Final report

Project code:	B.LMS.0050
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Date published:	October 2013
ISBN:	9781741919516

PUBLISHED BY

Meat & Livestock Australia Limited

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NORTH SYDNEY NSW 2059

Impact of mob size during lambing on lamb survival from merino and maternal ewes

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

The literature review undertaken highlighted the lack of clear recommendations for sheep producers on lambing paddock management, particularly regarding the impact of ewe mob size on resultant marking percentage. The template designed in this project to record mob-paddock observations and lambing results has proven to be highly effective for collecting detailed information on key variables influencing lambing results. A total of 750 mob-paddock observations were collected and the information collected has been used to further define the relationship between the number of ewes in a lambing paddock and marking percentage.

It was found that ewe mob size has a significant impact on marking percentage. Across the 750 mob-paddock observations 20% of the variation in marking percentage was due to the ewe mob size at lambing ($p<0.001$). The strength of this relationship reduced when the data was analysed in breed groups (R-squared of 11% for merino ewes and 10% for non-merino ewes), although it was still statistically significant ($p<0.001$). The strength of this relationship reduced even further when the analysis was undertaken for ewe breed and parity (single and twin bearing mobs) separately, primarily due to a significant reduction in the number of cases in each grouping. Similarly, it was difficult to determine the effects of other variables such as ewe stocking rate, condition score, feed-on-offer, shelter and weather on the relationship between ewe mob size and marking percentage.

The impact of the number of ewes in the mob at lambing on marking rate was significant in non-merino twin and single bearing ewes ($p<0.001$). For every 100 extra non-merino ewes in the mob at lambing twin lamb marking rates declined by 9% in twins and 5% in singles. The number of merino ewes in a mob at lambing was also found to significantly affect twin lamb marking rates ($p<0.01$) but was not significant for single lamb marking rates ($p>0.10$). For every 100 extra merino ewes in the mob at lambing, twin lamb marking rates declined by 6%.

This project has provided encouragement for further work to be undertaken in this area, to aid in the quest to improve the survival of lambs born. Lamb survival continues to be a significant wastage point in the flocks surveyed, with only 75% of the foetuses conceived resulting in live lambs at marking. This outcome appears to be influenced significantly by ewe mob size at lambing, particularly for twin born lambs. Across all the data collected (750 paddock-mob records), for every 100 extra ewes in the mob at lambing, marking percentage decreases by about 10% ($p<0.001$). The majority of producers in this study (62%) have already demonstrated a willingness to manipulate single and twin bearing mob sizes at lambing, however they require more precise guidelines to optimise their decisions regarding mob size at lambing. Hence, further investigation is warranted given that very limited research has been undertaken on the relationship between lambs born per day (governed by mob size, parity, joining length and pattern) and lamb survival rates.

Executive summary

There is a need to develop more rigorous recommendations for mob size of ewes at lambing to optimise lamb survival, or at least provide an understanding of the likely implications of varying mob sizes at lambing (with consideration for other key factors), particularly for twin lambs. This will enable producers to make a more informed decision about the cost-benefit of implementing smaller mobs at lambing. The objective of this project is to determine if there is enough existing information to provide rigorous recommendations on the optimum mob size for lamb survival of both single and twin born lambs. A survey of producers was used to determine if the factors affecting lamb survival can be separated.

The first part of this project involved undertaking a review of the literature, previous research projects and demonstration sites addressing the impact of lambing mob size and paddock aspects on single and twin lamb survival. The literature review highlighted the lack of clear recommendations for sheep producers on lambing paddock management, particularly regarding the impact of ewe mob size on lamb marking percentage.

The second part of this study involved designing a survey for sheep producers that included a template for recording mob and paddock details at lambing and to provide the basis for data to be collected in any future trials in this area. The survey was designed using an excel spread sheet for a mob-paddock based template. The survey firstly records farm summary data including the following;

- property details - name, size, location,
- overall flock reproduction data - ewes joined, scanning and marking percentage,
- lamb survival - single, twin and overall, and
- flock management - predator control, condition score and pasture assessment skill level, weather rating for lambing and average lambing mob sizes.

The survey then has a mob-paddock template that records the following;

- paddock details - name, size,
- ewe details - lambing date, ewe breed, ram breed, number of ewes, ewe age, pregnancy status, potential number of lambs, stocking rate,
- ewe observations - condition score profile,
- pasture observations - feed-on-offer, pasture quality, major species,
- supplementary feeding - feed type, ration, feeding technique and frequency,
- paddock description - topography, shape, aspect, degree of shelter, and
- paddock results - marking percentage, lamb survival and ewe mortality.

The third part of this project involved surveying 150 sheep enterprises to quantify the impacts of mobs size at lambing on marking percentage. A total of 750 mob-paddock observations were recorded from 150 sheep enterprises using the lambing template, via a combination of phone surveying, farm visits and self-reporting by producers. The property details for the enterprises surveyed included a total of 203,055 ha farmed, averaging 1354 ha per enterprise, while the number of ewes joined per annum totalled 397,533 and averaged 2650 ewes per enterprise.

The excel template developed proved to be very effective for collecting large volumes of data, and could be completed independently by producers. A number of these producers expressed interest in using the template to help record paddock lamb survival data so they can reflect on survival results and alter paddock allocation and attributes in the future. Also the template will be effective for collecting data on the key variables influencing lambing results, if the second phase of this project involving paddock demonstrations is undertaken.

Sixty three percent of the enterprises surveyed ultrasound pregnancy scanned their ewes for dries, singles and twins, with an average reproductive rate of 135% (foetuses per ewe joined) and a lamb marking percentage of 101% (lambs marked per ewe joined). This represented an overall lamb survival rate of 75% from scanning to lamb marking, comprising of an 87% survival of single born lambs and a 67% survival of twin born lambs. This equated to a loss of 136,783 lambs between scanning and lamb marking, or 912 lambs per enterprise. The average mob size for lambing was 236 ewes. However, 62% of the enterprises surveyed lambed single and twin bearing ewes in separate paddocks, with an average mob size for single bearing ewes of 268 and an average mob size for twin bearing ewes of 170.

In the fourth part of this project the information collected was used to further define the relationship between the number of ewes in a lambing paddock and marking percentage. It was found that ewe mob size has a significant impact on marking percentage. Across the 750 mob-paddock observations 20% of the variation in marking percentage was due to the ewe mob size at lambing ($p<0.001$). The strength of this relationship reduced when the data were analysed in breed groups (R-squared of 14% for merino ewes and 13% for non-merino ewes), although it was still statistically significant ($p<0.001$).

The strength of this relationship reduced even further when the analysis was undertaken for ewe breed and parity (single and twin bearing mobs) separately, primarily due to a significant reduction in the number of cases in each grouping. Similarly, it was difficult to determine the effects of other variables such as ewe stocking rate, condition score, feed-on-offer, shelter and weather on the relationship between mob size and marking percentage.

The impact of the number of ewes in the mob at lambing on marking rate was significant in non-merino twin and single bearing ewes ($p<0.001$). For every 100 extra non-merino ewes in the mob at lambing twin lamb marking rates declined by 9% in twins and 5% in singles. The number of merino ewes in a mob at lambing was also found to significantly affect twin lamb marking rates ($p<0.01$) but was not significant for single lamb marking rates ($p>0.01$). For every 100 extra merino ewes in the mob at lambing, twin lamb marking rates declined by 6%.

Finally, it is recommended that a series of participatory research sites be undertaken to more accurately record and define the impact of mob size on lamb survival under a range of circumstance, so that clearer recommendations can be provided to industry. Simultaneously, the mob-paddock lambing template developed in this project could be used to collect many more records during the next lambing season, with a heightened accuracy of reporting key variables rather than relying of producers

recalling key information after the event. The design of the participatory research sites should enable the relationship between ewe mob size and lamb survival rate for singles, twins and perhaps triplets to be more clearly defined, as well as exploring the influence of other key variables on this relationship.

This project has provided encouragement for further work in this area, to improve the survival of lambs born in the Australian flock, given this outcome appears to be significantly influenced by ewe mob size at lambing.

