Final report

Managing fecund flocks to improve survival of triplet dams and their lambs

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Abstract

Many sheep meat producers have focused on increasing the reproductive performance of both Maternal and Merino ewes through better genetics, ewe nutrition and management. Collectively, these practices are increasing the proportion of triplet-bearing ewes which can result in excessive mortality of both ewes and lambs under some circumstances. The potential for high rates of ewe and lamb mortality in this cohort limits potential productivity gains and more significantly represents a downside risk for the sheep industry if animal welfare practices do not align with consumer and community expectations. However, the precise magnitude of this risk was unknown as only about 5% of ewes are scanned for triplet foetuses and hence the current mortality of these ewes and lambs could not be determined across the industry with confidence.

This national project began with completion of a literature review and industry consultation in 2018 to identify research gaps and components of management strategies currently adopted to reduce mortality rates of triplet-bearing ewes. Consultation with producers who scanned for triplets found that, on average, 5.9% of all ewes joined were identified as carrying triplets (6.6% of non-Merino ewes and 2.9% of Merino ewes). The average mortality of triplet-bearing ewes was 6.4% and this did not differ between breeds. The average survival of triplet-born lambs was 59% and survival was significantly higher for lambs from non-Merino compared to Merino ewes (60.1 vs 52.9%).

The key strategies adopted by producers to reduce the mortality of triplet-bearing ewes and their lambs were management of ewe condition score (CS), food on offer (FOO), mob size at lambing and the use of shelter. Significant variation existed between producers for targets for CS at lambing (2.8 – 3.5), mob size at lambing (10 – 150 ewes) and FOO (800 – 2,500 kg DM/ha). The highest priorities identified by producers for further research were ewe CS, mob size at lambing, FOO at lambing and mineral supplementation.

Management tools identified by producers during the 12-month engagement process were tested at 65 on-farm research sites across Australia between 2019 and 2021. The experimental treatments investigated impacts on the survival of triplet-bearing ewes and their lambs and included:

(i) mixed vs separate management of twin- and triplet-bearing ewes between pregnancy scanning and lamb marking,

(ii) 'High' vs 'Low' CS of Merino and Maternal ewes from pregnancy scanning to lamb marking,

(iii) 'High' vs 'Low' mob size at lambing,

(iv) 'High'/'Low' Feed-On-Offer (FOO) x 'High'/'Low' supplementary feeding between pregnancy scanning and lambing, and

(v) mineral supplementation during late pregnancy and lambing.

Results from the experimental work showed that best-practice management of triplet-bearing ewes to improve ewe survival should include managing nutrition of Merino ewes so that they are in a greater CS at lambing and managing the nutrition of both Maternal and Merino ewes so that they gain CS between pregnancy scanning and lambing. Best-practice management of triplet-bearing ewes to improve the survival of their lambs should include managing triplet-bearing ewes separately to twin-bearing ewes between pregnancy scanning and lambing and allocating triplet-bearing ewes to lamb in smaller mobs. For Merinos, this should also include managing triplet-bearing ewes so that they are in greater CS at lambing and/or to gain CS between pregnancy scanning and lambing to increase the survival of their lambs.

Best-practice guidelines and factsheets for the identification and management of triplet-bearing ewes and their lambs have been developed for extension to industry, including results of a comprehensive economic analysis. Four scentific publications including a literature review and

three publications reporting findings from the industry consultation and experimental work have been published in peer-review journals.

Executive summary

Background

Many sheep producers have focused on increasing the reproductive performance of both Maternal and Merino ewes through better genetics, ewe nutrition and management. Collectively, these practices are increasing the proportion of triplet-bearing ewes which can result in excessive mortality of both ewes and lambs under some circumstances. The potential for high rates of ewe and lamb mortality in this cohort limits potential productivity gains and more significantly represents a downside risk for the sheep industry if animal welfare practices do not align with consumer and community expectations. However, the precise magnitude of this risk was unknown as only about 5% of ewes are scanned for triplet foetuses and hence the current mortality of these ewes and lambs could not be determined across the industry with confidence. This national project aims to (i) identify research gaps and consult broadly with industry to determine the current mortality of triplet-bearing ewes and their lambs, management strategies currently adopted to reduce rates of mortality and priorities for research, and (ii) conduct participatory research on commercial farms to assess the impacts of the management tools identified by producers during the consultation process on the survival of triplet-bearing ewes and their lambs. Economic modelling will evaluate the economic value of adopting the management strategies which improve ewe and/or lamb survival. Best-practice management guidelines to improve the survival of triplet-bearing ewes and their lambs will be developed for dissemination to industry. The primary target audience for this project was the 25% of sheep producers that scan for multiples but don’t specifically identify triplets, as well as ensuring those sheep producers that already scan for triplets (<5%) are implementing best-practice management. The project particularly targets producers with maternal breeds given they have higher fecundity and a greater proportion of triplets in the flock than Merino producers.

Objectives

The following objectives were achieved:

- Complete a literature review and identify knowledge gaps on management practices to reduce the mortality of triplet-bearing ewes and their lambs.
- Consult with industry to (i) determine baseline data for triplet-bearing ewes and their lambs, (ii) identify current industry recommendations and suggested best-practice for managing triplet-bearing Maternal and Merino ewes, and (iii) identify research priorities.
- Test a suite of management practices identified by producers at on-farm research sites to determine their impacts on the survival of triplet-bearing ewes and their lambs.
- Complete economic modelling and develop best-practice guidelines and extension materials for extension to industry.
- Submit at least two scientific publications to a refereed journal.

Methodology

- Literature review during 2018 to identify knowledge gaps and opportunities for reducing the mortality of triplet-bearing ewes and their lambs in extensive farming conditions relevant to southern Australia.
- Industry consultation via surveys, workshops and a webinar during 2018 to compile baseline data on current mortality rates of triplet-bearing ewes and their lambs, identify the range in current industry recommendations and suggested best-practice for managing triplet-bearing ewes, and identify research priorities.
- Experimental work at on-farm research sites across Australia between 2019 and 2021 to determine the impact of management strategies identified by producers during the consultation process on the survival of triplet-bearing ewes and their lambs.
- Economic modelling to determine the economic value of adopting best-practice management strategies to improve the survival of triplet-bearing ewes and their lambs.

Results/key findings

Benchmark surveys completed by 64 sheep producers across southern Australia who scanned their ewes for triplets revealed that, on average, 5.9% of all ewes joined in 2017 and 2018 conceived triplets. The proportion of ewes which conceived triplets was significantly higher for non-Merino ewes compared with Merinos (6.6% vs. 2.9%; $P < 0.05$). The average mortality of these triplet-bearing ewes was 6.4%, regardless of ewe breed, which was double that for twin-bearing ewes and four times that for single-bearing ewes. The average survival of triplet-born lambs was significantly higher for non-Merinos than Merinos (60.1% vs 52.9%; $P < 0.01$). The key strategies adopted by producers to reduce the mortality of triplet-bearing ewes and their lambs were management of ewe CS, FOO, mob size at lambing and the use of shelter, but significant variation existed between producers for targets for CS at lambing (2.8 – 3.5), mob size at lambing (10 – 150 ewes) and FOO (800 – 2,500 kg DM/ha). The highest priorities for further research identified by producers from surveys, workshops and a webinar were ewe CS, mob size at lambing, FOO at lambing and mineral supplementation.

On-farm research across southern Australia between 2019 and 2021 found that managing triplet-bearing ewes separately to twin-bearing ewes between scanning and marking increased the survival of triplet-born lambs compared with combined management with twins (53.0 vs 41.8%; $P < 0.001$) but had no impact on ewe survival. The survival of triplet-bearing Merino ewes ($P < 0.01$) and their lambs ($P < 0.001$) was greater when ewes were managed at a 'High' compared with a 'Low' CS between pregnancy scanning and lambing, but this was not observed for Maternals. The survival of Merino but not Maternal lambs was higher when ewes were in greater CS pre-lambing ($P < 0.01$) and when ewes gained CS between pregnancy scanning and pre-lambing ($P < 0.01$). Mortality of triplet-bearing ewes was lower when ewes gained CS between pregnancy scanning and pre-lambing ($P < 0.05$). Merino ewes were more likely to die than Maternal ewes for a given change in CS between pregnancy scanning and pre-lambing ($P = 0.065$). Reducing mob size at lambing by 10 triplet-bearing ewes increased the survival of their lambs to marking by 1.5% when mob size ranged from 10 – 139 triplet-bearing ewes and stocking rate ranged from 0.7 – 13.4 ewes/ha ($P < 0.001$). There was no impact of FOO and supplementary feeding or mineral supplementation on the survival of triplet-bearing ewes or their lambs.

The economic modelling conducted to date has shown that the value of an extra triplet-born lamb surviving to weaning ranges from $27 – 75 for Merinos and $46 – 171 for Maternals across a range in lamb price of $4 – 11/kg. The value of an extra triplet-bearing ewe surviving to lambing across this range in lamb price ranges from $105 – 225 for Merinos and $180 – 545 for Maternals. The profitability of scanning for triplets is dependent on ewe breed, time of lambing, reproductive rate and meat price. With standard prices and standard reproduction levels, scanning for litter size and managing the Maternal flocks increased profit by up to $18.50/triplet ewe or $1.60/total ewe. The $1.60/ewe compares with $2.75/ewe for scanning wet and dry and an additional $3/ewe for scanning for multiples. Differential management of the Merino flocks did not increase profit with standard reproductive rates.

The optimum nutritional profile for triplet-bearing ewes across all scenarios is to have them 0.2 – 0.5 condition score higher at lambing than twin-bearing ewes. The current best estimate is that differential management of the triplet-bearing ewes increases profit by about $1.60 per ewe scanned or $20 per triplet-bearing ewe after paying the extra costs associated with scanning and the extra labour for managing the feed supply and supplementary feeding. The optimum mob size at lambing varies depending on enterprise-specific factors such as the target return-on-investment, stocking rate of the ewes, breed and lamb price. The optimum mob size for triplet-bearing ewes is approximately 30% that for twins if ewes are allocated to existing paddocks. The optimum mob size for triplet-bearing ewes is between 20 and 38 ewes when paddocks are subdivided in half using permanent fencing with lamb price at $7/kg and a target return-on-investment of 5%. This optimum mob size is approximately 35% that for twins, which reflects the greater response in lamb survival for triplets compared with twins. The indication from the preliminary analysis is that scanning and identifying triplet-bearing ewes, costing an extra $0.40/ewe scanned, is justified purely from the benefits of differential paddock allocation even if the scanning percentage is only 150%.

Benefits to industry

This research has demonstrated that a mixed-method approach involving more than 200 sheep producers from across southern Australia was effective at establishing the research priorities of producers to improve the survival of triplet-bearing ewes and their lambs. The experimental work has identified that differential management of twin- and triplet-bearing ewes from pregnancy scanning to marking, managing ewe CS in late pregnancy and lambing ewes in smaller mobs can improve the survival triplet-bearing ewes and/or their lambs. Best-practice guidelines have been developed for extension to industry and these will assist producers to improve productivity, profitability and animal welfare. Reduced deaths and improved animal welfare will also (i) improve the wellbeing and satisfaction of producers, and (ii) help meet consumer demands for ethical sheep meat and wool.

