GENOTYPE-ENVIRONMENT INTERACTIONS IN LAMB MORTALITY WITH PARTICULAR REFERENCE TO BIRTH COAT AND HAEMOGLOBIN TYPE

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Summary

Factors contributing to neonatal mortality of lambs have been studied over a four year period on Kangaroo Island. The mean mortality (21.5 per cent) of fine birth coated South Australian Merino lambs was significantly ($P < 0.001$) higher than coarse birth coated lambs (12.6 per cent). In the two wettest lambing seasons, the mortality (13.0 per cent) of fine and medium coated lambs from haemoglobin AA type ewes was significantly ($P < 0.01$) lower than similar coated lambs born from haemoglobin BB type ewes (33.3 per cent) ; the difference (3.9 per cent) between ewe types in the two drier seasons was not significant.

Evidence presented indicates that the mortality associations with birth coat and haemoglobin types are governed by wind and rain experienced during the first six hours of life.

The genotype-environment interactions described provides a basis for low cost management practises to reduce lamb losses under some field conditions.

I. INTRODUCTION

Low cost management practises to reduce peri-natal lamb losses from 20 to 30 per cent to 10 to 15 per cent are an urgent requirement in the Australian sheep industry. Selection for genetic characters associated with survival under adverse environments could be one low cost method of increasing lamb survival.

Alexander (1958, 1962) concluded from laboratory studies on heat production that lambs with a coarse birth coat could have a survival advantage over fine birth coat types in conditions of rapid heat loss. However, few reports from field studies have substantiated this conclusion.

Documentation of climatic conditions by Davies (1964), Mullaney (1966) and Purser and Karam (1967) appear to be insufficient to determine whether mortality responses to birth coat type were governed by the degree of heat loss. Evidence supporting Alexander's claim is presented in this paper.

From a study of sheep haemoglobin (Hb) gene frequencies in many parts of the world (Evans and Phillipson 1957; Evans, Harris and Warren 1958), these workers postulated that the Hb AA type sheep were physiologically better adapted to cold harsh environments than were the Hb BB types and that the converse applied in warmer environments. Suggestions that lamb survival to weaning was associated with the Hb type of the ewe were presented by Evans and Turner (1965)

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and Dooley (1965) but considerable variation in response occurred between years, environments and mating groups.

Trials to define the significance of birth coat and Hb type in relation to lamb mortality were conducted on the Department of Agriculture Research Centre at Parndana on Kangaroo Island. Results of these trials are presented in this paper and indicate that selection for coarse birth coats or Hb AA types with fine birth coats would increase lamb survival under wet and windy conditions.

II. MATERIALS AND METHODS

(a) *Mating and Management*

Rams of known Hb type (AA, AB or BB) fitted with sire-sine harnesses and crayons were individually mated to six ewe groups, each of 35-40 South Australian Merino ewes. Ewe groups were selected with similar proportions of specific body weights, ages and Hb types. The mating period was for six weeks from mid-February to the end of March in 1966 and 1967, with a further two weeks random mating in 1967. Mating dates were recorded every second day.

(b) *Lambing Observations*

Ewes lambed in exposed areas during July and August of each year. Time of birth and birth coat type (Schinckel, 1955) (types 1 and 2, Fine; 3 and 4, Medium; 5 and 6, Coarse) of each lamb was recorded. In 1966, the Hb type of each lamb born was determined from mating data and/or blood electrophoresis patterns as described by Obst (1968). Time of death together with observations on ewe and lamb behaviour and a post-mortem (Macfarlane, 1965) were used to assess the cause of lamb death.

Wind velocity and rainfall at lamb height (0.25 m) was continuously recorded and mean values for the period 1-6 h after birth of each lamb in 1966 and 1967 were computed (Obst, 1968).

The 1964 and 1965 lambing records of ewes which were still in the flock in 1966 when the ewes were Hb typed are included in the analyses to allow differentiation of seasonal influences on mortality associations with ewe Hb type.

III. RESULTS

Of the total number of lamb deaths, 18.3 per cent were classified as ante-partum, 3.3 per cent partum and 78.4 per cent post-partum. Mis-mothering and post-partum deaths of unknown cause accounted for 22.3 per cent and 51.7 per cent respectively, of all post-partum deaths. At autopsy, 87.2 per cent of lambs classified into post-partum deaths exhibited some degree of kidney fat metabolism and 57.4 per cent of these lambs had walked but not fed.

The post-partum (l-48 h) mortality (2.7 per cent) of all lambs experiencing less than 8 km/h of wind and no rain during the first six hours of life was significantly ($P < 0.001$) lower than the mortality of 33.9 per cent in winds greater than 10 km/h with rain in the same period.

When the mean wind speed during the first six hours of life was above 10 km/h the mortality of liveborn lambs up to 48 h of age with a fine birth coat was significantly ($P < 0.05$) higher than those with a coarse birth coat (Table 1), and the mortality of Hb AA types was lower than Hb BB types (Table 2). Mortality differences between coat types and Hb types were not significant at mean wind speeds below 10 km/h with no rain.

TABLE 1

The effect of birth coat type on post-partum lamb mortality in relation to weather conditions during the period 1-6 h after birth for 1966 and 1967. (Number of lambs born in parentheses)

Weather		Birth Coat Type			Difference between Fine and Coarse	
Wind km/h	Rain mm	Fine Mortality %	Medium Mortality %	Coarse Mortality %	Chi-Square	P
0–8	0	2.9 (38)	5.0 (40)	0.0 (33)	—	n.s.
>10	0–>0.25	21.4 (56)	26.2 (42)	6.0 (50)	4.50	*
Chi-Square		6.02	5.88	—		
P		*	*	n.s.		

n.s. ($P > 0.05$).
* ($P < 0.05$).