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1. Background

Current industry twin lamb survival rates are estimated to be in the order of 50 to 60% for Merinos and 60 to 70% for crossbreds. Comprehensive studies and recommendations are available and adopted widely for the management of ewe nutrition (www.lifetimewool.com.au) to improve lamb survival, however current recommendations to the sheep industry provide vague recommendations about mob size and stocking density at lambing to optimise reproductive performance. For example, the guidelines outlined in Module 10 - Wean More Lambs of the Making More from Sheep manual recommend a maximum mob size for single bearing mature ewes of 400-500, single bearing maiden ewes of up to 250-400 and mature twin bearing ewes of 100-250 ewes. In addition, a maximum stock density of 18 ewes/ha is recommended. There is little information to back up these guidelines. A recent MLA Producer Demonstration Site (PDS) at Glenthompson in western Victoria (B.PRS.0708/PIRD2007/V01) observed that lamb marking percentages improved by between 14-22% with smaller mob size, although the number of flocks involved was limited. Smaller mob size should improve lamb survival by reducing the risk of mismothering. If this was a true representation of the potential improvement, major industry benefits could be gained by managing mob size at lambing.

A range of factors affect lamb survival and it would seem that from limited information, mob size at lambing can have a significant affect. The PDS mentioned above demonstrated the impact of mob size, when a property running adult crossbred ewes (not pregnancy scanned) lambed in 3 smaller mobs (101, 124, 131) with an average mob of 119 ewes marked 151% lambs compared to 3 larger mobs (235, 298, 328) with an average mob of 287 ewes marked 129% lambs. Observations on a number of Mackinnon Project clients' properties indicated a similar response.

Work by Doug Fowler in the 1980s found smaller mob size increased lamb survival in twin bearing ewes; however, industry does not appear to have embraced the findings of this work by changing on farm practices to implement smaller mob sizes of twin bearing ewes at lambing.

2. Project objectives

The objective of this project is to determine if there is enough existing information to provide rigorous recommendations on the optimum mob size for lamb survival of both single and twin born lambs to enable producers to make a more informed decision about the cost-benefit of implementing smaller mobs at lambing.

3. Methodology

The four parts of this project are outlined below, and relate directly to the stages in the methodology undertaken;

1. Completion of a review of the literature, research projects and demonstration sites addressing the impact of lambing mob size and paddock aspects on single and twin lamb survival.

2. Design of a survey that includes a template for recording mob and paddock details for use in this phase of the project along with any future work in this space.

3. Survey of 150 sheep producers to quantify the impacts of mob size at lambing on lamb survival using existing data from commercial properties that have detailed lambing records, plus research and demonstration sites including MLA-funded Producer Demonstration Site's (PDS).

4. To analyse these outcomes along with past research to determine if there is adequate evidence to develop guidelines for recommended mob size for ewes at lambing, with consideration for other factors such as FOO, condition score, stocking rate, paddock size and breed type.

5. Provide recommendations on the requirements for further R&D in this space and to guide the development of any future R&D

Methodology of the survey

The survey conducted comprised of two parts, firstly a general survey summarising overall farm reproductive performance and general farm management relating to the reproduction, including rating the producers' ability to assess FOO and condition scoring. The second part of the survey collected detailed paddock specific information. The survey template is listed in Appendix one.

Data were collected from farms about their specific sheep enterprises by mail out, phone interview, email and direct property visit where producers confirmed they had the data available. Data were collected primarily for 2012 and 2013 lambings, with a few from earlier years. Many producers could not complete the survey due to inadequate records specifically relating to the number of ewes in individual paddocks and their lamb marking percentages. In addition, many producers combine the small mobs at lamb marking to improve throughput thus lose the specific data for individual paddock mobs.

The overall flock reproductive data collected included the number of ewes joined, the breakdown of scanning performance including, the number of dry, single and multiple pregnancies so the potential reproductive performance (foetuses) could be calculated. The overall number of lambs marked was recorded so overall lamb marking percentage and lamb survival could be calculated.

General farm management information was collected, including management of predators, skills in pasture and condition score assessment and allocation of pregnant ewes to lambing paddocks.

Detailed individual paddock records were collected where available. Basic information on individual mobs including paddock area, ewe number to calculate stocking rate, mob size and age, ewe and ram breed and lambing time were all

recorded. Pregnancy status was recorded where available to calculate potential lambing performance and lamb survival.

Given the importance of fertility, data were collected on nutritional status including FOO at the point of lambing, serial body condition score, supplementary feeding and strategies associated with supplementary feeding. Information about the type and perceived effectiveness of shelter and paddock topography were also collected. Ewe mortality rates over the lambing period were collected where available and all data from each enterprise and paddocks were collated for analysis.

Scales from 1 to 5 with relevant descriptors were developed for subjective paddock factors. These included rating the paddock shelter, weather conditions during lambing, pasture quality and fox control. For the producers' self-assessment of pasture quantity and condition scoring skills, scales were developed from 1 (low skill level) to 10 (high skill level).

Nature of data

Collection of survey data was undertaken via postal return via mail out, phone, email and farm visits. Retrospective collection of data was difficult at a number of levels. Firstly, many producers (estimated at over 60% of producers contacted) could not contribute to the data set due to insufficient accurate paddock and lambing records. Secondly, recollection of physical information was difficult at a number of levels. Pasture assessment (FOO) and ewe condition score and feeding records were based on farmer recollection with few having written details. Recollection of the weather during lambing was subjective and the perspective of the severity was variable even on closely located properties lambing at similar times.

The view of the skill of the operator particularly if assessing pasture FOO and condition score of ewes should be reasonable as many have being trained either through LTEM courses, Prograze courses, through other groups such as BESTWOOL/ BESTLAMB or individually. Even so there is a significant potential source of error when compounding the skill of the operator with the fact that many records were based on farmer recollection.

Records are also subject to interpretation which will potentially complicate the results. For example, the rating of paddock shelter was rather subjective. The perspective of how good shelter is varies with the individual producer and without individual inspection of all paddocks there can be variation of the rating given. For example, a producer living on the plains of western Victoria will have a different view of good shelter compared with a producer in north east Victoria surrounded by steep hills. Where possible, attempts were made to minimise the individual interpretation though it would not be eliminated.

The whole-farm reproduction data presented in this study should not be interpreted as being representative of the broader sheep industry, as nearly three quarters of the producers were scanning for multiples, which is almost 5-times the national average.

4. Results and discussion

1.1 Literature review

Introduction

Many studies have been made of the contributing factors to lamb survival; ewe condition (Oldham et al., 2011), nutrition during pregnancy (Thompson et al., 2011) and maternal behaviour/breed (Dwyer, 2007) have all received considerable research effort. However, none of these studies have looked at variable mob size or stock densities as a cause of mismothering, and consequent lamb mortality. Furthermore, many studies that have investigated the role of maternal behaviour on lamb survival have employed a methodology that has used only small mob sizes, or where ewes have been in relative isolation from other ewes through the use of lambing pens or yards (Holmes, 1976; Owens et al., 1980). In such cases it is impossible to assess the impacts of mob size and stocking density on lamb survival.

Whilst reproductive processes can be influenced by stress (Giles et al., 1994) which can be caused by elevated stock densities, there remains little research into the impacts of both stocking rate and mob size on lamb survival.

In semi-wild or feral scenarios, ewes have been observed to isolate themselves from the mob during parturition for up to 3-4 days, this period of isolation reduces the chance for mismothering and is critical to the formation of the bond between the dam and newborn lamb (Kilgour R, 1972). As lamb production intensifies in an agricultural context, we inadvertently reduce the opportunity for this period of isolation and it may be that specialised management guidelines are required to minimise losses associated with mismothering. Cloete (1992) concludes that management practices should facilitate ewes remaining at the birth site for as long as possible after lambing, with a need to avoid higher stock densities at lambing.