Future research and recommendations

The following research, development and extension is recommended based on the outcomes from the experimental sites and consultation with producers:

- Recording and emphasis should be placed on ewe age and collection of additional data of its relationship with ewe death as part of any demonstration and/or future research and development with triplets.
- Recording of the exact timing of death and post-mortem of ewes to better understand the relationship between the management factors identified to impact ewe survival and the cause of death (e.g. CS and pregnancy toxaemia).
- Producer demonstration sites related to the impact of reducing mob size at lambing and optimising privacy for lambing ewes on triplet lamb survival, including the economics of paddock subdivision. This should clearly outline the value proposition and practicalities for

mixed-farming enterprises in the low to medium rainfall zones where the primary focus is cropping, and both mobs and paddocks are larger.

- Further research is required to understand the impacts of shelter availability at lambing on the survival of triplet-born lambs.
- The primary future research and development interest of producers attending the collaborator workshops related to investigation of ewe fitness (ability to of ewe to remain mobile in late pregnancy and up to the point of lambing) and its links with requirement for shepherding during lambing, and ewe and lamb survival.

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1. Background

Lamb marking rates in Australia have increased by more than 10% over the last 15 years (ABARES). This has resulted from widespread adoption of practices to improve ewe nutrition before joining and during pregnancy (Trompf *et al.* 2011; Thompson *et al.* 2020), improved management during lambing (Lockwood *et al.* 2020a; Lockwood *et al.* 2020b) and increased use of sires with higher breeding values for the number of lambs born and weaned. In addition, there has been significant displacement of Merino sheep by more fecund maternal ewe types (Trompf *et al.* 2018). These increases in fecundity are associated with an increase in the proportion of multiple-bearing ewes, including those carrying triplets (Amer *et al.* 1999), which can result in higher rates of mortality of both ewes and lambs (Kenyon *et al.* 2019a). The potential for high rates of mortality in the triplet cohort limits potential productivity gains and more significantly represents a downside risk for the sheep industry if animal welfare practices do not align with consumer and community expectations (MISP 2020). The precise magnitude of this risk is unknown as only about 5% of ewes are scanned for triplet foetuses (E.REP.1404; J. Trompf *unpublished data*). Hence, the current mortality of these ewes and lambs cannot be determined across the industry with confidence.

Lamb survival is dependent on the co-ordinated expression of appropriate ewe and lamb behaviours that result in the formation of a close and exclusive bond between the ewe and her lambs, which is essential for suckling and colostrum intake (Nowak and Poindron 2006). Birthweight is the major determinant of lamb survival and triplet-born lambs are often about 20% and 40% lighter than twin- and single-born lambs, respectively. Lighter triplet lambs are more vulnerable to starvation, mismothering and hypothermia as they have lower energy reserves to generate heat and yet a faster rate of heat loss associated with a higher surface area to birth-weight ratio. In addition, their behavioural development is impaired which compromises the formation of the ewe-lamb bond. The incidence of dystocia at birth is also higher for low birthweight triplet lambs. The lamb may suffer asphyxia and trauma to the central nervous system subsequent to dystocia or a prolonged birth. Dystocia is also linked with death due to the starvation-mismothering complex, possibly due to sub-lethal hypoxia experienced by the lamb during parturition, poor lamb vigour, and/or poor neonatal and maternal behaviours (Dwyer *et al.* 1996; Brown *et al.* 2014). Therefore, management factors which influence the birthweight and the formation of the ewe-lamb bond are important in improving the survival of triplet-born lambs.

Increasing the birthweight of triplet-born lambs is a logical goal to increase their survival, as the average birthweight of triplets in most studies is about 0.5 to 1.0 kg below the birthweight required to achieve near-maximum survival. The potential to increase birthweight via better nutrition of triplet-bearing ewes in early- to mid- or late-pregnancy is well documented (Greenwood *et al.* 2009; Paganoni *et al.* 2014). However, there is surprisingly little robust information on feed-on-offer (FOO) or ewe condition score (CS) targets at key times, including mid-pregnancy and before lambing, to underpin management guidelines for triplet-bearing ewes. There has been considerable research in New Zealand, mostly small-plot scale on research stations, which collectively indicate no effects of ewe CS at lambing ranging from 2.1 to 3.4 (Kenyon *et al.* 2011; Kenyon *et al.* 2013) or FOO ranging from 800 to 2,000 kg DM/ha (Everett-Hincks *et al.* 2005; Corner *et al.* 2010) on survival of triplet-born lambs. However, most if not all these studies included limited or no replication and low numbers of ewes, plus we know treatment effects on lamb survival are less evident at a small plot-scale compared to paddock-scale (Behrendt *et al.* 2011; Oldham *et al.* 2011b). Several of the New Zealand studies did detect effects of nutrition or FOO on the birthweight of triplet-born lambs, which under commercial farming conditions would influence survival. Two of eight larger scale experiments within the current '*Lifetime Maternals*' project with sufficient numbers of triplet born lambs indicated a large effect of ewe CS at lambing on survival at one site (40% survival per CS) but this was not evident at the other site where the average birthweight of triplets across treatments was an atypical 4.8 kg and climatic conditions at lambing were milder. There have been no rigorous attempts to quantify the effects of ewe CS profile and FOO during lambing on ewe mortality and indications from industry are that over-feeding triplet-bearing ewes to increase birthweight is resulting in higher rates of ewe mortality.

Management factors that enhance disturbance of ewes and lambs during the early post-natal period would logically increase the risk of separation and lamb mortality, especially with triplet-bearing ewes. Research has shown that larger mob sizes at lambing reduce the survival of single- and twin-born lambs, with little to no effect of the stocking rate of ewes (Lockwood *et al.* 2020a; Lockwood *et al.* 2020b). There has been no work on the effects of mob size or stocking rate of the survival of triplet born lambs, or how these factors interact with others that influence lamb survival. Several other management interventions including mid-pregnancy shearing (Corner *et al.* 2006) and supplementation with specific nutrients (Capper *et al.* 2006; Rooke *et al.* 2008; McCoard *et al.* 2017) have the potential to positively impact traits associated with lamb survival, including placental nutrient transfer and thus foetal growth, birthweight, lamb vigour, thermoregulatory capacity and colostrum production. In most cases, further work is still needed to verify these impacts on the survival of triplet-born lambs under commercial conditions to develop cost-effective and practical solutions.

There has been little investment in developing strategies to reduce the mortality of triplet-bearing ewes and lambs, yet the mortality of triplet-bearing ewes and their lambs costs the Australian sheep industry an estimated $32M p.a (J. Young, *unpublished data*). Feedback from leading sheep meat producers across Australia is that the mortality of triplet-bearing ewes and their lambs is a growing issue that is not being adequately addressed by any research, development and extension program and that mortality in this cohort is limiting the potential for transformative change in on-farm production efficiency. This project will review the literature to identify research gaps and consult broadly with industry to determine the current mortality of triplet-bearing ewes and their lambs, management strategies currently adopted to reduce rates of mortality and priorities for research. Participatory research on commercial farms will then assess the impacts of the management tools identified by producers during the consultation process on the survival of triplet-bearing ewes and their lambs. Economic modelling will be conducted to evaluate the economic value of scanning for triplets and adopting the management strategies. Best-practice management guidelines to improve the survival of triplet-bearing ewes and their survival will be developed for dissemination to industry. The primary target audience for this project was the 25% of sheep producers that scan for multiples but don't specifically identify triplets, as well as ensuring those sheep producers that already scan for triplets (<5%) are implementing best-practice management. The project particularly targets producers with maternal breeds given they have higher fecundity and hence a greater proportion of triplets in the flock than Merino producers.

2. Objectives

The objectives of this project and their status are reported in Table ***2.1***.

Table 2.1. Objectives of project L.LSM.0013 'Managing fecund flocks to improve survival of triplet dams and their lambs' and their completion status

Objective		Status
1	Completed a literature review and identification of knowledge gaps on management practices to reduce the mortality of triplet-bearing ewes and their lambs.	Achieved
2	Identified the range in current industry recommendations and suggested best practice for managing triplet-bearing Maternal and Merino ewes, from consultants, leading sheep advisors and producers.	Achieved
3	Compiled baseline data on current mortality rates of triplet-bearing ewes and their lambs from sheep producers by working with the pregnancy scanning industry.	Achieved
4	Identified a suite of management practices currently adopted by producers to reduce ewe and lamb mortality and assessed their apparent effectiveness.	Achieved
5	Testing of the effectiveness of these practices at commercial scale, as single or multiple factor comparisons, on a network of participating farms across Australia.	Achieved
6	Completed bioeconomic modelling covering optimum mob size at lambing, cost-benefit of differentially managing triplet bearing ewes and relative economic value of litter size.	Achieved (draft)
7	Developed regionally based 'best-practice' management guidelines for triplet ewes and their lambs.	Achieved (draft)
8	Collated the information into a format suitable for inclusion into the proposed 'Maternals' module for Bred Well Fed Well and other MLA extension programs as required.	Achieved
9	Completed and submitted at least two scientific publications to refereed journal.	Achieved

3. Literature review

This project commenced with a literature review to identify knowledge gaps and opportunities for reducing the mortality of triplet-bearing ewes and their lambs in extensive farming conditions relevant to southern Australia. The literature review was published by Kenyon *et al.* (2019a) in the *New Zealand Journal of Agricultural Research* (see Appendix – section 13.1).

3.1 Abstract

Triplet-bearing ewes and their lambs have the potential to improve flock productivity however, the lack of robust information on optimal nutrition and management is limiting their performance. In comparison to twins, the triplet lamb is; lighter, more metabolically challenged, has lower body temperature, and receives less colostrum and milk which combined results in lower survival rates and weaning weights. While scientifically based management guidelines are available for singletons and twins, guidelines are generally lacking for triplets. Although there is some knowledge on the impacts of nutrition, further studies are required to examine the impacts of varying feeding regimens in pregnancy and lactation, across the body condition range. Characterising the impacts of shelter and other paddock factors, stocking rate, mob size and human intervention would also be of

benefit. Future studies must be large enough to allow for evaluation of lamb survival and litter birth weight variation.

3.2 Knowledge gaps identified

The literature review highlighted that there had been little research conducted in Australia regarding triplets, and most experimental work was small-scale and not representative of commercial or extensive conditions. Interventions that had been tested successfully had also not been extended widely so the true potential to improve lamb and/or ewe survival was not known. Key gaps in the literature that were identified regarding management and productivity of triplet-bearing ewes and their lambs included:

- Most research activities have been based in New Zealand or Europe and not relatable to Australian conditions.
- Lack of knowledge of the interactions between CS and FOO for triplet-bearing ewes, including the economic effectiveness of managing any interaction.
- Few alternative pasture types have been assessed (i.e. non New Zealand "herbage").
- Whether triplet-bearing ewes should be lambed in separate mobs or in combination with other pregnancy classes to optimise ewe and lamb survival.
- The impacts of:
    - Ewe nutrition during pregnancy and lactation on ewe and lamb survival and performance.
    - Mob size and stocking rate at lambing on lamb survival
    - Shelter availability during lambing on lamb survival.

