the angle of exposure are likely to modify the relationships. They do, however, provide a guide in describing the effect of shelter from wind.

Especial Problems of the Lamb

The dimensions of the lamb are a further major determinant of the difference in susceptibility to cold between the young and adult because whereas heat loss is proportional to surface area, capacity for heat production is proportional to body weight (Alexander, 1974). A small body has a larger surface area per unit weight than a large one of the same shape.

Critical Temperature

The lower critical temperature for lambs was estimated by Slee (1979) to range between 22 and 37°C in still air depending on body weight and age of lamb (Table 2). Comparable data for adult sheep illustrate the large difference between mother and offspring.

Summit Metabolism

The lethal temperature for a lamb below the critical temperature is determined by its capacity for heat production (summit metabolism) which is usually about 5 to 6 times normal heat production. Calculated values for the cold lethal temperatures are given in Table 3 which shows the low temperatures at which the lamb can effect short term survival in still air and the marked effect of windspeed and

TABLE 2 Critical temperatures (°C) of new-born lambs* and adult sheep** in still air conditions.

Lamb age (hr)	Birth weight (kg) 4	6	Adult	Well-fed	At maintenance
			full fleece	−10	−3
1 to 6	37	32			
14 to 20	33	26			
			shorn	18	25
30 to 34	31	22			

* Slee (1979)
** Blaxter (1962)

TABLE 3 Calculated environmental temperatures (°C dry bulb) at which heat loss would equal summit metabolism in lambs and adult sheep.

State of coat	Weight (kg)	Windspeed (m/s) 0.1 Dry	∿7 Dry	∿7 Wet
Lambs—short coat	5	−69	−25	+4
	2	−32	−4	+23
Adults—7 mm fleece	—	−56	−11	+14
100 mm fleece	—	< −250	−120	−70

particularly rain and natural wetness of the birthcoat in raising this lethal limit. The lethal limits for an adult sheep in full fleece are, theoretically, extremely low.

The Need for Shelter

The need for shelter which protects the lamb from temperatures which are, effectively, below the critical temperature could be argued on the grounds of more efficient food utilisation. It is, however, unrealistic to suppose that the lamb can be protected from the necessity to increase thermogenesis (useful heat production) because even in still air conditions temperatures of over 20°C would generally be required. The likely effect of decrements in windspeed on "effective temperature" and therefore the temperature gradient between the lamb and its environment—with consequent reduction in necessity for cold-induced thermogenesis—can be seen in Fig. 1. There are no data from which this can be converted into realised increase in efficiency of food utilisation or improved weight gain, though the effects must be strongly positive and were estimated by Slee (1979).

One must not underestimate the ability of the lamb to provide a more favourable microclimate for itself than is measured by traditional meteorology which seeks to minimise effects of micro-climate. The trials described have measured precisely the climate to which the animal has actually been exposed. Field data on lamb survival has inevitably used meteorological records which tend to describe more severe conditions.

Lamb Survival in the Field

The ability of the lamb to sustain an exaggerated rate of thermogenesis depends on its energy reserves. Body fat, the major energy reserve of the newborn along with glycogen and amino acid (Alexander, 1961), comprises only 2% of body weight, compared with 20 to 30% in adult sheep. Lambs born from undernourished ewes have smaller reserves. However, even the least well-endowed lambs (Alexander, 1962) could be expected to be able to support summit metabolism for at least 6 hr. Provided the lamb can utilise these reserves at a rate which allows maintenance of homeothermy and that suckling occurs during this period, the lamb would appear able to tolerate relatively severe environments. In practice, however, this may not be the case and, moreover, breed variation may exist. Work in which body temperature was measured within 20 min of birth in lambs of 6 breeds, in a range of climatic circumstances, has suggested considerable variation in ability to maintain homeothermy immediately *post partum* (Sykes *et al.*, 1976). Many lambs of the Merino, Southdown and Finnish Landrace breeds showed reductions of up to 10°C in the body temperature in cold environments (−5 to −1°C effective ambient temperature), indicating a lack of ability to increase thermogenesis rapidly soon after birth. Small lambs generally showed greatest depression of body temperature, but there were exceptions. For example, the primitive Soay sheep, which has been maintained for centuries on the remote Scottish island of St. Kilda with only natural selection operating, maintained normal body temperatures in the cold despite a low birth weight. The Scottish Blackface although of a similar birth weight to the Merino, had much better capability for maintaining homeothermy. There were more favourable responses in all breeds in effective temperatures of between 1 and 10°C. Other more recent data (Alexander *et al.*, 1980) have also implicated low rectal temperature *peri partum* in lambs which subsequently died. The significance of these responses is increased by the findings of that at low body temperature below 36°C capacity for heat production falls. Further, teat seeking and suckling activity in new-born Merino lambs may be suppressed at body temperatures below 37.5°C (Alexander and Williams 1966). Thus not only do lambs which fail to maintain homeothermy soon after birth have greater difficulty in generating body heat, but their ability to replenish body energy is diminished. This is part of the ever-tightening cycle of starvation/exposure.