We are concerned that ewes run in larger mobs will have altered maternal behaviour, isolating themselves from the lambing mob for a reduced period of time, if at all, whereby the incidence of mismothering will be greater – along with an increase in lamb mortality. This review collates literature relevant to the impacts of stocking rates and mob size on lamb survival.

Current recommendations

Despite a number of organisational documents recognising the importance of stocking rate at lambing to subsequent lamb survival, there appears to be a paucity of published peer reviewed research that underpins any of the available recommendations.

For example Cottle (1991) identifies that mismothering appears to increase with very high stocking rates, yet offers no recommendation on how to deal with the risk than to suggest that mobs with a high proportion of multiples should be lambed in several smaller paddocks (with good feed and several water sources to minimise chances of permanent separation of lambs from ewes).

Kelly and Dean (1987) go one further, and providing a recommended stocking rate – in this case a generic recommendation with no mention of the ewes pending birth status.

- 'Stocking rates of more than 18 lambing ewes per hectare were typical of research studies where mismothering and lamb stealing were evident' Kelly and Dean (1987)

Other examples are focused on the needs of multiple bearing ewes.

- Stocking rates of 11-15 ewes + multiples/ha are typical with a sward height of 6 cm at turnout. With higher stocking rates than this mismothering is more likely, but singles have been stocked at up to 35-40/ha to keep swards short and reduce birth weight and hence lambing difficulty (Meat Promotion Wales, 2004).

Furthermore, there are a limited number of industry publications that cite specific stocking rate/management recommendations for triplet bearing ewes.

- To date there is no published research data on the effect of triplet densities and survival. However, it is recommended to manage lamb densities so that triplets are not all lambing at the same time in a small paddock (Beef + lamb New Zealand, 2005).
- Lamb at a lower stocking rate, 5-10 ewes per ha has been suggested. However, on intensive farms more ewes per hectare might be grazed, but good shepherding is required (Burton, undated).

Interesting, none of the previously quoted recommendations, including Kelly and Dean (1987), studies actually cite specific research findings. Of the available published scientific literature Cloete (1992) recommends avoiding stock densities of greater than eleven pregnant ewes per ha, while Robertson (2012) is less prescriptive and concludes that caution is needed when lambing ewes at high stocking rates.

Stocking rate

Robertson (2012) found that the survival rates of twin born lambs was 24% lower from merino ewes run at high (30 ewes/ha) compared to low (16 ewes/ha) stocking rates at lambing. Increases in lamb losses were attributed to a greater portion of lambs dying from starvation, mismothering and exposure in the high stocked treatment. In this case, all lambing ewes had access to shelter belts, and the variable stocking rate was achieved by altering the number of ewes per plot, as opposed to varying the plot area with a consistent mob size; the high stocked treatment having fifteen ewes per 0.5ha plot, and the low stocked treatment having eight ewes per 0.5ha plot. These results show there was 24% lower survival of twin born lambs at high compared to low stocking rates. Although it should be noted that very small mob sizes were being employed in this study, which may have influenced the results. It could be reasonably expected that at larger mob sizes the incidence of mismothering would be even greater, given the increased number of ewes lambing on a given day (Alexander et al., 1983a).

In agreement, Cloete (1992) found that for every one ewe increase in stocking rate per hectare at lambing, there was a 2% increase in the number of twin bearing ewes being permanently separated from one of their lambs. The studied stocking rates ranged from 2 to 20 ewes per ha, and included both Dormer and SA Mutton Merino ewes. While there was no reported breed difference in the number of lambs being permanently separated from the ewe, the incidence of permanent separation caused by interference from other ewes was greater in Dormers than SA Mutton Merinos, indicative of breed based differences in the ability for ewes to successfully rear multiple lambs.

Contra to the finding of increased lamb losses at higher stocking rates of Robertson (2012) and Cloete (1992), Winfield (1970) evaluated two different stocking rates (14.3 versus 143 ewes/ha) at lambing and found no treatment effect on overall lamb survival – yet there was variation in the cause of lamb losses between the two stocking rates. Both stocking rate groups produced 144 lambs from 116 Corriedale ewes. With 93 and 97 lambs surviving from the low and high stocking rate groups, respectively. Importantly to this review, both treatments were run at a relatively low mob size of 116 ewes, and are unable to be used in an assessment of mob size on ewe behaviour and lamb survival. For the high stocking rate treatment, there was double the number of lambs separated from their dams within 2hrs of birth due to the interference of an 'alien' ewe – the higher stocking rates facilitated contact between poorly mothered lambs and alien ewes, with approximately half of these 'mismothered' lambs then subsequently dying. At the lower stocking rate, more lambs died from desertion, which means the lambs died after becoming permanently separated from their dams, with no interference from other ewes.

Winfield concluded that stocking rate had no impact on overall lamb survival, and that the survival rate of mismothered lambs was high (despite being only 50%). However, under poor weather conditions interference from alien ewes may be more critical, and having weakened lambs in such conditions may result in higher levels of lamb loss.

The longer that a ewe remains at the birth site, the better the ewe lamb bond. This has been shown to be instrumental in reducing mismothering and increasing lamb survival rates (Cloete, 1992; Alexander et al., 1983b). However, neither Winfield (1970) nor Robertson (2012) reported on the duration that ewes remained at the birth site, and were unable to show reduced time at the lambing site at higher stocking rates. To date there has been no published material found that investigates the link between stocking rate and the length of time that the lambing ewe isolates from the mob. While Cloete (1992) presents results linking both stocking rate and time at the birth site to lamb survival, there is no connection of these two variables.

Whilst the impacts of stocking rate on ewe isolation has not been evaluated, available feed has been shown to influence the time that a ewe remains at the birth site. Alexander et al., (1983b) found that ewes remained at the birth site 2hr when feed was sparse, compared to 6.5hr when feed was more abundant – although there may have been a breed effect on maternal behaviour in this particular case. As stocking rate impacts on the available pasture, which then impacts the length of time a ewe stays at the birth site, it is reasonable to expect that an unfavourable relationship would exist between stocking rate and time ewes spend at the birth site.

Additionally, there are factors other than mob and paddock size that will contribute to periods of altered stock density. Wet weather has the potential to cause high concentrations of lambing ewes in sheltered areas, and can increase mismothering (Meat Promotion Wales, 2004) and may contribute to the deaths of poorly mothered lambs (Winfield, 1070).

Mob size

Work conducted by the Glenthompson BESTWOOL/BESTLAMB group on lamb survival looked at mob size as a contributor to lamb survival (Glenthompson BESTWOOL/BESTLAMB, 2011). Three independent on farm case studies repeated the finding that there were higher survival rates in smaller lambing mobs. Stocking rates, feed on offer and available shelter were kept consistent between lambing mobs, with mob size being the primary variable. When mature crossbred ewes, which had not been pregnancy scanned (ie. twin and singles were randomised across paddocks), lambed in smaller mobs (avg 119 ewes) they marked 22% more lambs than ewes in larger mobs (avg 287). There was a similar trend for merino ewes that had not been pregnancy scanned; mobs with greater than 200 ewes at lambing averaged 79.8% lamb marking rate, while mobs less than 200 ewes averaged 93.3% lamb marking rate. The final on farm trial assessed lamb survival from cross bred ewes scanned as twin bearing. In this case mobs of fewer than 200 ewes had an average lamb survival to marking of 89.3%, while those over 400 averaged 79% lamb survival to marking. The stocking rate for these on farm trials was not provided, but there remains a consistent result by which lamb survival has been greater in smaller mobs.

The on-farm trials associated with the Glenthompson BESTWOOL/BESTLAMB group demonstrate that the impacts of various mob sizes may be different for cross bred versus merino ewes. Differences in survival may be due to other factors associated with different breeds such as the length of parturition and time taken for ewes to stand (Cloete, 1992) but will also be driven by the ability for a ewe to maintain contact with her lambs at various stock densities at lambing. Alexander et al., (1983b) found that 46% of twin bearing merino ewes became permanently separated from one of their lambs, versus 9% for New Zealand Romneys that had been selected for their ability to rear multiple lambs.