4. Initial industry consultation

Findings from the initial consultation with sheep producers and industry members have been published by Thompson *et al.* (2023) in *Animals* (see Appendix – section 13.2).

4.1 Methods

4.1.1 Benchmark surveys

Telephone or in-person surveys were conducted in 2018 for 95 producers who had either pregnancy scanned to identify some triplet-bearing ewes and managed them separately from twin-bearing ewes ('Separated' management; *n* = 64) or who always scanned for multiple-bearing ewes only and did not manage triplet-bearing ewes separately from twin-bearing ewes ('Combined' management; *n* = 31). Contact details for producers to survey were obtained mostly through professional networks. Pregnancy scanning contractors and sheep production consultants also provided contacts of their clients who had confirmed their interest and eligibility for participation in the surveys. The ewe management system for a farm was classified as 'Separated' if the triplet-bearing ewes from at least one ewe flock on their farm were identified and separated from twin-bearing ewes in either 2017 or 2018, where 'flock' represented all adult Merino or non-Merino ewes on a farm. In other words, over the two years, a farm classified as 'Separated' could include both separated and combined flocks.

Survey participants were from New South Wales (NSW, *n* = 17), South Australia (SA, *n* = 15), Tasmania (TAS, *n* = 4), Victoria (VIC, *n* = 40) and Western Australia (WA, *n* = 19; Figure 4.1). The producers surveyed included 26 farms with Merino ewes, 50 farms with non-Merino ewes and 19 farms with both Merino and non-Merino ewes. These surveys collected background farm-level information including location, total farm area, percentage of farm cropped, ewe breed, number of ewes mated, and date and length of the joining period for both the 2017 and 2018 breeding seasons. Data collected included scanning percentage (number of foetuses conceived per 100 ewes mated) and lamb marking percentage (number of lambs marked per 100 ewes mated) for each flock on the farm, and ewe mortality and lamb survival for single-, twin- and triplet-bearing ewes, where possible. The producers surveyed were also asked to provide data on the number of dry, single, twin and triplet-bearing ewes, where triplet-bearing ewes were identified.

The producers that had some experience in separating and differentially managing twin- and triplet-bearing ewes were asked to rank the primary causes of mortality of triplet-bearing ewes and lambs, as well as the key practices they had adopted to improve survival of triplet-bearing ewes and/or triplet-born lambs. The practices described by producers were distilled into six key themes: (i) ewe CS at lambing; (ii) FOO during lambing; (iii) ewe mob size during lambing; (iv) shelter during lambing; (v) handling pre-lambing, and disturbance before and during lambing; and (vi) supplementary feeding in late pregnancy with grain and/or minerals. Producers then identified which of these six strategies were their first, second and third priorities for reducing the mortality of triplet-bearing ewes and/or improving the survival of their lambs. Where appropriate, producers also provided the targets they adopted for ewe CS, FOO and mob size at lambing, including how they compared to targets for twin-bearing ewes. In the context of this paper, a ‘mob’ refers to a group of sheep managed together within the same paddock. Finally, the producers were asked to identify key research priorities to improve the survival of triplet-bearing ewes and their lambs.

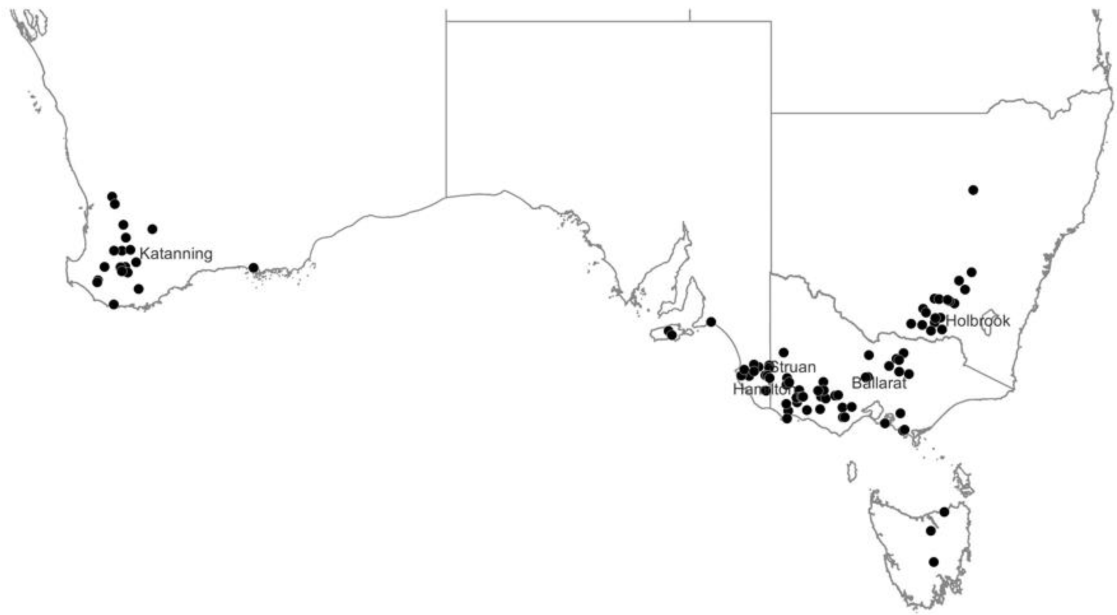

Figure 4.1. Location of participants of benchmarking surveys (black circle; n = 95) and workshops (location; n = 5) across southern Australia.

4.1.2 Workshops and webinar

Five workshops involving 78 producers were conducted across Australia in 2018, including at Katanning, WA (*n* = 8), Struan, SA (*n* = 5), Hamilton, VIC (*n* = 37), Ballarat, VIC (*n* = 13) and Holbrook, NSW (*n* = 15) (Figure 4.1). There was also a webinar conducted involving a further 35 producers who could not attend the workshops. The workshops and webinar started by introducing the purpose of the project and a summary of the literature review on the survival of triplet-bearing ewes and their lambs (Kenyon *et al*. 2019a). A summary of the benchmark surveys was then presented regarding the proportion of triplet-bearing ewes in flocks across Australia, the mortality rates of both ewes and lambs and management practices being adopted for triplet-bearing ewes. Producers were then asked to respond using a Likert scale (Barua 2013) regarding the relative importance or need for further research on 14 different management options identified from the literature review (Kenyon *et al.* 2019a) and benchmarking surveys, and to individually rank their top priority for further research. These research priorities presented for ranking included: (i) ewe CS at lambing; (ii) FOO during lambing; (iii) proportion of legume in the pasture on offer during lambing; (iv) use of alternative forages for lambing; (v) mob size during lambing; (vi) stocking rate during lambing; (vii) methods for supplementary feeding with grain; (viii) mineral supplementation; (ix) supplementation with specific nutrients such as vitamins and amino acids; (x) shelter options; (xi) intensive monitoring during lambing; (xii) mid-pregnancy shearing (demonstrated to increase lamb birthweight); (xiii) lamb fostering systems; and (xiv) quantification of foetal mortalities between pregnancy scanning and birth.

4.1.3 Statistical analysis

All data were analysed using GENSTAT (Edition 22). Overall scanning percentage, marking rate, start of joining, length of joining and lamb survival were analysed using the method of Restricted Maximum Likelihood with ewe breed (Merino, non-Merino and mixed) and management system (‘separated’ or ‘combined’) at the farm level and flock level (nested within farm level) fitted as fixed effects, while year, state (nested within year), farm (nested within state) and flock (nested within farm) were fitted as random effects.

Where farms identified and separated twin- and triplet-bearing ewes, ewe mortality and lamb survival for each birth type were analysed by the method of Restricted Maximum Likelihood with ewe breed at the flock level fitted as a fixed effect while year, state (nested within year), farm (nested within state) and flock (nested within farm) were fitted as random effects. Pearson correlation was used to measure the association between any two of the various parameters. The influence of the key management practice adopted by survey participants to reduce mortality of triplet-bearing and/or improve survival of their lambs on actual ewe mortality and lamb survival were analysed by the method of Restricted Maximum Likelihood with the main priority fitted as a fixed effect while year, state (nested within year) and farm were fitted as random effects.

4.2 Results

4.2.1 Survey participants

Producers that completed surveys managed approximately 352,000 ewes, including 153,000 Merino ewes and 199,000 non-Merino ewes. Farm and flock demographic data for survey participants are shown in Table *4.1*. On average, the farms managed by survey participants in NSW and WA were larger and a greater proportion of their farm was allocated to crops than the farms in VIC and SA. All farms in NSW and WA except one were mixed farms with both sheep and crops, whereas more than 50% of the farms in SA and VIC were specialist sheep producers with no crop. Participants with Merino ewes only had larger farms than those with non-Merino ewes only, and Merino ewes were more common on larger mixed farms with sheep and crops. Farms with both ewe breeds had, on average, fewer Merino than non-Merino ewes (1,774 vs. 2,173). One-third of the producers surveyed always managed multiple-bearing ewes together, and the key reasons given for not identifying triplet-bearing ewes were insufficient numbers of triplet-bearing ewes (68%), lack of capability of pregnancy scanning contractors (16%) and too many different mobs of ewes to manage (16%). There were no major differences in the total farm area, proportion of farm cropped or the total number of ewes between farms that had separated triplet-bearing from twin-bearing or always managed multiple-bearing ewes together.

Table 4.1. Number of farms, average size of farms (total ha), proportion of the farm cropped and total number of ewes mated for survey participants across Australia in 2017 and 2018. The farm-level benchmarking data are presented for different states, ewe breed types on each farm (Merino, non-Merino or both) and the management system utilised for triplet-bearing ewes ('Separated' or 'Combined' with twin-bearing ewes). The ewe management system for a farm was classified as 'Separated' if the triple-bearing ewes for at least one ewe flock were identified and separated from twin-bearing ewes in either 2017 or 2018.

	Number of farms	Farm area	Crop area	Ewes mated
State				
New South Wales	18	2,234	41.6	3,226
Victoria	43	1,652	12.4	3,631
South Australia	15	1,373	6.6	2,924
Western Australia	19	3,072	36.8	4,974
Farm ewe breed				
Merino	25	3,178	34.2	4,713
Non-Merino	50	1,286	14.7	3,116
Merino and non-Merino	20	2,324	23.0	3,947
Farm management system for triplet-bearing ewes				
Separated	64	1,891	20.4	3,608
Combined	31	2,210	23.6	3,925

At the farm level, participants with non-Merino ewes achieved a higher overall scanning percentage, lamb marking rate and lamb survival than those with Merino ewes only or a combination of both ewe breeds (**Error! Not a valid bookmark self-reference.**). These estimates of scanning percentage at the farm level will be underestimated and lamb survival overestimated as the data includes combined flocks where triplet-bearing ewes were not identified, but the estimated means are adjusted for management system. On average, the start of the joining period was more than 2-weeks earlier for farms with both ewe breeds compared to farms with non-Merino ewes only, and the lamb marking rate achieved by farms with both breeds was intermediate between those with Merino or non-Merino ewes only.

