Lamb Survival in Australian Merino Sheep - Is Genetics the Answer?

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Summary

At present a single simple approach to increase lamb survival in Australian Merino sheep remains elusive. Lamb survival is the end result of a complex series of physiological and behavioural changes on the part of the ewe and lamb that can be drastically impacted by the environment at lambing. While genetics offers a permanent relatively low cost solution, there is an urgent need to identify appropriate selection criteria that can be measured between birth and 7 days of age. Maternal bond score and birthcoat hairiness as assessed currently have little to no impact on lamb survival. In the meantime, current generation genetic improvement can be achieved by using pregnancy scanning information and 'wet & drying' ewes at marking to cull ewes with poor maternal rearing ability. Manipulation of lamb birth weight through maternal nutrition in late pregnancy is unlikely to produce dramatic increases in lamb survival. Nevertheless meeting the nutritional demands of ewes during late pregnancy; particularly those bearing twins will promote a successful parturition, onset of lactogenesis and maternal behaviour and adequate levels of lamb body reserves for heat production by the lamb.

Introduction

Following a period of prolonged drought and low wool prices, the size of the Australian sheep flock has decreased by more than 26% over the past 10 years. The total number of sheep and lambs in 1998 was reported as 117.5 million head (Australian Bureau of Statistics 2001) compared with an estimated 86.3 million head in 2007 (Australian Bureau of Statistics 2007). In this context the ability of Merino ewes to successfully raise lambs to weaning is of great importance to the rebuilding of the national sheep flock. However it is well known that when compared to other breeds the reproductive performance of the Australian Merino is low (Dalton *et al.* 1980; McGuirk 1982) with the major source of reproductive wastage being losses shortly after lambing (Kleemann and Walker 2005). In the past it has been difficult to determine the extent of lamb mortality; estimates varied from 4 to 75% of lambs born and relied on counting lamb carcases when found and relating this to the number of ewes mated. Development of commercial ultrasound services for the sheep industry in the early 1980's provides a means for commercial sheep producers to establish the lambing potential of their flock. This knowledge combined with lamb counts at marking and weaning allows lamb survival to be determined with more certainty on both an industry and individual flock basis. As a result specific areas of concern can be identified and remedial action taken to improve lamb survival. Reducing lamb mortality will have a large impact on the reproductive efficiency of the Australian sheep flock. But lamb survival is the end result of the interaction of a complex series of events with many factors affecting the ultimate outcome of an individual pregnancy.

Lamb survival - a complex series of events

Lamb development and survival depend almost entirely on the care provided by their dam prenatally and in the immediate postnatal period. Neuroendocrine changes associated with parturition work to make a significant transformation to both ewe behaviour and physiology at parturition (Figure 1). In sheep, maternal behaviour is displayed only at parturition and the maintenance of that behaviour depends on interactions that take place between the mother and her young at the birth site during the first day postpartum (Lindsay *et al.* 1990).

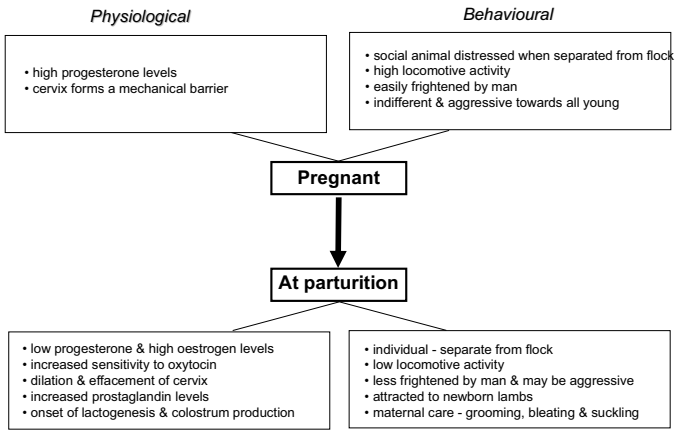

Figure 1. Summary of the physiological (Scaramuzzi and Lindsay 1986) and behavioural (Lindsay *et al.* 1990) transformation of a ewe at parturition

At birth lambs face enormous heat loss as their environmental temperature decreases from 39.5°C *in utero* to less than 10°C and potentially much lower depending on the time of lambing, geographical location and weather conditions. The birthcoat is wet with amniotic fluid rendering its thermal insulation properties almost useless and evaporation of foetal fluid drives heat loss. To maintain body temperature, new born lambs must rapidly increase heat production by both shivering and metabolism of brown adipose fat. They must also display sufficient vitality and vocalisation levels to facilitate a strong ewe lamb bond (Lindsay *et al.* 1990). This is vital for twin lambs in particular as Merino ewes are renowned, rightly or wrongly, for failing to recognise the size of their litters and providing inadequate care to twin lambs (Lindsay *et al.* 1990; Stevens *et al.* 1982).