Table 1. Suggested mob sizes at lambing for single and twin bearing, maiden and mature ewes (Glenthompson Best Wool final report, 2011)

Flock type	Maximum recommended flock size
Twin bearing mature ewes	200
Single bearing mature ewes	400
Single bearing maiden ewes	300
Twin bearing maiden ewes	150

While results presented within the final report do not state which case studies used maiden as opposed to mature ewes, recommended flock sizes are provided for both stock classes. The recommendations for mature ewes in Table 1 are repeated within the Wean More Lambs module of Marking More from Sheep (undated) yet are presented as a guide only, and in the context that other factors need to be considered.

The hypothesis that mob size is an important consideration to lamb survival is supported by Kleemann et al., (2006) who concluded that lamb survival (in merinos) was related to mob size, not stocking rate. They suggest a curvilinear relationship, with an optimum size of 414 and 386 ewes for single and twin bearing mobs respectively, although we have some reservations about this conclusion for the data presented. While this provides some alignment to the recommendations in the Glenthompson BESTWOOL/BESTLAMB (2011) (Table 1) for single bearing ewes, there is a considerable discrepancy for guidelines for twin bearing ewes. They speculated that the relationship between lamb survival and flock size may be due to reduced predation pressure on a per ewe basis in larger flocks, or that in larger flocks parturient ewes were less likely to move prematurely from the birth site – however they also conclude that a number of factors are likely to be involved, but that the significance of them is not well understood.

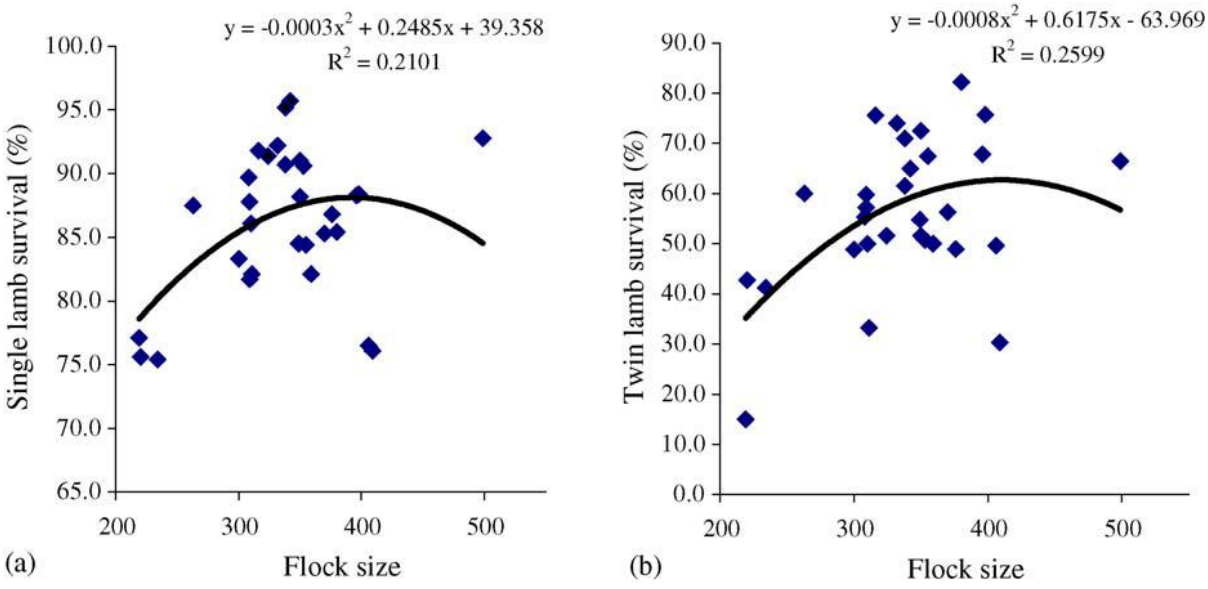

Figure 1. Quadratic relationship of (a) single lamb survival (single lambs at tail docking of expected lambs born) and (b) twin lamb survival (twin lambs at tail docking of expected lambs born) with flock size in mature (2 year old) South Australian commercial Merino flocks exposed to rams in the October to December period, Kleemann *et al*. (2006).

The studied stocking rates of Kleemann et al., (2006) ranged from 2.9 to 23.9 ewes/ha and did not influence the survival of either single or twin born lambs. The finding that stocking rate did not impact on lamb survival is in agreement with that of Winfield (1970). Although, given stocking rate impacts on the available pasture, which then impacts the length of time a ewe stays at the birth site, it is reasonable to expect that an unfavourable relationship between stocking rate and lamb survival. Beyond stocking rates, Hatcher et al., (2010) raised concerns over the number of ewes making use of stock camps during a lambing period – given the period of increased stock densities that may result in higher rates of mismothering, particularly with twin bearing ewes. As a result, they recommend a mob size of no larger than 200 to alleviate the problems, but highlight the limitations in terms of number of lambing paddocks with adequate shelter.

At high stocking rates, (30 versus 16 ewes/ha) ewes have higher levels of contact with their lambs and walk further per day (Broster et al., 2012). The possible explanation for the greater distance walked is that the ewes from the high stocking rate treatment spent greater periods of time searching for their lambs – given the greater number of unrelated lambs in their proximity. Whilst this cannot be definitively concluded, it is plausible and supports that it is not just overall stocking rate that is important, but the actual number of animals in a given environment that is important.

In trials undertaken by Fowler (1989) investigating management strategies for high fecundity flocks it was found that twin bearing ewes should be lambed in mobs of less than 200, meaning that less than 10 fresh lambs would be born per day over a conventional lambing period. The fewer number of lambs born per day means there are fewer interactions between ewes and other lambs, less mismothering and higher twin lamb survival (Fowler 1989). In this study increases in twin lamb survival also resulted when twin bearing ewes were lambed in larger paddocks, further reducing the interactions between ewes and lambs other than their own, reducing mismothering. The number of ewes lambing per day and paddock size was found to have no effects on single lamb survival (Fowler 1989).

Mismothering

Mismothering is the most important contributor to the increased lamb mortality associated with higher stocking rates (Robertson, 2012; Coetle, 1992), and whilst the Glenthompson BESTWOOL/BESTLAMB (2011) final report does not outline the causes of lamb mortality, mismothering remains the most likely contributor to increases in lamb mortality associated with mob size.

Alexander et al., (1983a) studied the incidence of mismothering at lambing, along with the subsequent survival of those lambs separated from their mothers. Of lambs that had been separated from their mothers only 43% of singles, 34% of twins and 9% of triplets survived through to weaning due to foster ewes – the others died. In this case, 600 ewes were lambed in 6ha paddocks (on a daily basis, ewes yet to lamb were drifted out of the paddock, leaving behind freshly lambed ewes – gradually reducing the number of ewes in the shifted mob). Results show that a daily inspection of lambing ewes would have resulted in 9% of singles, 15% twins and 24% of triplets having incorrect pedigree information due to mismothering.

Whilst this evidence of the number of lambs that at less than 1 day of age are suckling from a ewe that is not their birth dam highlights how readily mismothering can, and does occur, it fails to make an assessment of the impacts of various mob sizes or stocking rate on this relationship. Pertinent to this review is not only the issues associated with accurate pedigree information for seed stock producers, as was the impetus behind this work, but more pressingly the subsequent survival through to weaning of lambs that are separated from their birth mother. The presented results do not make an assessment of the impact of mob size on mismothering, and this remains an area of required research.

In the collection of data on the incidence of mismothering, there is a need to account for breed and parity data. For example, research by Shelly (1970) found that 'pre-lambing maternal interest' was relatively uncommon – only 14 of 235 ewes displaying such behaviour, even at a stocking rate of 235 ewes/ha. In this case ewes that had displayed pre-lambing maternal interest in another ewes' lamb, lost interest in the alien lamb during labour, to the point that only three of sixty one lambs that died were linked to mismothering. However, this is for a mob of merino ewes of mixed ages, with presumably a limited number of multiple births. The same relationships of limited losses to mismothering may not translate to a more highly fecund scenario, and indeed the work of Alexander *et al.* (1983a) would indicate this to be true.