At the flock level, ewes were mated 17 to 22 days earlier but for 9 days longer on farms that always mixed multiple-bearing ewes together than ewes on farms that identified and separated at least some triplet-bearing ewes from twin-bearing ewes in either 2017 or 2018. There were no significant differences in flock scanning percentage, lamb marking rate or lamb survival between farms that always mixed multiple-bearing ewes together versus those who had identified and separated some triplet-bearing ewes from twin-bearing ewes in either 2017 or 2018. For farms that had separated some triplet-bearing ewes from twin-bearing ewes, flocks that were separated had a higher scanning percentage and marking rate, but there was no difference in reported lamb survival. Like above, this comparison needs to be treated with caution because the scanning percentage is underestimated, and lamb survival is overestimated in flocks where multiple-bearing ewes are combined. There were no significant interactions between ewe breed by ewe management system either at a farm level or flock within the farm level for overall scanning percentage, lamb marking rate or lamb survival. The raw means for Merino and non-Merino ewe flocks that identified and separated triplet-bearing ewes were 150.2% and 172.4% for scanning percentage, 112.8% and 137.4% for lamb marking rate and 75.1% and 79.9% for lamb survival.

Table 4.2. Average date at start of joining period, length of joining period (days), scanning percentage (%; foetuses per 100 ewes mated; 245 flocks), lamb marking rate (%; lambs marked per 100 ewes mated; 240 flocks) and lamb survival (%; lambs marked per 100 foetuses scanned; 227 flocks) for survey participants in 2017 and 2018. The data are presented for farms with different ewe breeds (Merino, non-Merino or both), and for flocks where multiple-bearing ewes were always combined together (‘Combined/Combined’), flocks where multiple bearing ewes were combined from farms that separated some triplet-bearing ewes from twin-bearing ewes in either 2017 or 2018 (‘Combined/Separated’), and flocks were twin- and triplet-bearing ewes were always separated (‘Separated/Separated’).

	Start of joining	Length of joining	Scanning percentage	Lamb marking rate	Lamb survival
Farm ewe breed					
Merino	24 January ^{ab}	44 ^{a}	144.5 ^{a}	112.7 ^{a}	78.2 ^{a}
Non-Merino	5 February ^{a}	46 ^{a}	165.7 ^{b}	136.5 ^{b}	82.0 ^{b}
Merino and non-Merino	16 January ^{b}	44 ^{a}	148.1 ^{a}	118.3 ^{c}	77.9 ^{a}
P-value	<0.05	n.s.	<0.001	<0.001	<0.01
Ewe flock management system					

Combined/Combined	16 January [a]	49 [a]	146.3 [a]	121.2 [a]	80.8 [a]
Combined/Separated	7 February [b]	40 [b]	148.8 [a]	117.1 [a]	79.0 [ab]
Separated/Separated	2 February [b]	40 [b]	164.4 [b]	127.1 [b]	77.5 [b]
P-value	<0.01	<0.001	<0.001	n.s.	<0.05

[a,b,c] Values within columns with different superscripts denote differences between farms with different ewe breeds or ewe flock management systems ($P < 0.05$).

4.2.2 Proportion of triplet-bearing ewes

The average scanning percentage was 163%, and 5.9% of ewes mated were identified as carrying triplets across all ewes managed by survey participants that provided the percentage of dry, single-, twin- and triplet-bearing ewes. The proportion of triplet-bearing ewes was significantly higher for non-Merino than Merino ewes (6.6% vs. 2.9%; $P < 0.05$), but at a given reproductive rate, the proportion of twin- and triplet-bearing ewes appeared to be similar for Merino and non-Merino ewes.

The proportion of twin-bearing ewes increased to a maximum of around 60–65% at a corresponding scanning percentage of about 180%, and then started to decline as higher-order multiples increased (Figure 4.2). On average, the proportion of triplet-bearing ewes corresponding with scanning percentages of 140%, 160%, 180% and 200% were 2.2%, 5.7%, 11.4% and 21%, respectively.

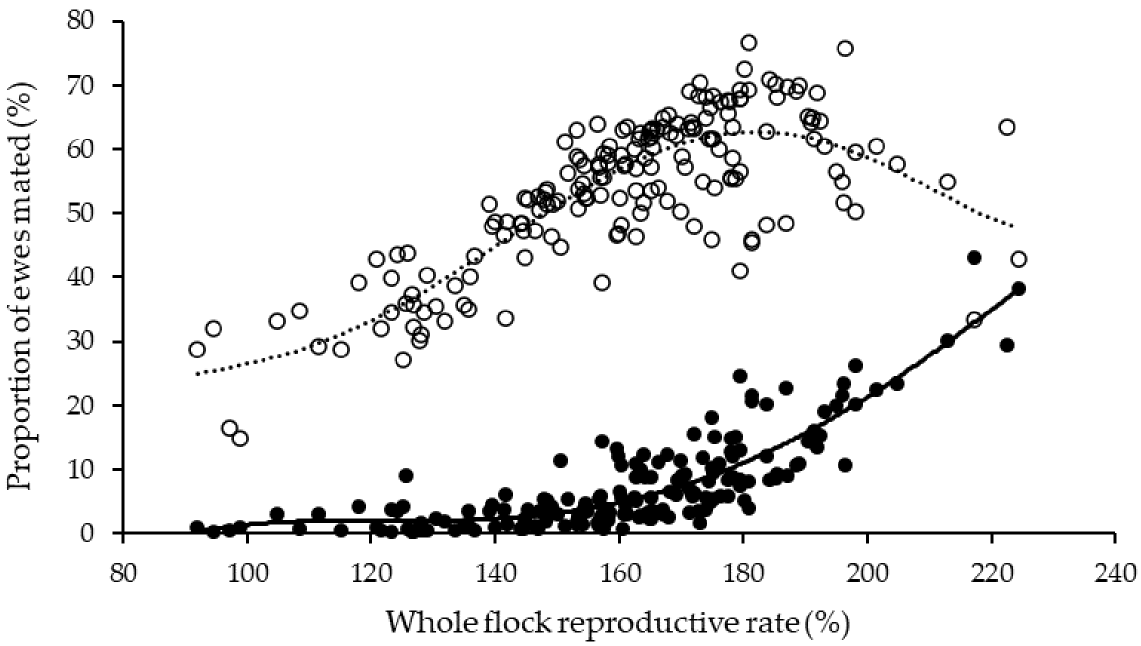

Figure 4.2. The proportion of twin-bearing (open circles) and triplet-bearing (solid circles) ewes relative to flock scanning percentage from survey data collected across the 2017 and 2018 breeding seasons in Australia. Raw data represents 145,000 Merino and non-Merino ewes.

4.2.3 Survival of triplet-bearing ewes and their lambs

Where triplet-bearing ewes were identified and managed separately from twin-bearing ewes, the average mortality of triplet-bearing ewes was 6.4% and ranged from 0% to 27% between individual flocks (10th percentile = 1.8% and 90th percentile = 14.5%). By contrast, the mortality of twin-bearing ewes was 3.3% and ranged from 0.5% to 17% (10th percentile = 1.2% and 90th percentile = 5.0%), and the mortality of single-bearing ewes was 1.6% and ranged from 0% to 8% (10th percentile = 0.5% and 90th percentile = 3.0%). There were no differences in the average mortality of single-, twin- or triplet-bearing ewes between ewe breeds (**Table *4.3*. Average survival of single, twin- and triplet-born lambs to marking and mortality of single, twin- and triplet-bearing ewes from pregnancy scanning to marking for Merino and non-Merino flocks where triplet-bearing ewes were managed separately from twin-bearing ewes.** The data were derived from 105 flocks from 64 survey participants. Data for ewe mortality were angular transformed, and back-transformed values are presented.Table ***4.3***). Of the survey participants that reported the main causes of mortality of triplet-bearing ewes, 61% indicated pregnancy toxaemia, 55% indicated ewes being too heavy and 53% indicated dystocia. The reported causes of death were similar for triplet- and twin-bearing ewes, with the exception that only 24% of producers indicated that excessive liveweight was a major cause of death for twin-bearing ewes.

The overall survival of triplet-born lambs was 59% and ranged from 34% to 79% between individual flocks (10th percentile = 45.3% and 90th percentile = 70.3%). By contrast, the average survival of twin-born lambs was 80% and ranged from 59% to 93% (10th percentile = 71.0% and 90th percentile = 88.6%), and the average survival of single-born lambs was 92% and ranged between 70% and 100% (10th percentile = 86.2% and 90th percentile = 96.8%). On average ewe breed had no significant impact on survival of single-born lambs. However, survival of twin and triplet lambs from non-Merino ewes was significantly higher compared to their Merino counterparts (Table ***4.3***). Of the survey participants that reported the main causes of death for triplet-born lambs, 90% indicated mismothering, 68% low birthweight and 60% exposure to adverse weather conditions and hyperthermia. Fewer farmers reported that low birthweight was a significant cause of death for twin-born lambs (41%), but other differences in perceived causes of death between triplets and twins, including those likely to be related to birthweight, were minimal.

Table 4.3. Average survival of single, twin- and triplet-born lambs to marking and mortality of single, twin- and triplet-bearing ewes from pregnancy scanning to marking for Merino and non-Merino flocks where triplet-bearing ewes were managed separately from twin-bearing ewes. The data were derived from 105 flocks from 64 survey participants. Data for ewe mortality were angular transformed, and back-transformed values are presented.

	Lamb survival (%)			**Ewe mortality (%)**		
	Single	**Twin**	**Triplet**	**Single**	**Twin**	**Triplet**
Merino	89.9^{a}	75.5^{a}	52.9^{a}	1.3^{a}	2.5^{a}	6.7^{a}
Non-Merino	92.2^{a}	81.4^{b}	60.1^{b}	1.5^{a}	3.1^{a}	4.9^{a}
P-value	n.s.	<0.01	<0.01	n.s.	n.s	n.s.

^{a,b} Values within columns with different superscripts denote differences between ewe breeds ($p < 0.05$).

Table 4.4. Correlations between start of joining (date) and length of the joining period (days), overall flock scanning percentage (%), marking rate (%) and lamb survival (%), mortality of single-, twin- and triplet-bearing ewes (%) and survival of their lambs to marking (%). The data were derived from 105 flocks of Merino and non-Merino ewes from 64 survey participants, where triplet-bearing ewes were managed separately from twin-bearing ewes.