To prevent depression of body temperature and excessive heat production at birth an effective temperature above 0°C seems to be desirable. From Fig. 1 it can be seen that this would be achieved if windspeed was maintained below 0.8 m/s at +5° and below 2.8 m/s at +10°C.

A major deficiency in the work of Sykes *et al.* (1976) was their inability to account for rainfall. In a study of association between climate and peri-natal lamb losses at relatively high mean daily temperatures—between 8.6 and 12.3°C—Obst and Day (1968) found that rainfall of less than 5 mm/d in the absence of wind did not increase losses. Rainfall of greater than 5 mm/d associated with windspeed of 7 to 14 m/s increased mortality rates of Corriedale and Merino lambs by 26 and 53%, respectively, above those in similar wind conditions when rainfall was below 5 mm.

The Canterbury Climate

Minimum ambient temperature and average daily windspeed recorded at the Lincoln weather station during the month of September during the last 5 years are given in Fig. 2. Minimum temperature rarely fell below 0°C but many situations existed in which effective ambient temperature fell below −10°C. In different years, combinations of wind and

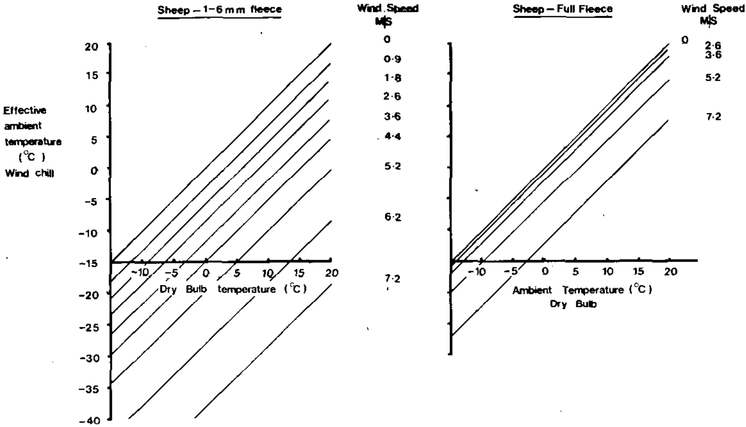

FIG. 1 Effect of windspeed of effective temperature for a shorn and a full fleeced sheep. Diagonal lines represent effective ambient temperatures. (Source—see text).

temperature produced these circumstances on 10 to 40% of days. Particular short-term combinations could be worse because of the averaging effect of

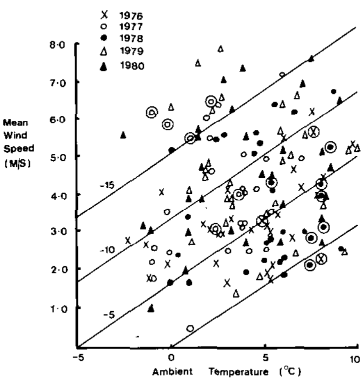

FIG. 2 Daily mean windspeed and minimum temperature combinations for Lincoln College during September 1976/80. Symbols circled represent days on which precipitation was greater than 5 mm. Diagonal lines represent effective ambient temperatures for combinations of windspeed.

daily wind run. Those days on which precipitation was greater than 5 mm have been circled. During 1978 there were numerous occasions on which conditions were comparable to those described by Obst and Day (1968) and in 1977 they were much more severe.

The Practical Situation and Animal Behavioural Considerations

It would be too easy to over-react to these data. A major difficulty is that of projecting from the calorimeter to the field, because of the problems of describing the microclimate which the lamb achieves for itself or is provided for it by the ewe. Another is the complexity in weather recording of providing the short term, detailed associations of climate which could prove critical for the individual newborn lamb. One must further ask the question as to whether, if these data were available on a forecasting basis, the farmer could respond by moving those ewes most at risk. This is a very risky and difficult operation at the height of lambing and especially on extensive properties.

Much of the work demonstrating the benefit of shelter on survival has involved close confinement of ewes, often in pens or indoors (McLaughlin *et al.*, 1970; Watson *et al.*, 1968; Egan *et al.*, 1972; Lynch and (Alexander, 1976), conditions inappropriate in sheep systems in New Zealand. Alexander *et al.* (1979) however described a tendency for fleeced

Merino ewes to seek isolation from the remainder of the flock for lambing, rather than to shelter where other sheep with lambs congregated. This suggests that the most effective shelter will be rather diffuse and therefore difficult to provide within existing management systems. In this regard it is interesting to speculate on the desirable extent of removal of tussock from hill grazings and hedges from flat grazings.

Finally, the loss of production resulting from climate must be balanced against the loss of productive land used for shelter. In a recent report on progress in hill farming research and development, Lucas (1979) quoted Alcock's doubts as to whether the benefit of shelter for herbage growth counterbalanced the land lost in providing shelter. In order to make this judgement for livestock further data are required on the detailed micro-climate experienced by lambs in relation to conventional weather records; of the shelter actually required to provide the climate desirable for lamb survival; efficient food utilisation for the type and frequency of situations requiring this provision; the likelihood that ewes will ensure that their lambs benefit at critical times from any shelter provided.

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