Concluding remarks

There are conflicting data on the role of increased stocking rates on lamb survival. Both Winfield (1970) and Kleeman et al., (2006) found that increased stocking rates had no impact on lamb survival, while Robertson (2012) found the opposite – citing a 24% reduction in the survival of twin born lambs from high to low stocking rates. However, in many of these examples mob sizes have been small, and mob size may be so important that in some cases it is the small mob sizes that have offset the potential effects from stocking rate. For example, it may be that the only reason that Winfield (1970) found no impacts of two extreme stocking rates on lamb survival was that all groups were only run in small mobs of 116 ewes – and while this is larger than the numbers used by Roberston (2012), they are still considerably smaller than those found in many commercial lamb operations.

The impacts of mob size on lamb survival are less ambiguous, where there has been research the results are all in agreement that survival rates will be greatest at lower mob sizes. However, there has been limited research in this space, to the point that there is little in the way of recommendations – with even less in regards to specific recommendations of mature versus maiden, single versus multiple bearing ewes, maternal versus merino genetics or under varying amounts of paddock feed.

It is likely that all of these four considerations; (i) prior reproductive experience, (ii) parity, (iii) breed and (iv) paddock variables (eg. level of feed or shelter) will be interrelated in how they impact on both mob size and stocking rates. To that end, the design of any future research would be well served to account for these variables. Furthermore, and while it will be impacted on by the complexities with addressing multiple contributing factors, there is a need for research that addresses the issues of mob size at a realistic paddock scale, as opposed to those typically used in a more intensive research environment.

The concern that ewes run in larger mobs at lambing having altered maternal behaviour, has not been dispelled through reviewing the available literature. There is little evidence to link various stocking rate or mob sizes to key maternal behaviours such as ewes isolating themselves from the lambing mob. Furthermore there remains a paucity of data that enables an assessment of the links between stocking rates and mob sizes to mismothering, and subsequent increases in lamb mortality.

1.2 Design template for mob-paddock lamb survival data

The methodology undertaken in this project involved designing a survey for recording lambing mob and paddock details. The survey was designed using an excel spread sheet for the mob-paddock based template, which is outlined in Appendix 1. The survey firstly records farm summary data including the following;

- property details - name, size, location,
- overall flock reproduction data - ewes joined, scanning and marking percent,
- lamb survival - single, twin and overall, and
- flock management - predator control, condition score and pasture assessment skill level, weather rating for lambing and average lambing mob sizes.

The survey then has a mob-paddock template that records the following;

- paddock details - name, size,
- ewe details - lambing date, ewe breed, ram breed, number of ewes, pregnancy status, potential number of lambs ewe age, stocking rate,
- ewe observations - condition score profile,
- pasture observations - feed-on-offer, pasture quality, major species,
- supplementary feeding - feed type, ration, feeding technique and frequency,
- paddock description - topography, shape, aspect, degree of shelter, and
- paddock results - marking percentage, lamb survival and ewe mortality.

The excel template developed proved to be very effective for collecting large volumes of data, and can be completed independently by producers. In fact a number of producers have expressed interest in using a template of this nature to help record paddock lamb survival data so they can reflect on survival results and alter paddock allocation and attributes in the future. Also, the template will provide the basis for data to be collected if the second phase of this project involving on-farm participatory research is undertaken.

Prior to using the template for the purposes outlined above, it should be refined based on the usefulness of the data collected in each section of the template and the nature of responses to the questions during this study.

1.3 Survey 150 sheep enterprises with mob-paddock template

A total of 750 mob-paddock observations have been recorded from 150 sheep enterprises on the template using a combination of phone surveying, farm visits and self-reporting by producers.

Properties details

The property details for the 150 sheep enterprises surveyed are outlined in Table 2. The area farmed totalled 203,055 ha and averaged 1354 ha per enterprise, while the number of ewes joined per annum totalled 397,533 and averaged 2650 ewes per enterprise.

Table 2. Properties details for the 150 sheep enterprises surveyed

Parameter	Average	Range
Farm area (ha)	1354	100-13,000
Number of ewes joined per annum (ewes)	2650	228-31800
Potential reproductive rate - foetuses/ewe joined (%)	135	75-176
Percentage of ewes pregnant (%)	91	75-98
Marking rate - lambs marked/ewes joined (%)	101	60-154
Overall lamb survival (%)	75	54-95
Single lamb survival (%)	87	63-97
Twin lamb survival (%)	67	36-89
Single mob size for lambing (ewes)	268	100-1,000
Twin mob size for lambing (ewes)	170	72-500

Sixty three percent of the enterprises surveyed ultrasound pregnancy scanned their ewes for dries, singles and twins, with an average reproductive rate of 135% (foetuses per ewe joined) and a lamb marking percentage of 101% (lambs marked per ewe joined). This represented an overall lamb survival rate of 75% from scanning to lamb marking, comprising of an 87% survival of single born lambs and a 67% survival of twin born lambs (Table 2). This equated to a loss of 136,783 lambs between scanning and lamb marking, or 912 lambs per enterprise. Previous studies indicate that typically only a small component (<5%) of this loss is due to abortion prior to lambing.

The average mob size for lambing was 236 ewes (data not presented). However, 62% of the enterprises surveyed lambed single and twin bearing ewes in separate paddocks, with an average mob size for single bearing ewes of 268 and an average mob size for twin bearing ewes of 170 (Table 2).

Ninety four percent of the producers surveyed felt they had previously undertaken training in condition scoring and rated their own skill level for condition scoring sheep 8 out of 10 (data not presented). Ninety seven percent of the producers surveyed felt they had previously undertaken training in pasture assessment and rated their skill level for assessing pasture quantity and quality 7.9 out of 10 (data not presented).

1.4 Quantify the impacts of mob size on lamb marking rates

The aim of this section of the project was to analyse data collected to determine if there is adequate evidence to quantify the impacts of mob size on lamb marking rates. If so, more precise guidelines for recommended mob size for ewes at lambing could be developed, with consideration for the impact of other factors such as breed type, ewe stocking rate, condition score, feed-on-offer, paddock size and weather/paddock shelter, on the relationship between mob size and marking rate.

Relationship between ewe mob size at lambing and marking percentage

From the data collected in the survey, where there were 750 individual mob-paddock observations, the relationship between ewe mob size and marking percentage across all paddocks and breeds is depicted in Figure 2.

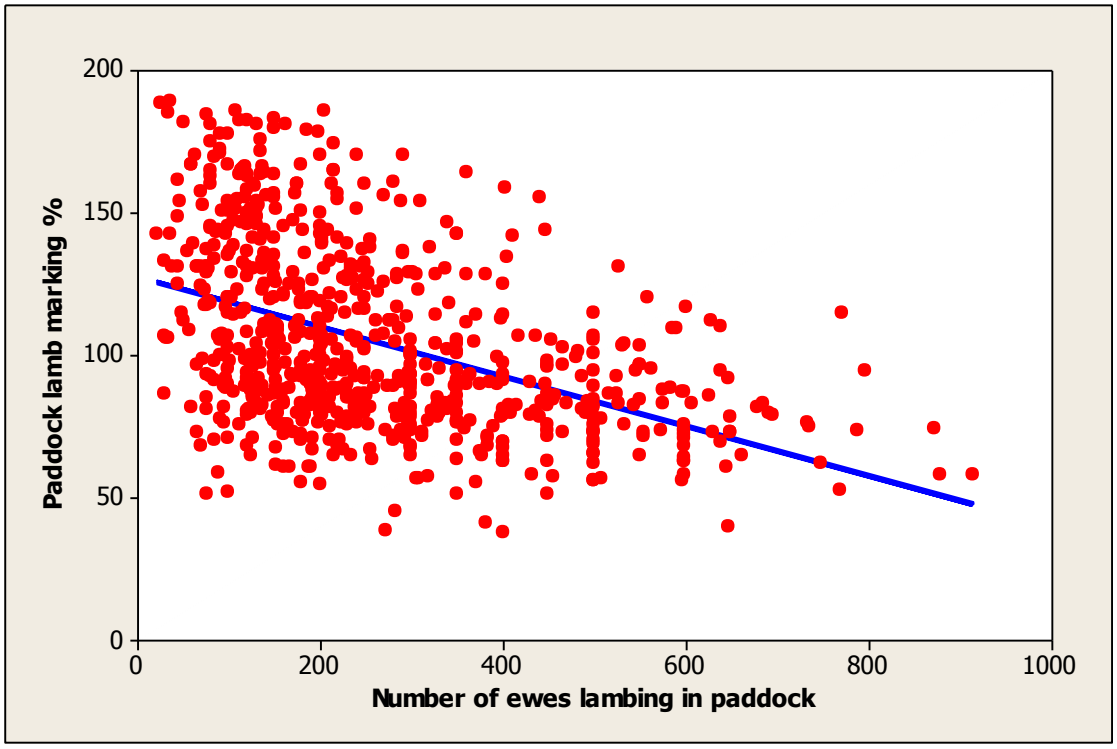

Figure 2. Relationship between ewe mob size at lambing and lambs marked.