	Start of joining	Length of joining	Flock scanning percentage	Flock lamb marking rate	Flock lamb survival	Single ewe mortality	Single lamb survival	Twin ewe mortality	Twin lamb survival	Triplet ewe mortality
Length of joining	0.10									
Flock scanning percentage	0.20	0.21								
Flock lamb marking rate	0.29 **	−0.01	0.73 ***							
Flock lamb survival	0.17	−0.28 *	−0.15	0.56 ***						
Single ewe mortality	−0.10	−0.09	0.07	−0.17	−0.34 **					
Single lamb survival	0.18	0.14	0.41 ***	0.55 ***	0.32 **	−0.30 **				
Twin ewe mortality	−0.09	0.07	0.14	−0.19	−0.42 ***	0.71 ***	−0.12			
Twin lamb survival	0.13	−0.25 *	0.30 **	0.71 ***	0.59 ***	−0.31 **	0.41 ***	−0.31 **		
Triplet ewe mortality	−0.15	0.17	0.06	−0.24 *	−0.44 ***	0.32 **	−0.01	0.48 ***	−0.39 ***	
Triplet lamb survival	0.28 **	−0.17	0.09	0.47 ***	0.67 ***	0.30 **	0.26 *	−0.38 ***	0.56 ***	−0.63 ***

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Farm area, proportion of the farm cropped or the total number of breeding ewes had no significant effect on ewe mortality or lamb survival, regardless of litter size. Likewise, correlations between time of joining or length of the joining period and overall scanning percentage, marking rate and lamb survival or mortality of single, twins and triplets bearing ewes and their lambs, were generally not significant or very weak (Table 4.4). As expected, across all flocks, overall lamb marking rate was significantly correlated with both scanning percentage and lamb survival, especially survival of twin-born lambs. Furthermore, lamb survival was logically negatively correlated with ewe mortality for each litter size, especially for triplets.

Ewe mortality and lamb survival benchmarks for single-, twin- and triplet-bearing ewes and their lambs to achieve varying levels of overall lamb survival were generated by categorising the data and are summarised in Table 4.5. Survey participants that achieved less than 3.6% mortality of triplet-bearing ewes and 70% survival of triplet-born lambs achieved lamb survival rates across the whole flock of 90% or more.

Table 4.5. Lamb survival and ewe mortality benchmarks corresponding to varying rates of lamb survival across whole flocks. The data were derived from 105 flocks from 64 survey participants that identified and differentially managed twin- and triplet-bearing ewes between pregnancy scanning and lamb marking in 2017 and/ 2018. Data include Merino and non-Merino ewe flocks.

Overall lamb survival (%)	Lamb survival (%)			Ewe mortality (%)		
	Single	Twin	Triplet	Single	Twin	Triplet
70 (67.5–72.5)	88.5	73.5	51.9	2.0	4.0	7.5
80 (77.5–82.5)	92.9	81.1	59.0	1.3	3.0	5.2
90 (87.5–92.5)	92.8	87.8	69.6	1.1	2.0	3.6

4.2.4 Management practices adopted to improve survival of triplet-bearing ewes and their lambs

About one-third of participants reported that the management of CS of triplet-bearing ewes at lambing was their highest priority (Table *4.6*). In addition, 80% of these producers indicated the primary reason for managing ewe CS at lambing was to reduce ewe mortality, and almost 50% of these producers, who almost exclusively managed non-Merino ewes, indicated they tried to prevent ewes from getting over-fat. Mob size and shelter at lambing were the second and fourth highest priorities and, in all cases, smaller mobs and increased access to shelter were adopted to improve lamb survival rather than reduce ewe mortality. Management of FOO at lambing was the third highest priority, mostly to improve survival of lambs (46%) or to both improve survival of lambs and reduce mortality of ewes (39%). Reducing ewe handling pre-lambing and disturbance during lambing was seldom the highest priority, but about 30% of producers still included these strategies in their top three management priorities, primarily to reduce ewe mortality and improve lamb survival, respectively. The final strategies adopted to reduce both mortality of triplet-bearing ewes and improve survival of their lambs were supplementary feeding with grain and/or supplementation with minerals during pregnancy.

There were no significant differences in mortality of triplet-bearing ewes or survival of their lambs between producers that prioritised the adoption of certain management practices despite varying rates of adoption of these management practices (Table *4.6*). Furthermore, there was substantial variation between participants in their targets for ewe CS, mob size and FOO at lambing, and there were no significant correlations between actual CS, mob size or FOO targets for triplets and mortality of triplet-bearing ewes or survival of triplet-born lambs.

Table 4.6. The proportion of producers that identified different practices as their first, second and third priorities to reduce mortality of triplet-bearing ewes and/or improve survival of their lambs, their recommendations (average and range) for condition score (CS), mob size and feed-on-offer (kg dry matter/ha) at lambing for twin- and triplet-bearing ewes, and the average mortality of triplet-bearing ewes and survival of their lambs for producers that identified the management practice as their first priority. Data were collected from 64 participants of the benchmarking surveys conducted in 2017 and 2018 for producers that had pregnancy scanned to identify triplet-bearing ewes and managed them separately from twin-bearing ewes.

Management Practice	Respondents (%)				Recommendations		Triplet ewe mortality (%)	Triplet lamb survival (%)
	First priority	Second priority	Third priority	Total	Triplet-bearing ewes	Twin-bearing ewes		
CS at lambing	34	11	9	51	3.3 (2.8–3.5)	3.2 (2.9–3.8)	5.1 [a]	61.7 [a]
Mob size during lambing	23	30	21	64	52 (10–150)	134 (50–250)	6.1 [a]	58.7 [a]
Feed-on-offer at lambing	20	28	14	54	1,710 (800–2,500)	1,530 (800–2,200)	4.6 [a]	58.5 [a]
Shelter during lambing	16	19	7	44	-	-	6.5 [a]	58.8 [a]
Ewe handling and monitoring	3	6	33	31	-	-	-	-
Supplementary feeding	2	7	7	14	-	-	-	-

[a] Values within columns are not statistically significant ($P > 0.05$).

4.2.5 Research priorities to improve survival of triplet-bearing ewes and their lambs

Survey participants that identified and separated at least some triplet-bearing ewes from twin-bearing ewes over the two-year period identified the need for further research on 14 different management options to reduce the mortality of triplet-bearing ewes and/or improve the survival of their lambs. The top four priorities identified for further research, which represented 73% of all research ideas, included targets for ewe CS at lambing (31%), mob size during lambing (22%), FOO during lambing (11%) and mineral supplementation (9%).

Similarly, the top four research priorities identified by producers during the workshops and a webinar were FOO during lambing, mob size during lambing, ewe CS at lambing and mineral supplementation (**Figure *4.3*. Percentage of respondents, on a seven-point scale ranging from strongly agree (on the left, black), agree, somewhat agree, neutral, somewhat disagree, disagree and strongly disagree (on the right, white), who believed further research was needed on different management options to reduce mortality of triplet-bearing ewes and/or improve the survival of their lambs**. The respondents were sheep producers that attended workshops at sites across the sheep-producing regions of Australia or a webinar in 2019.Figure ***4.3***). Between 62 and 72% of producers indicated that further research was needed regarding each of these four management strategies. When producers identified a single management strategy as their highest research priority, these top four priorities again represented 78% of all responses: mob size during lambing (30%), ewe CS at lambing (16%), FOO during lambing (16%) and mineral supplementation (16%).

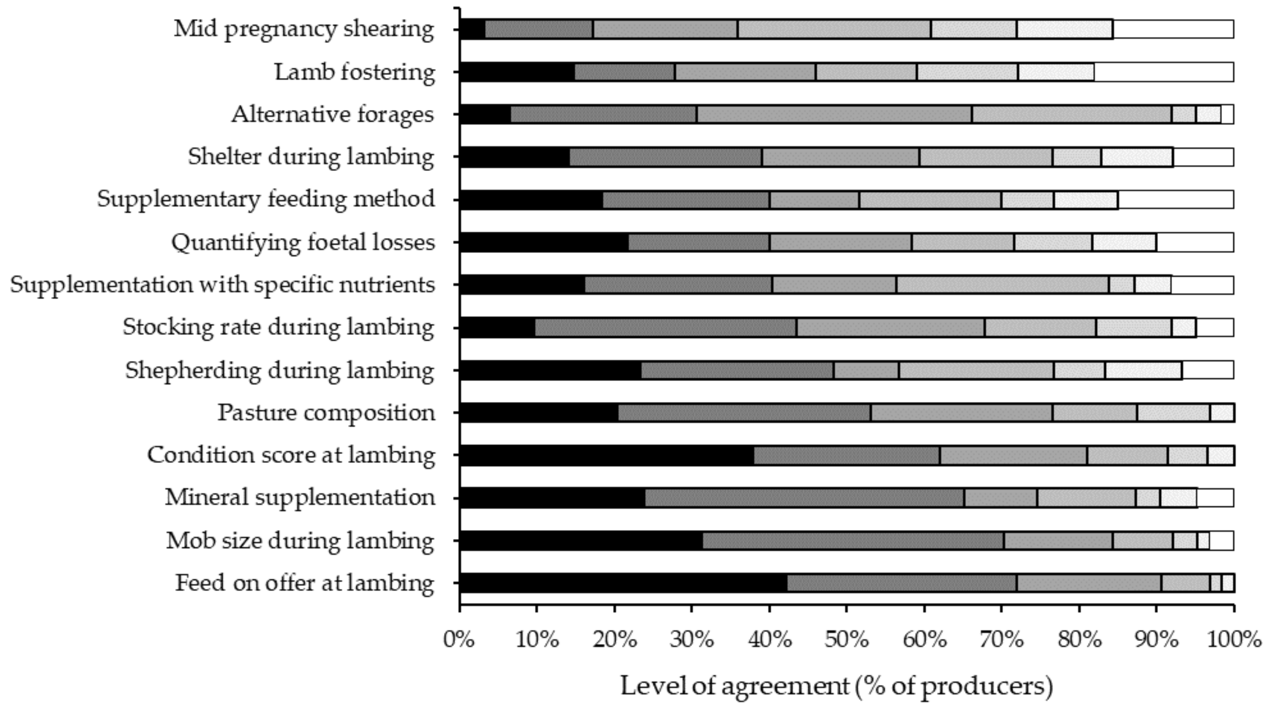

Figure 4.3. Percentage of respondents, on a seven-point scale ranging from strongly agree (on the left, black), agree, somewhat agree, neutral, somewhat disagree, disagree and strongly disagree (on the right, white), who believed further research was needed on different management options to reduce mortality of triplet-bearing ewes and/or improve the survival of their lambs. The respondents were sheep producers that attended workshops at sites across the sheep-producing regions of Australia or a webinar in 2019.