$\% = \left(\frac{\text{Dead}}{\text{Born}} \times \frac{100}{1}\right)$ where Dead = number of lamb deaths from 1–48 h.
Born = number of lambs born alive.

An interaction between ewe Hb type and lamb birth coat type is indicated in Table 3. The mortality of fine and medium coated lambs from Hb AB or BB ewes was higher than from Hb AA ewes. The mortality of coarse coated lambs between ewe Hb types was similar.

Table 4 shows a significantly ($P < 0.01$) higher mortality of fine and medium coated lambs from Hb BB type ewes compared to Hb AA ewes in the wetter seasons. However, in the "dry" seasons there was no significant ($P > 0.05$) difference in mortality of fine and medium coat types between ewe Hb types.

IV. DISCUSSION

Provision of shelter belts to reduce the incident wind on new born lambs to less than 8 km/h for the first six hours of life could reduce the mean lamb loss on Kangaroo Island over a 10 year period by 8 per cent per annum to 10-1 5 per cent of all lambs born. This estimate is based on the report of Obst (1968) which considered the frequency of occurrence of bad lambing weather from 1954 to 1964 at the Knngaroo Island Research Centre.

TABLE 2

The effect of micro-wind in the period 1-6 h after birth on mortality between lamb haemoglobin types in 1966. (Number of lambs born in parentheses)

Wind	Lamb Hb type			Difference between AA and BB	
	AA	AB	BB		
km/h	Mortality %	Mortality %	Mortality %	Chi-Square	P
0–8	12.5 (24)	5.1 (39)	9.5 (21)	—	n.s.
>10	10.0 (20)	21.3 (47)	30.0 (20)	2.50	n.s.
Chi-Square	—	5.89	3.16		
P	n.s.	*	n.s.		

n.s. ($P > 0.05$).
* ($P < 0.05$).

$\% = \left(\frac{\text{Dead}}{\text{Born}} \times \frac{100}{1}\right)$ where Dead = number of lamb deaths from 0–48 h i.e. includes dead at birth.
Born = number of lambs born (dead or alive).

TABLE 3

The association of lamb birth coat and ewe haemoglobin type with mortality of Merino lambs for the years 1964-67 (Number of lambs born in parentheses)

Ewe Hb type	Lamb coat type: Fine Mortality %	Medium Mortality %	Coarse Mortality %	Totals Mortality %
AA	16.9 (59)	17.3 (52)	12.1 (66)	15.3 (177)
AB	22.0 (127)	10.6 (131)	13.2 (159)	18.2 (417)
BB	25.0 (60)	25.4 (67)	11.8 (68)	20.5 (195)
Totals	21.5 (246)	21.2 (250)	12.6 (293)	18.1 (789)

$\% = (\frac{\text{Dead}}{\text{Born}} \times \frac{100}{1})$ where Dead = number of lamb deaths up to 25 days of age.
Born = number of lambs born (dead or alive).

Chi-Square values of the total mortality difference between fine and coarse coat types = 7.92 ($P < 0.01$) and between Hb AA and BB = 1.82 ($P > 0.05$).

It is obvious from Tables 1 and 3 that without provision of shelter, the high survival rates of 85-90 per cent of all lambs born could be achieved by selection for coarse birth coats. The heritability of birth coat as determined by Schinckel (1955) is 0.72.

Selection for coarse birth coats may result in increased variability of fibre diameter in the adult fleece (Schinckel 1958), a reduction in crimps/inch and an increase in staple length and clean fleece weight (Morley 1955). Potter and Day (1962) indicated that if coarse birth coated lambs were heavily culled at 4 to 6 weeks of age, 60 per cent of these would have been unnecessarily eliminated if sebsequently classed on their adult fleece quality. The comparable figure for fine coat types was 77 per cent, but percentages would obviously vary with the selection criteria.

Recent market trends in price per unit weight of wool favour fine wool (64-70's + quality) and not stronger wool, therefore an economic evaluation of not only wool quality but also wool weight and net reproductive rates in different strains of sheep and environments appears necessary.

If coarse birth coats developed into economically undesirable adult fleece types,

TABLE 4

The association of ewe haemoglobin type and mortality of fine and medium birth coated Merino lambs for the "wet" years (1964, 1966) and the "dry" years (1965, 1967) (Number ol lambs born in parentheses)

Year	Rain mm†	Ewe haemoglobin type: AA Mortality %	AB Mortality %	BB Mortality %	Difference between AA and BB: Chi-Square	P
1964	354					
1966	319	13.0 (54)	23.8 (143)	33.3 (63)	6.80	**
1965	294					
1967	176	21.1 (57)	18.3 (115)	17.2 (64)	—	n.s.

n.s. ($P > 0.05$).
** ($P < 0.01$).
† Total rainfal for the months of June, July and August of each year.

$\% = (\frac{\text{Dead}}{\text{Born}} \times \frac{100}{1})$ where Dead = number of lamb deaths up to 25 days of age.
Born = total number of lambs born (dead or alive) with fine or medium birth coats.

selection of fine and medium coats with Hb AA type would be indicated from Tables 2 and 4 to achieve high survival in wet and windy environments.

Hb type in sheep is controlled by a pair of alleles at a single locus (Evans *et al.* 1956) and therefore the Hb AA gene frequency of any flock can readily be increased by mating with Hb AA type rams.

The observed relationship between Hb type and lamb mortality supports the postulate presented by Evans and Phillipson (1957) and Evans *et al. (1958)* of Hb AA type sheep being better physiologically adapted to cold harsh environments than Hb BB types. However, the exact physiological mechanisms involved in this adaptation remain speculative.

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