In the Australian sheep industry we expect a Merino ewe and her lamb/s to be able to make these physiological and behavioural adaptations with no outside assistance when nutrition, the lambing environment and predator control are often inadequate. Under these circumstances it is little wonder that lamb marking percentages in the Australian sheep flock have remained relatively stagnant compared to those achieved in other countries (Kleemann and Walker 2005).

A lamb's tale

Consider the following scenario: *A lamb, number 318, is born. He was the second of a pair of twins born to a 6 year old dam on the Central Tablelands of NSW in early September 2007 and weighed 4.68 kg at birth with a reasonably hairy birthcoat. His littermate was female and weighted 4.04 kg, neither birth was assisted and both littermates survived the first post-partum week. Their dam phenotypically cut above average clean fleece weight, was fed at 90% of maintenance from mid-pregnancy and successfully reared twins lambs to weaning in 2006*. Based on this information what is the likelihood of 318 surviving to weaning and beyond?

Mothering ability and dam age

The fact that 318's dam had successfully reared twins to weaning during her previous pregnancy was not a reliable indicator of her ability to do so again in 2007. Analysis of more than 14,000 lambing records from the Trangie 'D' flock between 1975 and 1983 found that the mothering ability of Merino ewes after the first post-partum week was not an important factor in lamb survival (Hatcher *et al*. unpublished data). For those ewes the repeatability of maternal rearing ability was about 10% at birth and between 1 - 7 days, but after that decreased by a factor of 10. So while it is clear that some ewes repeatedly lose lambs at birth and in the early post natal period, lamb survival beyond the first week of life is largely outside the control of the ewe. Ewes that lose lambs at marking or weaning are no more or less likely to subsequently lose lambs at these times. Improvement in maternal rearing ability is therefore only likely to be achieved using selection criteria, whatever they may be, measured in the first week post-partum.

Lamb survival tends to be poorest for young and aged dams and maximised for dams at about 4 years of age (Hatcher *et al*. unpublished data). Younger ewes tend to have lower birth weight lambs and more stillbirths but fewer losses due to difficult labour than older ewes (Purser and Young 1964). They also tend to have poorer maternal behaviour, especially when undernourished (Lindsay *et al.* 1990). Older ewes have a higher potential for udder damage either through shearing injury or other causes which can negatively affect lamb survival (Jordan and Mayer 1989).

Birth weight

The relationship between lamb birth weight and survival to weaning is curvilinear with lamb mortality being highest at both low and high birth weights and survival optimized between about 3 - 5 kg regardless of birth type (Atkins 1980a; Dalton *et al.* 1980). However when the relationship between birth weight and survival is analysed at various times between birth and weaning some distinct differences become evident. In the Trangie 'D' flock, across all birth types, the relationship between birth weight and survival at birth was much flatter when compared to that for survival to weaning (Hatcher *et al*. unpublished data). For these lambs there was little difference in survival (just 0, 0.5 and 2.5% for singles, twins and multiple born lambs respectively) between the average birth weight and the optimal birth weight for survival (Figure 2a). This indicates that the potential to increase the survival of Merino lambs at birth through increasing average birth weights is very limited. In fact, any increases in birth weight are likely to lead an increased incidence of difficult birth and dystocia and thus put at risk the survival of the dam.