4.3 Discussion

Consultation with sheep producers that had previously identified and differentially managed at least some triplet-bearing ewes indicated that reducing the mortality of triplet-bearing ewes was a high priority. The average mortality of triplet-bearing ewes from the benchmarking surveys was reported to be 6.4%, which was double that for twin-bearing ewes and four times that for single-bearing ewes. To our knowledge, this is the first study to quantify the mortality of triplet-bearing ewes on commercial farms across southern Australia. Kleemann *et al*. reported an average mortality of 12% for triplet-bearing ewes across three years at a single research site, which is within the range for flocks in our study. As expected, the mortality of triplet-bearing ewes was strongly correlated with the survival of triplet-born lambs, whereas the correlation was weaker for twin- and single-bearing ewes and lambs. Indeed, the 3.1% higher mortality of triplet- compared to twin-bearing ewes was a key reason for the relatively small differences in overall lamb marking rates reported between triplet- and twin-bearing ewes (176 vs. 160%). The high average mortality of triplet-bearing ewes, together with the high frequency of farms with mortality rates greater than 10%, represents a significant loss of production for individual farms and an animal welfare risk for the sheep industry. Conversely, the 10th percentile for mortality of triplet-bearing ewes was only 1.8%, which indicates there is significant scope to reduce ewe mortality rates if the adoption of pregnancy scanning to identify triple-bearing ewes can be increased, and the components of best-practice management for these ewes can be identified and adopted.

The average survival of triplet-born lambs from the benchmark surveys was reported to be 59%, which was 22% and 33% lower than their twin- and single-born counterparts. The survival of triplet-born lambs was considerably lower than the 68% survival reported across 29 research studies, mostly based in New Zealand, which could reflect, in part, that the data in our study were collected from commercial farms, whereas most of the data reported in Kenyon *et al.* (2019a) were from smaller-scale experiments and research farms. It is known that the survival of multiple-born lambs is lower at a commercial paddock scale compared to an experimental plot scale (Behrendt *et al.* 2011; Oldham *et al.* 2011a) or in larger mobs (Behrendt *et al.* 2019; Bulmer *et al.* 2019; Brown *et al.* 2014). Furthermore, most of the studies reported by Kenyon *et al*. utilised non-Merino ewes, and it was evident both in our data and Paganoni *et al*. that the survival of both twin- and triplet-born Merino lambs was 5–10% lower than their counterparts from non-Merino ewes. The survival of triplet-born lambs varied from 35% to 79% between flocks, which is similar to that reported by Kenyon *et al.* (2019a). Like ewe mortality, the 90th percentile for the survival of triplet-born lambs demonstrates the scope for improvement, particularly on some farms. Collectively, a survival rate of 70 to 75% for triplet-born lambs would seem to be an achievable target for extensive production systems in Australia where ewes lamb outdoors with minimal supervision. This is especially the case if the knowledge gaps identified by producers in this study can be addressed by further research and used to develop practical management guidelines for triplet-bearing ewes.

One-third of producers surveyed did not identify triplet-bearing ewes, and approximately two-thirds of these producers indicated the main reason for their decision was an insufficient number of triplet-bearing ewes. On average, each of these producers managed nearly 4,000 breeding ewes and had they identified triplet-bearing ewes, their actual reproductive rate was likely to be around 153% rather than 148% based on scanning for multiples only. Therefore, it is likely that approximately 100 triplet-bearing ewes were mixed with the twin-bearing ewes in these flocks. As only 3% of all ewe flocks in Australia are scanned for triplet-bearing ewes (Kubeil 2017), further work is clearly needed to understand the value proposition for producers to separate triplet- from twin-bearing ewes based on the numbers of ewes mated, current scanning percentages, farm characteristics and management capability. The value proposition will also be influenced significantly by the overall increases in lamb survival and weaning rate that can be achieved from separating triplet-from twin-bearing ewes compared to running all multiple-bearing ewes together. Lamb survival is overestimated in flocks where twin- and triplet-bearing ewes are combined, and in the current study the actual survival in these flocks across all lambs born was likely to be around 78% rather than 80%. In any case, this was still similar to the survival rate achieved by flocks where triplet- and twin-bearing ewes were separated, albeit from an estimated 11% lower scanning percentage. However, it is possible that the lack of difference in survival between flocks that did or did not differentially manage twin- and triplet-bearing ewes is because their differential management may not be optimal. Further research is needed to identify best-practice guidelines for triplet-bearing ewes, including quantifying the potential improvements in lamb survival from separating twin- and triplet-bearing ewes. Benefits could be substantial, especially if management guidelines for triplet-bearing ewes can be developed by addressing the research gaps identified by producers in this study. The non-economic advantages of adopting best practice management guidelines for triplets also need to be considered, including the ethical and emotional impacts of fewer ewe and lamb deaths and satisfaction from achieving greater productivity and profitability.

A mixed-method approach involving more than 200 sheep producers from across southern Australia was effective at establishing the research needs and priorities of producers to improve the survival of triplet-bearing ewes and their lambs. The top four priorities for further research identified by producers were to establish targets for ewe CS, FOO, mob size at lambing and quantify the impacts of supplementation with minerals, regardless of the ewe breed managed. These top four priorities represented between 73 and 81% of all responses, despite variations in the consultative processes used to identify the research priorities. The key research priorities to improve the survival of triplet-bearing ewes and their lambs identified from producer consultation in this study align with the knowledge gaps identified by Kenyon *et al*. 2019. Priorities for further work will also be informed by knowledge from the current study of management practices currently adopted by farmers, their production levels and the potential effect of changing a management practice on the mortality of triplet-bearing ewes and their lambs. These priorities will also be weighted based on the ease with which a management change can be achieved within the farming systems and hence the scale of the opportunity to reduce the mortality of triplet-bearing ewes and their lambs.

Most producers indicated the primary reason for managing the CS of triplet-bearing ewes at lambing was to reduce ewe mortality. On average, the target CS at lambing for triplet-bearing ewes of 3.3 was similar to that for twin-bearing ewes, but the target varied from 2.8 to 3.5 between producers. To our knowledge, there has been no detailed experimental work relating CS profile during pregnancy and at lambing to risks of ewe mortality on commercial farms. In contrast to best practice management guidelines for twin-bearing Merino and non-Merino ewes, which require increased feeding to achieve a higher CS at lambing for most farms, none of the producers involved in the benchmark surveys in our study indicated that low CS at lambing contributed to mortality of triplet-bearing ewes, whereas almost 50% indicated they tried to prevent ewes from getting over-fat. Concern over multiple-bearing ewes getting too fat appeared to be a bigger issue for producers with non-Merino ewes than Merino ewes and for triplet- than twin-bearing ewes. This was consistent with beliefs that pregnancy toxaemia and ewes being too heavy at lambing were the main causes of mortality of triplet-bearing ewes. It is well recognised that over-fat ewes, especially those with multiple foetuses, are at greater risk of pregnancy toxaemia due to the direct and indirect effects of excessive fat on feed intake. Optimising the CS of triplet-bearing ewes will also be influenced by the impacts of CS on lamb survival, and low birthweight was perceived to be a more dominant cause of mortality of triplet- compared to twin-born lambs by producers in our study. Studies in New Zealand and Australia using non-Merino ewes have found variable effects of ewe CS at lambing on survival of triplet lambs, but most of these studies were small-plot scale on research stations rather than commercial scale and, in many cases, involved a limited range in CS. Manipulating ewe CS at lambing has a greater influence on the survival of twin-born lambs from Merino ewes compared to non-Merino ewes due in part to lower average birthweights of lambs from Merino ewes, which may indicate a greater positive response of improving CS in triplet-bearing Merino ewes than for non-

Merino ewes. There is a clear need to better define the impacts of CS at lambing on the mortality of triple-bearing ewes and their lambs at the commercial scale, and it is expected that these responses may differ between ewe breeds.

Producers considered FOO at lambing important to reduce both ewe mortality and especially to improve lamb survival. Whilst the three-fold range in target FOO levels from 800 to 2500 kg DM/ha would, in part, reflect different production environments and time of lambing in relation to seasonal pasture supply, the producers indicated there was a need to better define the FOO targets for optimal survival of triplet-bearing ewes and their lambs. Studies in New Zealand found that offering around 800 kg DM/ha from mid-pregnancy until birth reduced birthweights of triplet-born lambs compared to higher FOO levels, but other studies have indicated that triplet-bearing ewes could be offered a minimum of 800 kg DM/ha without adverse effects on lamb survival provided intake was not restricted during the 2 weeks before lambing. Another study from New Zealand showed a negative effect of offering triplet-bearing ewes a minimum of 1,600 kg DM/ha in late pregnancy compared to 900 kg DM/ha on survival of triplet-born lambs, irrespective of ewe conditions score at mid-pregnancy. As summarised by Kenyon *et al*. 2012, literature regarding the effects of ewe nutrition and FOO during late pregnancy and lambing are variable. However, in many cases, studies are limited by low numbers of lambs per treatment, and few have subjected ewes to levels of nutrition well below their theoretical demand, which can occur in environments across southern Australia, especially when lambing in autumn or early winter. There are currently no industry recommendations for the FOO requirements for triplet-bearing ewes during late pregnancy and lambing under commercial farming conditions in Australia. More detailed studies are also needed to better understand the requirement for supplementary feeding triplet-bearing ewes in late pregnancy and lambing, depending on pasture conditions, to reduce ewe mortality and improve lamb survival.

Sheep producers reported that reducing mob size at lambing was a key practice they had adopted to improve the survival of triplet-born lambs, yet this remained a priority for further research. The average mob size at lambing from the benchmark surveys was reported to be 52 triplet-bearing ewes, but it was apparent that producers had very different opinions of the optimum mob sizes, which varied from 10–150 triplet-bearing ewes. Bates *et al*. 2023 recently reported that mob sizes at lambing varied from 30–200 for triplet-bearing ewes across a small sample of farms, mostly in NSW. Lockwood *et al*. 2023 reported survey data collected from sheep producers in southeastern Australia, which indicated the survival of single- and twin-born lambs increased by 1.4% and 3.5% when mob size at lambing was reduced by 100 ewes. This was verified by experimental data, which found that reducing mob size at lambing by 100 twin-bearing ewes increased the survival of their lambs by 1.9 to 2.5%, regardless of breed and stocking rate at lambing. The optimum mob size for twin-bearing ewes was typically less than half that for single-bearing ewes depending on several enterprise-specific factors. There are currently no recommendations for the optimum mob size during lambing for triplet-bearing ewes. Mismothering was perceived to be the main cause of death for triplet-born lambs in the current study, and the effects of mob size on lamb survival are likely to be driven by the risk of mismothering. The risk of mismothering is likely to be greater for triplet-born than twin- or single-born lambs, given more triplet lambs will be born per day for the same ewe mob size, triplet-born lambs and their dams have poorer behavioural traits than both singletons and twins (Cloete *et al.* 2002; Dwyer 2003; Dwyer and Lawrence 2005; Dwyer and Morgan 2006), and triplet-bearing ewes have been observed to take longer to deliver their litter than twin- and single-bearing ewes. More detailed studies to quantify the effects of mob size on lamb survival are needed to underpin economic modelling and determine the optimal mob size for triplet-bearing ewes for specific management settings.