The R-squared for the relationship between ewe mob size at lambing and lamb marking percentage is 20%, and is statistically significant at $p<0.001$. Therefore 20% of the variation in marking percentage is explained by the number of ewes in the lambing paddock. For every 100 extra ewes in the lambing paddock, lamb marking rates drop by 9% (Figure 2).

The next analysis undertaken was to segregate the mob-paddock observations based on ewe breed. This resulted in 529 mob-paddock observations that involved merino ewes and 212 mob-paddock observations that involved non-merino ewes.

The relationship between merino ewe mob size and marking percentage is depicted in Figure 3.

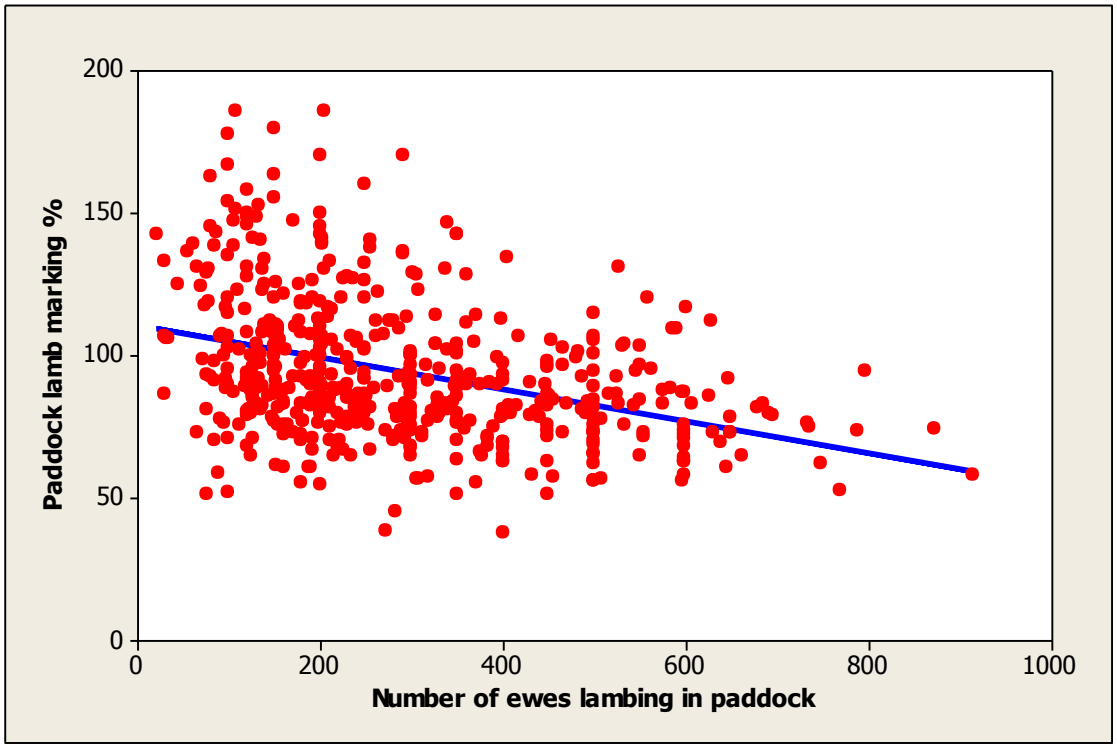

Figure 3. Relationship between merino ewe mob size at lambing and lambs marked.

The R-squared for the relationship between merino ewe mob size at lambing and lamb marking percentage is 14%, and is statistically significant at $p<0.001$. Therefore 14% of the variation in marking percentage in merinos is explained by the number of ewes in the lambing paddock. For every 100 extra merino ewes in the lambing paddock lamb marking rates drop by 6% (Figure 3).

The relationship between non-merino ewe mob size and marking percentage is depicted in Figure 4.

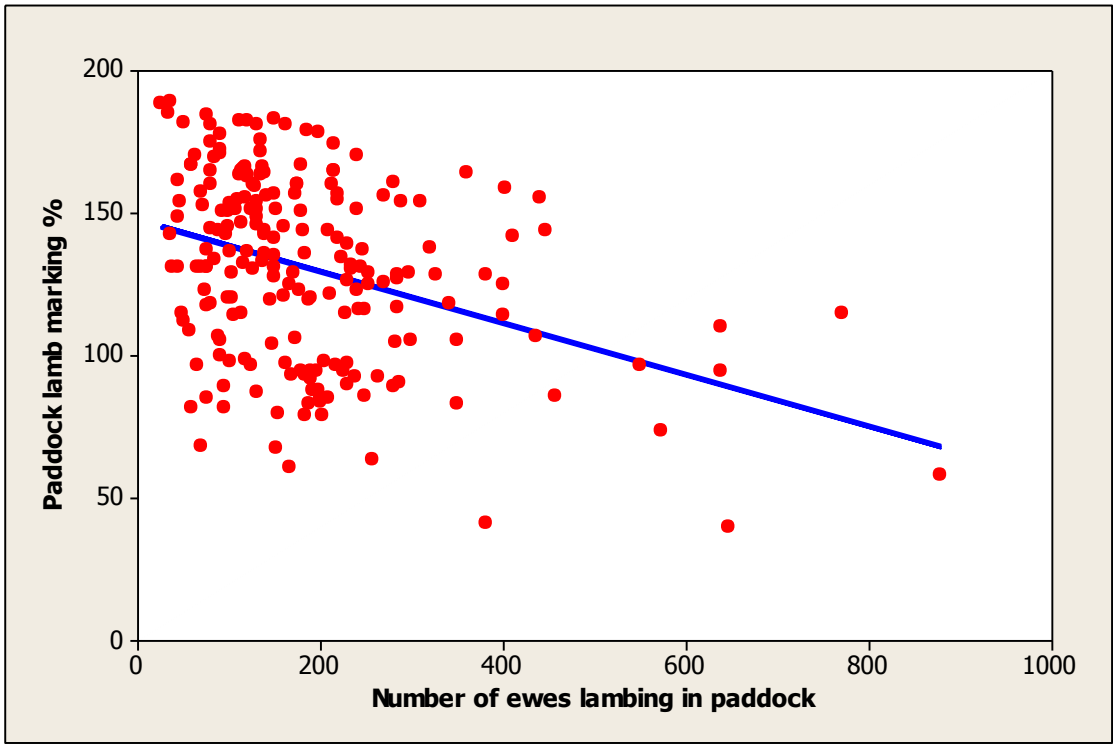

Figure 4. Relationship between non-merino ewe mob size at lambing and lambs marked.

The R-squared for the relationship between non-merino ewe mob size at lambing and lamb marking percentage is 13%, and is statistically significant at $p<0.001$. Therefore 13% of the variation in marking percentage in non-merinos is explained by the number of ewes in the lambing paddock. For every 100 extra non-merino ewes in the lambing paddock lamb marking rates drop by 9% (Figure 4).