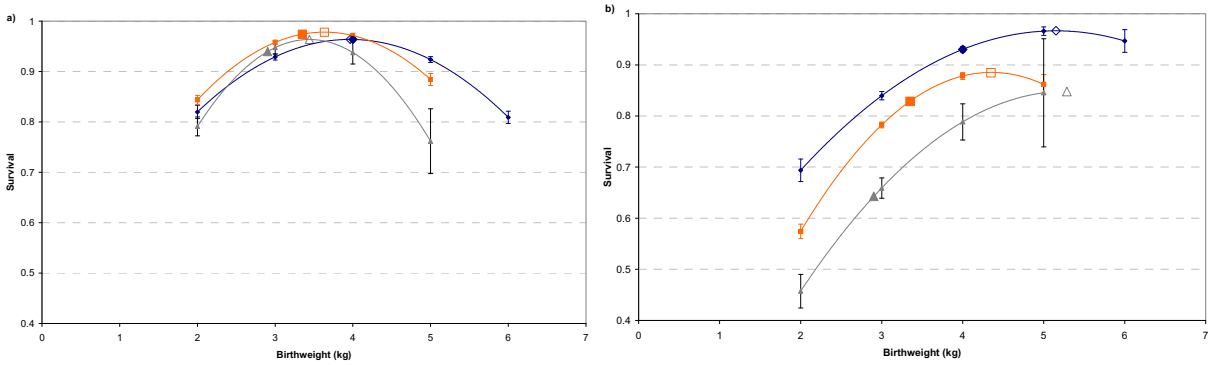

Figure 2. Birth weight (kg) versus survival a) at birth and b) between 1 to 7 days for single (◆), twin (■) and multiple (●) born lambs. For each birth type the larger closed symbols (◆■●) represent the average birth weight and the open symbols (◇□○) the birth weight at which survival at birth was optimised (Hatcher *et al.* unpublished data)

For those lambs that survive birth, heavier birth weight was a definite advantage in surviving the early post-natal period up to 7 days of age (Figure 2b). Compared to smaller lambs, heavier lambs are more able to regulate their body temperature following birth due to higher thyroid hormone levels and reserves of body fat (Vermorel and Vernet 1985), likely to forge a stronger bond with their dam (Lindsay *et al.* 1990; Lynch and Alexander 1986) and can influence milk production via a stronger sucking stimulus (Heath *et al.* 1984). Manipulating birth weight would provide little improvement in lamb survival after 7 days of age. For all birth types the relationship between birth weight and survival during this time period was almost horizontal. A similar trend of the strong association between birth weight and survival in the first 7 days of life but thereafter declining in significance is also evident in other breeds (Dalton *et al.* 1980; McMillan 1983; Purser and Young 1964). Based on these relationships, weighing 4.68 kg at birth and surviving the birth process as did 318 would be an advantage for any lamb, but particularly so for those born as twins.

Sex, birth type and impact of littermate survival

Firstly being a male, 318, was between 2 and 4% less likely to survive than his female litter mate (Hatcher *et al*. unpublished data) and secondly being a twin further decreased his chances of survival (Holst *et al.* 2002; Kilgour 1992; Kleemann and Walker 2005). A greater incidence of stillbirths has been reported amongst male lambs (Mullaney 1969) which may be a result of their heavier birth

weights. Despite the relatively lower survival rate of twins, selection for increased twinning in Merino flocks is a viable option to increase reproductive efficiency as long as the survival to weaning of twins is never less than half that of singles (Mullaney 1969).

It is no surprise that 318 survived birth as the majority of all twin lambs; up to 98% do survive the actual birth process (Hatcher *et al*. unpublished data). Most twin deaths occur in the first 3 days following birth generally due to starvation and mismothering (Holst *et al.* 2002). Interestingly, survival of twins to 7 days of age is dependent on the survival of their littermate. An 8% improvement in survival occurs, if both twins survive the birth process compared to those that lost a littermate at birth (Hatcher *et al*. unpublished data). But following 7 days of age, survival of twins was mainly due to the number surviving in the litter, favouring those whose littermate had died. Successful completion of the birth process, both physiologically and behaviourally, seems essential for both littermates to survive to 7 days of age, but after that time a surviving twin is at an advantage due to a lack of competition for milk.

Birthcoat

Hairier birthcoats conferred a slight survival advantage at birth for the 'D' flock lambs but had no impact on survival at any other time period (Hatcher *et al*. unpublished data). At birth finer birthcoats tend to retain a greater amount of amniotic fluid and take longer to dry, so hairier birthcoats provide a survival advantage through minimising heat loss and increasing resistance to cold (Vermorel and Vernet 1985). But once the birthcoat is dried and the lamb is able to maintain it own body temperature, birthcoat characteristics provide no further survival advantage.

Is genetics the silver bullet?

Given the complexity of lamb survival and the extensive low-input Merino production systems in Australia selecting sheep with a genetic propensity for lamb survival is a very attractive option. Genetics offers a permanent low cost solution provided effective selection criteria are developed that have favourable genetic correlations with survival and no unfavourable relationships with other economically important production traits. Two accounts of selection to improve reproduction in Merino sheep have been reported. Firstly, selection for high net reproductive rate with emphasis on increased twining, lamb survival and reduced number of dry ewes in the Trangie Fertility Flock produced a 33% improvement in lambs weaned per ewe joined in the final 3 years of selection (Atkins 1980b). However some of this difference was due to current generation improvement as dry ewes in any year were culled from the Fertility Flock as were those who failed to rear a lamb to weaning. Secondly, a South African selection experiment where ewes were divergently selected either for or against multiple rearing produced an annual 2.5% improvement in lambs weaned per ewe between 1986 and 2002 (Cloete *et al.* 2004). Similar improvements in lambs weaned per ewe have been reported in other breeds.