Little is known regarding whether mineral supplementation of lambing ewes can reduce ewe and lamb mortality. Subclinical deficiencies of calcium and magnesium are common in lambing ewes in Australia due to imbalances in pasture grazed by the ewes (Friend *et al.* 2020). Mineral imbalances in vegetative cereal crops also present a risk of low calcium status in ewes grazing these crops in late pregnancy. Subclinical deficiencies in calcium and magnesium may increase the risk of dystocia and related issues, including hypothermia in lambs and poor ewe-lamb behaviour (Friend *et al.* 2020). Providing lambing ewes with ad libitum access to mineral supplements containing magnesium, sodium and calcium has been reported to reduce the risk of ewe mortality when grazing cereal crops (McGrath *et al.* 2013). However, the impact of subclinical mineral deficiencies on lamb mortality and the benefits of mineral supplementation remains unclear. It could be assumed that the benefits of mineral supplementation would be greater for triplet-bearing ewes and their lambs compared to their single- or twin-counterparts, given their higher metabolic demands during pregnancy and lactation.

The sheep producers consulted in this study represented a biased sample, so caution is needed in extrapolating some of the findings across the national sheep flock, especially those relating to levels of reproductive performance. Producers must have utilised pregnancy scanning for litter size to be eligible for inclusion in the benchmarking surveys, and this only represents about 35% of Australian sheep producers. Furthermore, many producers known to have experience with differential management of triplet-bearing ewes were deliberately targeted. The average scanning percentages for farms that identified triplet-bearing ewes were 150% for Merinos and 172% for non-Merinos, which were significantly higher than the industry average scanning percentages of 122% and 147%, respectively. The average proportion of triplet-bearing ewes for these farms was over 6%, which is likely to be about double that present across the national flock, but nevertheless, it is still likely that 1 to 1.5 million ewes conceive triplets annually across Australia given that the flock size is approaching 45 million breeding ewes. As all of the producers surveyed had adopted pregnancy scanning for multiples, it is likely that they had also adopted other management strategies to improve reproductive performance compared to the broader population of sheep producers. Despite higher scanning percentages and, therefore, more multiple-born lambs, the average lamb survival rates for farms in this study were 75% for Merinos and 80% for non-Merinos, which were significantly higher than the industry average lamb survival rates of 69% and 71%, respectively. Mortality rates of triplet-bearing ewes and their lambs across the sheep industry in Australia are likely to be higher than reported in our study due to survey recall bias associated with self-reported retrospective surveys. Munoz *et al*. 2019 recently reported that a cohort of 32 farmers from across Victoria in south-eastern Australia reported their annual ewe mortality was 2.7% compared to 4.7% based on changes in actual sheep numbers over a calendar year. Furthermore, our data suggest that mortality rates of triplet-born lambs are likely to be higher in flocks where triplet-bearing ewes are mixed with twin-bearing ewes, especially when none of the ewes are pregnancy scanned. It is clear that changes in profitability from improving the survival of triplet-bearing ewes and their lambs will be relatively small for most farms where triplet-bearing ewes represent less than 5% of the ewe flock. The increasing prevalence of triplet-bearing ewes, however, means that identifying and adopting best-practice management of triplet-bearing ewes and their lambs will be important for improved productivity and to ensure animal welfare is optimised to meet consumer demands for ethical product.

5. On-farm research

5.1 Methods

The on-farm research involved five experiments which tested managed practices identified by producers as priorities for research; (i) combined versus separate management of twin- and triplet-bearing ewes during late pregnancy and lambing ('Mixed *vs.* Managed'), (ii) ewe CS from pregnancy scanning to marking, (iii) mob size at lambing, (iv) FOO and supplementary feeding during late pregnancy and lambing, and (v) mineral supplementation during late pregnancy and lambing. All experiments tested the effects of the treatments on ewe and lamb survival to marking. The number of research sites completed for each experiment is summarised in Table ***5.1***.

The experiments used ewes of Merino or Maternal breed. Maternal breeds include first-cross (Border Leicester x Merino) or composite ewes joined to composite or terminal sires. For all experiments except the FOO by supplementary feeding experiment, ewe CS was assessed at pregnancy scanning (average of 101 days from the start of joining) and/or pre-lambing (average of 136 days from start of joining) and at lamb marking by a single assessor at each research site. For the FOO by supplementary feeding experiment, the 'pre-lambing' ewe CS was assessed at an average of 124 days from the start of joining, when ewes were allocated to their treatments and lambing paddocks.

Visual assessments of FOO and the percentage of legume in the pasture were made at 25 sites in each paddock before lambing and at lamb marking at each research site. Visual estimates of FOO were calibrated against 10 quadrat cuts as described by Lockwood *et al.* (2020a). Characteristics of lambing paddocks were recorded by a single assessor at each research site and included paddock shape, topography, the number and type of watering points, and shelter availability. Paddock topography and shelter availability were characterised as described by Lockwood *et al.* (2020a).

Daily data for temperature, rainfall and windspeed between Day 145 from the start of lambing and lamb marking were collected via the Australian Gridded Climate Data (AGCD) and Australian Community Climate and Earth-System Simulator (ACCESS-G) services from the Australian Government Bureau of Meteorology for each research site. Windspeed at 10 m was provided by the Bureau of Meteorology and was converted to lamb height of 0.4 m using the formula described by Thornley and Johnson (2000). Daily chill index was calculated for each research site using the formula described by Nixon-Smith (1972), with weighting of daily temperature (0.75*maximum temperature + 0.25*minimum temperature) as per Horton *et al.* (2019). The mean chill index between day 145 from the start of joining and lamb marking was then calculated.

Lamb survival for each mob was calculated based on the number of fetuses identified to ewes allocated to the lambing mob and the number of lambs marked. Ewe mortality for each mob was calculated based on the number of ewes present pre-lambing and the number of ewes present at lamb marking. Individual ewe deaths were recorded between pregnancy scanning and lamb marking where observed. Ewes that were allocated to treatments at pregnancy scanning but were absent at the pre-lambing and/or marking measurements were also classified as dead.

Table 5.1. Number of research sites completed for the experiments examining the combined or separate management of twin- and triplet-bearing ewes ('mixed vs managed'; MvM), condition score of Maternal (CS Maternal) and Merino ewes (CS Merino) between pregnancy scanning and

lamb marking, mob size of ewes during lambing (Mob size), impacts of feed-on-offer and supplementary feeding (FOO by Supp) and mineral supplementation (Minerals) on the survival of triplet-bearing ewes and their lambs in Western Australia (WA), South Australia (SA), Victoria (VIC) and New South Wales (NSW) between 2019 and 2021.

	MvM	CS Maternal	CS Merino	Mob size	FOO by Supp	Minerals
WA	3	3[1]	1	6		1
SA	1	3				1
VIC	1	3	1	8	8	9
NSW	1	3	5	1	3	1
Total sites	6	12[1]	7	15	11	12

[1] Includes one site with Dorper sheep

5.1.1 Combined versus separate management of twin- and triplet-bearing ewes during late pregnancy and lambing ('Mixed *vs.* Managed')

This experiment involved comparison of two management systems:

i. mixed mobs of twin- and triplet-bearing ewes which were managed according to best-practice for twins between pregnancy scanning and lamb marking ('Mixed')
ii. separate mobs of twin- and triplet-bearing ewes which were managing according to best-practice for each birth type between pregnancy scanning and lamb marking ('Managed'). For triplets, best practice management for triplets was based on producer feedback.

Ewes of Maternal or Merino breed were randomly allocated into a treatment and replicate within 10 days of pregnancy scanning (average of 98 days from the start of joining); 'Mixed', 'Managed Twins' or 'Managed Triplets'. It was hypothesised that survival of triplet-bearing ewes and their lambs would be greater for Managed mobs compared with Mixed mobs. Data for the lambing paddocks and ewe CS at lambing are summarised in Table ***5.2***.

Table 5.2. Number of mobs, and average mob size at lambing, ewe condition score (CS) at lambing, feed-on-offer (FOO; kg DM/ha) at lambing, percentage of legume in the pasture at lambing and percentage of the lambing paddock with shelter for the Mixed and Managed mobs at research sites across Australia between 2019 and 2021.

Treatment		*n* mobs	Mob size		CS at lambing	FOO at lambing	Legume %	Shelter %[1]
	Twins			50	3.0			
Mixed		24	63			1,060	19	21
	Triplets			13	3.0			
Managed Twins		12	62		2.9	940	20	13

Managed Triplets	12	41	3.2	1,170	20	21

[1] The shelter percentage relates to shelter within the paddock boundary

5.1.2 Ewe CS from pregnancy scanning to lambing

The findings from the condition score experiment have been published in *Animals* (Haslin *et al*. 2023); see Appendix – section 13.3.

Triplet-bearing ewes of Maternal or Merino breed were randomly allocated into a treatment after pregnancy scanning at, on average, 97 days from the start of joining; 'High' or 'Low' CS. Treatments at each site were replicated where adequate ewes and lambing paddocks were available. The aim was for the CS of ewes in the High and Low treatments to differ by at least 0.3 of a CS at lambing. Target CSs at lambing for each treatment were determined at pregnancy scanning in consultation with the producer. To minimise overlap between CS treatments, the minimum CS target for the High treatment and the maximum CS target for the Low treatment were CS 3.3. Producers achieved these differences in CS by either allocating treatments to paddocks with differing FOO and/or altering the rates of supplementary feeding. The number of mobs per treatment and lambing paddock data are summarised in Table ***5.3***.

It was hypothesised that survival of triplet-bearing ewes and their lambs would be higher in the High CS treatment compared to the Low CS treatment, regardless of ewe breed.

Table 5.3. Number of mobs, and average for mob size and stocking rate at lambing, feed-on-offer (FOO; kg DM/ha) at lambing, percentage of legume in the pasture at lambing and percentage of the lambing paddock with shelter for the High and Low CS mobs of Merino and maternal breed at research sites across Australia between 2019 and 2021.

Breed	CS treatment	*n* mobs	Mob size	Stocking rate	FOO	Legume %	Shelter %[1]
Maternal	High	28	42	4.1	1,541	29.4	16
	Low	23	43	4.4	1,492	30.1	13
Merino	High	22	25	3.5	1,412	36.6	18
	Low	22	25	3.5	1,423	33.1	17

[1] The shelter percentage relates to shelter within the paddock boundary

5.1.3 Mob size at lambing

The findings from the mob size experiment have been published in *Animals* (Lockwood *et al*. 2023); see Appendix – section 13.4.

Triplet-bearing ewes of Maternal or Merino breed were randomly allocated into one of two treatments; 'High' or 'Low' mob size at an average of 135 days from the start of joining. The aim was for the mob sizes of the High and Low treatments to differ by at least 40 ewes within each research site. Treatments at each research site were replicated where adequate ewes and paddocks were available. Four research sites did not include replication whilst the remaining sites had one to four replicates of the High mob size treatment and two to six replicates of the Low mob size treatment.

Paddock selection aimed for ewes in the High and Low mob size treatments at each research site to be lambed at a similar stocking rate of within 2 ewes/ha. Data for the lambing paddocks and ewe CS at lambing are summarised in Table ***5.4***.

It was hypothesised that lambing triplet-bearing ewes in smaller mobs would improve the survival of their lambs but have no effect on ewe survival.