The sum of the R-squared values for merino ewes (14%) and non-merino ewes (13%) doesn't equate to the overall R-squared of 20%, due to the nature of the analysis undertaken.

The next step in the analysis was to segregate merino ewes in groups based on their parity, twin bearing and single bearing. The number of mob-paddock observations in each group dropped to 92 for merino twin bearing ewes and 75 for merino single bearing ewes. The relationship between ewe mob size and marking percentage for twin bearing merinos and single bearing merinos is depicted in Figure 5.

The R-squared for the relationship between merino ewe mob size at lambing and lamb marking percentage in twins is 7%, and is statistically significant at $p<0.01$. Therefore 7% of the variation in marking percentage in merino twins is explained by the number of ewes in the lambing paddock. For every 100 extra merino ewes in the lambing paddock lamb marking rates of twins drop by 6% (Figure 5). As can be seen in Figure 5, there was no significant relationship between ewes mob size at lambing and marking percentage in merino singles ($p>0.10$).

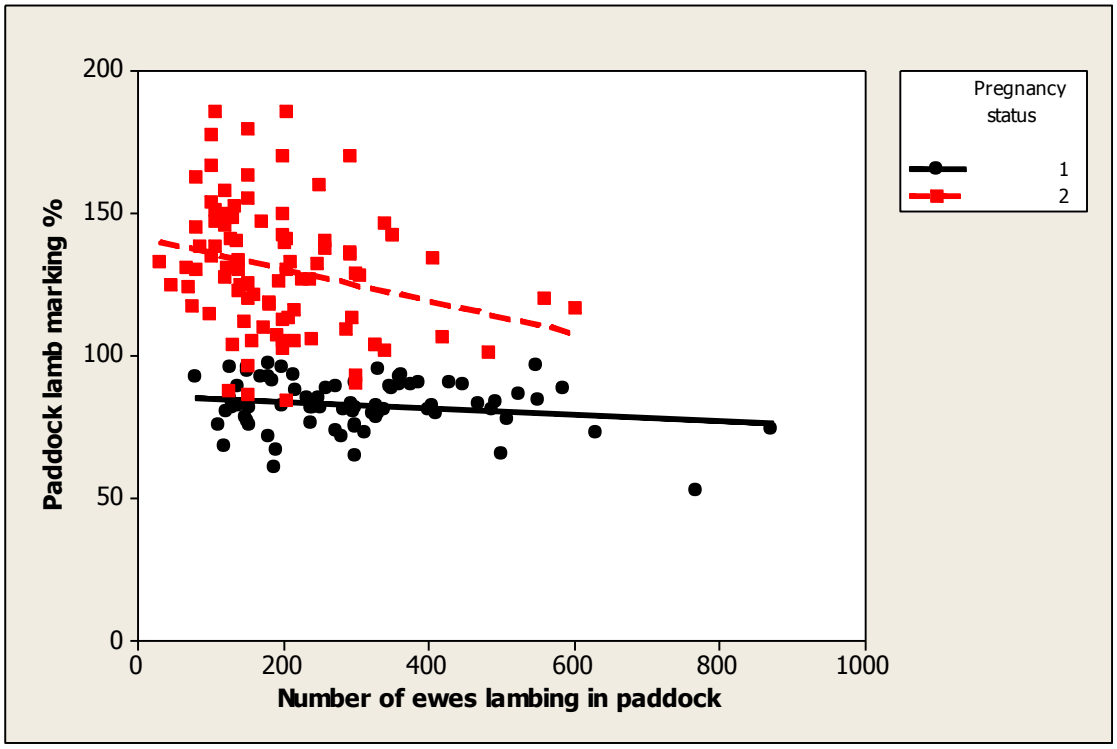

Figure 5. Relationship between merino ewe mob size at lambing and lambs marked in single (black) and twins (red).

The next step in the analysis was to segregate non-merino ewes in groups based on their parity, twin bearing and single bearing. The number of mob-paddock observations in each group dropped to 92 for non-merino twin bearing ewes and 41 for non-merino single bearing ewes. The relationship between ewe mob size and marking percentage for twin bearing and single bearing non-merinos is depicted in Figure 6.

The R-squared for the relationship between non-merino ewe mob size at lambing and lamb marking percentage in twins is 18%, and is statistically significant at $p<0.001$. Therefore 18% of the variation in marking percentage in non-merino twins is explained by the number of ewes in the lambing paddock. For every 100 extra non-merino ewes in the lambing paddock lamb marking rates of twins drop by 9% (Figure 6).

The R-squared for the relationship between non-merino ewe mob size at lambing and lamb marking percentage in singles is 32%, and is statistically significant at $p<0.001$. Therefore 32% of the variation in marking percentage in non-merino singles is explained by the number of ewes in the lambing paddock. For every 100 extra non-merino ewes in the lambing paddock lamb marking rates of singles drop by 5% (Figure 6).

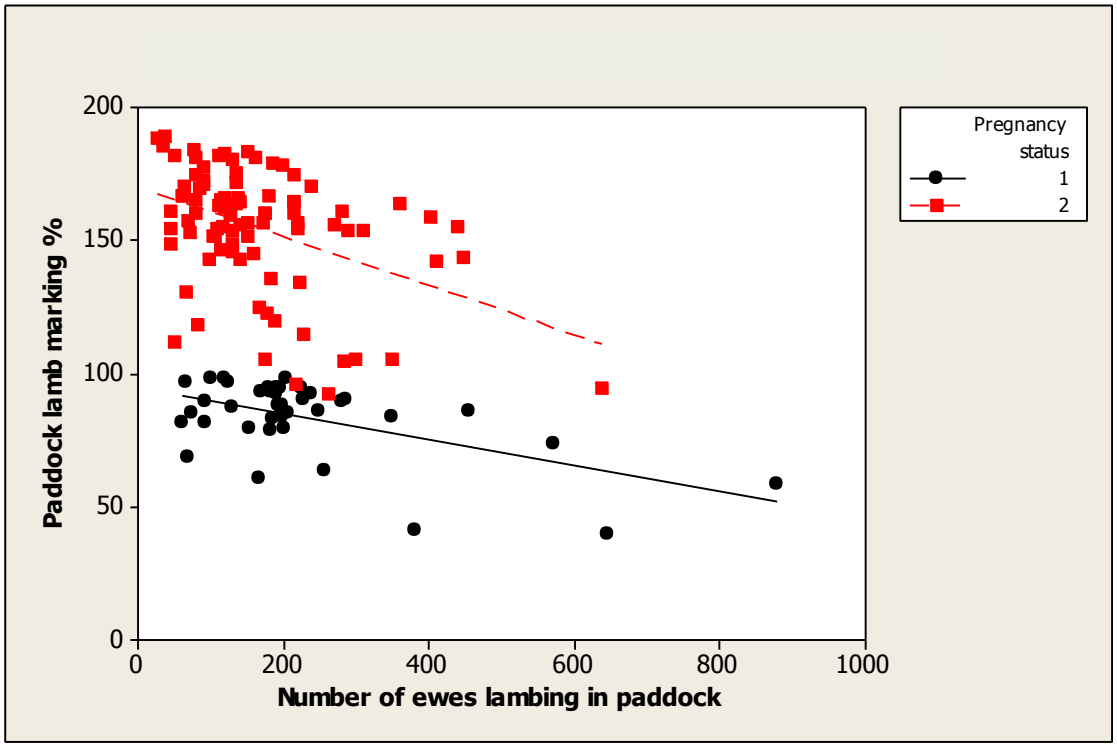

Figure 6. Relationship between non-merino ewe mob size at lambing and lambs marked in singles (black) and twins (red).

Comment on individual farm relationships between mob size and marking rates

When examining the data from individual properties, there were large variations in the relationship between mob size and lamb marking percentage. It was noted that on some properties with large ewe mob sizes in large paddocks, the R-squared was close to zero. Some of these properties had a huge abundance of feed at lambing or the topography was very undulating meaning that ewes were lambing in small microclimates rather than running as a large mob. In contrast, some properties had very good relationship between smaller mob size and larger lamb marking percentages with the R-squared in some cases exceeding 35-45%.