The components of lamb survival can be defined as the lamb's own capacity to survive, or viability, and the rearing ability of the dam. Genetic parameters for both traits need to be accurately estimated to allow an assessment of the effectiveness of genetic selection to increase lamb survival. Both lamb viability and maternal rearing ability have low heritabilities of about 0.03 (Hatcher *et al*. unpublished data). *Heritability* is a measure of future generation genetic responses so the low heritability for lamb survival, both the lamb and ewe component, suggest that genetic solutions to increase lamb survival are unlikely to be dramatic regardless of whether survival is treated as a trait of the lamb or of the ewe. But, despite the low heritabilities, there is still potential for improvement through selective breeding. *Repeatability* is a measure of the likely response to selection that can be achieved in the current generation. As the rearing ability of the dam has an estimated repeatability of at least 0.10, current generation improvement can be achieved by culling animals from the breeding flock with poor maternal rearing ability (Hatcher *et al*. unpublished data). The accuracy of selection can be improved by using multiple records on a ewe's rearing ability over its lifetime.

The estimated genetic parameters for both lamb survival and ewe rearing ability suggest that improvements in lamb survival will be very slow but some opportunity exists to identify ewes that are

more reliable in rearing their lambs. Survival in the later post-natal period (after 7 days) was less repeatable (Hatcher *et al*. unpublished data), which emphasises the need to record survival within 7 days of birth to improve the accuracy on the trait for evaluation and selection purposes. The key is to identify appropriate selection criteria. Maternal bond score is commonly used in research flocks to code the behaviour of a ewe towards the lamb at tagging. The scores range from 1 maintaining close contact with lamb to 4 ignoring the lamb. Although maternal bond score is a highly repeatable (0.66) and moderately heritable (0.36) trait of the ewe, the genetic and phenotypic correlations with lamb survival were essentially zero (0.05 ± 0.14 and 0.01 ± 0.01 respectively) (Hatcher *et al*. unpublished data). Maternal bond score is thus a very poor indirect selection criterion for maternal rearing ability.

Strategies to improve lamb survival

Events occurring in the early post-natal period are critical for lamb survival as most lamb deaths occur during this time. While manipulation of ewe nutrition to increase birth weight is unlikely to produce dramatic increases in lamb survival (Hatcher *et al*. unpublished data), the ewe must present at parturition with sufficient body reserves to facilitate a quick delivery, begin lactogenesis with an adequate quantity of colostrum and provide satisfactory maternal care to her lamb. The lamb will benefit by having a greater amount of body reserves, particularly brown adipose fat, to metabolise post-birth. Merino producers can facilitate this by ensuring the nutritional requirements of breeding ewes, particularly multiple-bearing ewes, are met during the later stages of pregnancy. Similarly provision of a suitable lambing environment that firstly encourages the ewe to choose a 'sensible' birth site and remain there for at least 6 hours and secondly moderates environmental conditions is likely to improve the chance of individual lambs surviving their first week of life.

Conclusions

For genetic selection to be effective in improving lamb survival, it is imperative to discriminate between traits that may have some explanatory role in the variation between animals in survival compared with their potential roles as selection or management criteria. Birth weight, for example, was shown to have a significant curvilinear relationship with survival to weaning. Animals with extreme birth weights had a lower survival rate. For the remainder, lambs surviving to weaning had a higher birth weight than those that died, leading to the classical curves relating survival to birth weight within birth types. Such relationships have been used in the literature to suggest that manipulating nutrition to increase birth weight, particularly among multiples, will attract an improvement in lamb survival. But, information on time of death in this study has shown that surviving the birth process is maximized at about the average birth weight (Hatcher *et al*. unpublished data). Any increase in birth weight will reduce lamb survival and, more critically, expose the ewe to increased risk of death or injury during the lambing process.

Similarly, maternal bond score has been used as a measure of maternal behaviour that is based on the movement of the ewe away from her lamb at tagging time. Maternal bond score is highly repeatable and moderately heritable. But genetic and phenotypic correlations with lamb survival were essentially zero, indicating that maternal bond score is a very poor indirect selection criterion for maternal rearing ability.

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