Comment on quantifying the cost-benefit of reducing mob size to improve marking rate

A key outcome of future work will be to accurately determine the relationship between mob size and lamb marking percentages. With the relationship between mob size and lamb marking percentage better understood, tools could be developed to enable producers to determine the cost benefit and return on investment of strategies such as investing in paddock subdivision with extra fencing and water, to improve lamb survival and reproductive performance. Currently, there is no good data to make these important decisions, though the survey highlights that there could be worthwhile investment to improve farm profitability.

5. Conclusion and recommendations

The literature review undertaken highlighted the lack of clear recommendations for sheep producers on lambing paddock management, particularly regarding the impact of ewe mob size on resultant marking percentage. The template designed in this project to record mob-paddock observations and lambing results has proven to be highly effective for collecting detailed information on key variables influencing lambing results. A total of 750 mob-paddock observations were collected and the information collected has been used to further define the relationship between the number of ewes in a lambing paddock and marking percentage.

It was found that ewe mob size has a significant impact on marking percentage. Across the 750 mob-paddock observations 20% of the variation in marking percentage was due to the ewe mob size at lambing ($p<0.001$). The strength of this relationship reduced when the data was analysed in breed groups (R-squared of 11% for merino ewes and 10% for non-merino ewes), although it was still statistically significant ($p<0.001$). The strength of this relationship reduced even further when the analysis was undertaken for ewe breed and parity (single and twin bearing mobs) separately, primarily due to a significant reduction in the number of cases in each grouping. Similarly, it was difficult to determine the effects of other variables such as ewe stocking rate, condition score, feed-on-offer, shelter and weather on the relationship between ewe mob size and marking percentage.

Despite the reduction in the number of cases when the data was analysed within ewe breed type and parity, the impact of the number of ewes in the mob at lambing on marking rate was still significant in non-merino twin and single bearing ewes ($p<0.001$). For every 100 extra non-merino ewes in the mob at lambing twin lamb marking rates declined by 9% in twins and 5% in singles. The number of merino ewes in a mob at lambing was also found to significantly affect twin lamb marking rates ($p<0.01$) but was not significant for single lamb marking rates ($p>0.01$).

As highlighted in the overall data collected on each enterprise, lamb survival remains a significant wastage point in the sheep flocks surveyed, with only 75% of the foetuses conceived resulting in live lambs at marking. For the 150 enterprises surveyed the loss totalled almost 137,000 lambs or 912 lambs per enterprise. Evidence collected in this project indicates that manipulating ewe mob size at lambing can result in significant reductions in lamb loss, although the response appears to be variable.

Given that the majority of producers involved in this study (62%) have already demonstrated a willingness to manipulate single and twin bearing mob sizes at lambing, it is recommended that a series of participatory research sites be undertaken to more accurately record and define the impact of mob size on lamb survival under a range of circumstance, so that clearer recommendations can be provided to industry. Simultaneously the mob-paddock lambing template developed in this project could be used to collect many more records during the next lambing season, with a heightened accuracy of reporting key variables rather than relying of producers recalling key information after the event.

The design of the demonstrations should enable the relationship between ewe mob size and lamb survival rate for singles, twins and perhaps triplets to be more clearly defined, as well as exploring the influence of other key variables on this relationship. Interest has also been expressed by a number of stud producers wanting to improve lamb survival in mobs that have been artificially inseminated, that are suffering from the same phenomenon as larger mob size with conventional joining lengths, having too many fresh lambs born per day resulting in significant losses.

This project has provided encouragement for further work to be undertaken in this area, to aid in the quest to improve the survival of lambs born in the Australian flock. It appears as though ewe mob size at lambing may at least be a ‘ten-percenter’ and hence warrants further investigation given that very limited research has been undertaken on the relationship between lambs born per day and survival rates.

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7. Appendices

Appendix 1 Survey Template

	Lamb Survival Survey- 2012 Results		
	Property Details		
1	Name		
2	Property Number		
3	Property Size		ha
4	Property Location		
	Overall Flock Reproduction Data for 2012 Lambing		
5	Number of ewes joined		**A**
6	Number of ewes scanned dry		**B**
7	Number of ewes that scanned single		**C**
8	Number of ewes that scanned twin		**D**
9	Total number of fetuses ((C+ (2*D))		**E**
	Overall scanning percentage (E / A)		
	Percentage of ewes scanned pregnant ((A-B) / A) x 100)		
10	Number of single lambs marked		**F**
11	Number of twin lambs marked		**G**
12	Total number of lambs marked		**H**
	Marking percentage (G / A)		
	Lambing survival		
	Overall survival % scanning to lambing (H / E)		
	Single survival % scanning to lambing (F / C)		
	Twin survival % scanning to lambing ((G /(2*D))		
	General farm management		
13	Rate predation management out of 5 (where 1=no predator control, 3=some predator control, 5=excellent predator control)?		
14	Have you been trained to condition score sheep (1=Yes or 2=No)?		
15	Out of 10 rate you skill level for condition scoring sheep, (where 1=low skill level and 10=high skill level)?		
16	Have you been trained to assess pastures- FOO and digestibility (1=Yes or 2=No)?		
17	Out of 10 rate you skill level for assessing pasture quantity and quality (where 1=low skill level and 10=high skill level)?		

18	Rate the weather conditions for lambing in 2012 out of 5, (where 1=severe weather condtions, 3=average, 5=mild weather)?			
19a	Do you lamb single and twins in separate mobs (1=Yes or 2=No)?			
19b	What was your average mob size for lambing in 2012? singles			
	twins			
	overall			
20	What are the reasons (if any) for not lambing twins in small mobs?			
	Paddock Template	1	2	3
	Paddock Details			
	Paddock name			
	Paddock number (farm number. paddock number)			
	Paddock size ha			
	Ewe Details			
	Lambing date			
	Lambing period (in days)			
	Ewe breed			
	Standard Reference Weight (weight bare shorn in CS 3.0) kg			
	Ram breed			
	Number of ewes lambing in paddock			
	Pregnancy status (ie. 1 scanned single or 2 twin or 3 unscanned or empty pregnant)			
	number of foetuses			
	Ewe age years			
	Stocking rate (ewes/ha) for lambing			
	Ewe observations			
	Ewe condition score at joining			
	Ewe condition score at scanning			
	Ewe condition score at lambing (most important)			
	Ewe condition score at marking			
	Pasture observations			
	Feed-on-offer at point of lambing (kg DM/ha)			
	Rate pasture quality (digestibility) at lambing out of 5 (where 1=very low, 2=low, 3=moderate, 4=high, 5=very high)			
	Major pasture species 1 in paddock			
	Major pasture species 2 in paddock			
	Supplementary feeding details			
	Main supplement fed during lambing			
	Ration fed in kg/ewe/week between lambing and marking			

	Trail fed (1=Yes or 0=No)			
	Self feeders (1=Yes or 0=No)			
	If trail feeding, how many times per week			
	If trail feeding, what time of the day did feeding occur			
	Paddock description			
	Paddock topography (1=flat, 2=undulating or 3=hill)			
	Paddock shape (1=sqaure, 2=rectangle, 3=triangle, 4=circle, 5=irregular)			
	Paddock aspect (1=northerly, 2=westerly, 3=southerly, 4 easterly, 5= not applicable, 6=various)			
	Rate paddock for shelter out of 5, (where 1=no shelter, 3=some shelter and 5=well sheltered)			
	Describe shelter type- species and height			
	Number of watering points in the lambing paddock			
	Were ewes reliant on water during lambing to survive			
	Mixed grazing of cattle and sheep during lambing (1=Yes or 2=No)			
	Paddock results			
	Number of lambs marked from paddock			
	Paddock lamb marking % (to ewes lambed in the paddock)			
	Lamb survival % (to fetuses lambed in the paddock)			
	Estimated ewe mortality during lambing (%)			