Table 5.4. Number of mobs for the High and Low mob size treatments and the mean (range) for mob size and stocking rate (ewes/ha) at lambing, ewe condition score (CS) at lambing, feed-on-offer (FOO; kg DM/ha) at lambing, proportion of legume in the pasture at lambing and percentage of the lambing paddock with shelter for the High and Low mob size treatments across Australia between 2019 and 2021.

Treatment	*n* mobs	Mob size	Stocking rate	CS	FOO	Legume %	Shelter %[1]
High mob size	31	63 (27 – 139)	5.1 (0.7 – 13.4)	3.1	1,110	34	10
Low mob size	47	20 (10 – 57)	5.0 (0.7 – 11.2)	3.2	1,210	26	7

[1] The shelter percentage relates to shelter within the paddock boundary

5.1.4 FOO and supplementary feeding during late pregnancy and lambing

Triplet-bearing ewes of Maternal or Merino breed were randomly allocated into a treatment at 120-125 days from the start of joining. This experiment examined a 2 x 2 factorial design of FOO and supplementary feeding; High FOO with higher rates of supplementary feeding (HFHS), High FOO with low rates of supplementary feeding (HFLS), Low FOO with higher rates of supplementary feeding (LFHS) and Low FOO with low rates of supplementary feeding (LFLS). 'High' and 'Low' FOO treatments were managed from pregnancy scanning to differ by 500-1,000 kg DM/ha at the start of lambing. Likewise, the 'High' and 'Low' supplementary feeding treatments were to differ by at least 300 g grain per day, plus the lowest feeding rate needed to be at least 100 g/day. Data for ewe CS at lambing and the lambing paddocks are summarised in Table **5.5**.

It was hypothesised that (i) lambs born to triplet-bearing ewes grazing higher FOO during lambing would be greater than those grazing lower FOO during lambing and (ii) survival of ewes and their lambs would be greater when ewes are supplementary fed during late pregnancy regardless of FOO levels during lambing.

Table 5.5. Number of mobs, and average for ewe condition score (CS) at lambing, feed-on-offer (FOO; kg DM/ha) at lambing and marking, percentage of legume in the pasture at lambing and percentage of the lambing paddock with shelter for the High/Low FOO x High/Low Supplementary feeding treatments (HFHS, HFLS, LFHS, LFLS) at research sites across Australia between 2019 and 2021.

Treatment	*n* mobs	CS at lambing	FOO at lambing	FOO at marking	Legume % at lambing	Shelter %
HFHS	11	3.3	2,010	2,250	22	6
HFLS	11	3.3	1,990	2,320	26	6
LFHS	11	3.3	1,210	1,370	31	7
LFLS	11	3.3	1,220	1,230	29	7

5.1.5 Mineral supplementation during late pregnancy and lambing

Triplet-bearing ewes of Maternal or Merino breed were randomly allocated into one of three treatments at approximately 110 days from the start of joining; (i) supplementation with the standard mineral used at the farm ('Standard mineral'), (ii) mineral mix formulated in WA ('WA mineral'; see Table ***5.6***) or (iii) no mineral supplementation ('None'). The 'Standard mineral' used by most farms consisted of 70% lime and 30% salt. Ewes were provided access to the mineral supplements from Day 110 from the start of joining until the end of lambing. Consumption of the minerals by each mob was not measured. All mobs were to be grazed on similar paddocks during late pregnancy and were managed to achieve a similar CS at lambing. Data for ewe CS at lambing and the lambing paddocks are summarised in Table ***5.7***.

It was hypothesised that supplementing triplet-bearing ewes with minerals during late pregnancy and lambing would improve ewe and lamb survival.

Table 5.6. Composition of the WA mineral mix provided to triplet-bearing ewes in the Mineral supplementation experiment at research sites across southern Australia between 2019 and 2021

Element	Concentration
Calcium (Ca)	160 g/kg
Sodium (Na)	100 g/kg
Sulphur (S)	40 g/kg
Magnesium (Mg)	28 g/kg
Phosphorus (P)	0 g/kg
Vitamin E	1 g/kg
Copper (Cu)	120 mg/kg
Molybdenum (Mo)	10 mg/kg
Iron (Fe)	1600 mg/kg
Manganese (Mn)	800 mg/kg
Zinc (Zn)	1000 mg/kg
Cobalt (Co)	20 mg/kg
Iodine (I)	20 mg/kg

Selenium (Se)	8 mg/kg

Table 5.7. Number of mobs, and average for ewe condition score (CS), feed-on-offer (FOO; kg DM/ha) and percentage of legume in the pasture at lambing and percentage of the lambing paddock with shelter for mobs receiving no mineral supplementation (None), WA mineral supplement (WA) or the standard farm mineral supplement (Standard) at research sites across Australia between 2019 and 2021.

Treatment	*n* mobs	CS at lambing	FOO at lambing	Legume %	Shelter %
None	11	3.4	1,780	16	21
WA	11	3.4	1,800	18	27
Standard	11	3.5	1,680	15	15

5.1.6 Statistical analysis

Data were analysed using Genstat 22nd edition (VSN International 2017), except where otherwise stated.

For lamb survival and ewe mortality at the paddock-level, the method of restricted maximum likelihood (REML) was used to fit the relevant treatments, breed (Maternal vs Merino), where appropriate, along with any relevant covariate as fixed effects while year, farm (nested within year) and paddock (nested within farm) were fitted as random effects, for all experiments. Once CS treatment and breed effects were determined for the CS experiment, the lamb survival model was re-run with the average CS of ewes pre-lambing and the CS change between pre-lambing and marking fitted separately as fixed effects instead of CS treatment. Similarly, for the mob size experiment further analysis was done to examine the actual effect of mob size given that the treatment effect was significant. This was done using REML by fitting the actual ewe mob size as a fixed effect while year, farm (nested within year) and paddock (nested within farm) were fitted as random effects.

For the CS experiment, ewe CS at pregnancy scanning, pre-lambing and marking, and the CS change between pregnancy scanning and pre-lambing, and pre-lambing and marking were analysed separately at the paddock-level using REML. Breed, CS treatment (High vs Low) and their two-way interaction were fitted as fixed effects and year and site nested within year were included as random effects. Estimates of individual ewe mortality and the probability of an individual ewe to be lactating at marking were assessed by fitting Generalized Linear Mixed Models (GLMM). The approach used a logit transformation and binomial distribution. Using additive models, logits were predicted as a function of breed, CS at pregnancy scanning and change in CS from pregnancy scanning to pre-lambing as fixed effects. Year and site (nested within year) were fitted as random effects. Both CS variates were tested for quadratic effects. The probability of ewes to be lactating at marking was analysed in SAS v9.4 (SAS Institute Inc., Cary, NC, USA) and included either alive ewes at marking only (i.e. lactating and non-lactating ewes) or alive and dead ewes at marking where dead ewes were considered as non-lactating.

For the FOO by supplementary feeding experiment, FOO and the percentage of legumes in the lambing paddocks in late-pregnancy and at lamb marking were analysed using linear mixed models in SAS v9.4 (SAS Institute Inc., Cary, NC, USA). The models included FOO levels (High vs Low), supplementary feeding rate (High vs Low) and their two-way interaction as fixed effects. Year and site, nested within year, were included as random effects in the models.

All possible models were examined with statistical significance of terms and interactions thereof accepted at $P < 0.05$.

5.2 Results

5.2.1 'Mixed *vs.* Managed'

The survival of triplet-born lambs was significantly greater when triplets were managed separately compared with mixed management of triplets and twins (Table ***5.8***). The survival of twin-born lambs, and mortality of twin- and triplet-bearing ewes was not significantly different when they were managed separately compared with when they were managed as mixed mobs during late pregnancy and lambing (Table ***5.8***). Ewe CS at lambing, shelter availability at lambing, paddock characteristics and the average chill index during lambing had no significant effect on lamb mortality.

Table 5.8. Mean mortality (%) of twin-bearing and triplet-bearing ewes of Maternal and Merino breed and survival (%) of their lambs to marking ewes when managed in mixed mobs of twins and triplets or managed separately during late pregnancy and lambing at research sites across southern Australia between 2019 and 2021.

	Mixed	**Managed separately**	***l.s.d.***	***P*-value**
Twin-bearing ewe mortality	3.7%	4.7%	2.8	0.474
Triplet-bearing ewe mortality	10.9%	12.9%	7.3	0.577

Twin-born lamb survival	76.7%	74.5%	5.4	0.413
Triplet-born lamb survival	41.8%	53.0%	5.9	<0.001

5.2.2 Ewe CS from pregnancy scanning to lambing

Ewe CS

The average CS at pregnancy scanning was 3.4 for Maternal ewes and 3.3 for Merino ewes (l.s.d.= 0.36). There was no breed by CS treatment effect on the CS of ewes at pregnancy scanning (P = 0.221). There was also no breed by CS treatment effect on the change in CS between pregnancy scanning and pre-lambing or between pre-lambing and marking (Table 5.9). The change in CS differed between the High and Low CS treatments between pregnancy scanning and pre-lambing (0.12 vs -0.33; P < 0.001) and between pre-lambing and marking (-0.39 vs 0.07; P < 0.001) but did not differ between breeds. The average CS at marking for ewes managed at the High and Low CS treatments were 3.1 and 3.0 for Maternals and 3.0 and 2.8 for Merinos (l.s.d. within breed = 0.09; l.s.d. between breeds = 0.19). There was no breed by CS treatment effect on the CS of ewes at marking (P = 0.244).

Table 5.9. Mean change in condition score (CS) between pregnancy scanning and pre-lambing, and pre-lambing and marking for triplet-bearing Maternal and Merino ewes managed at High and Low CS treatments at 19 commercial research sites across southern Australia between 2019 and 2021.

	Maternal		Merino		l.s.d. between breeds	l.s.d. within breeds	*P*-value[1]
	High CS	**Low CS**	**High CS**	**Low CS**			
Scanning to pre-lambing	0.26	-0.25	0.01	-0.43	0.29	0.06	0.094
Pre-lambing to marking	-0.44	-0.07	-0.34	-0.06	0.24	0.09	0.134

[1] *P*-value is for the interaction between breed and CS treatment.

Table 5.10. Mean mortality (%) of triplet-bearing ewes and survival (%) of their lambs to marking for Maternal and Merino ewes managed at High and Low condition score (CS) treatments between pregnancy scanning and marking at 19 commercial research sites across southern Australia between 2019 and 2021. Data for ewe mortality were angular transformed and back-transformed values are presented in brackets.

	High CS	Low CS	l.s.d.[1] between breeds	l.s.d.[1] within breeds	*P*-value[1]
Ewe mortality					
Maternal	14.3 (6.1%)	12.7 (4.8%)	5.1	4.7	< 0.01
Merino	11.8 (4.2%)	19.7 (11.4%)			

Lamb survival					
Maternal	56.2	59.3	7.2	4.1	< 0.001
Merino	53.4	47.1			

[1] *P*-values are for the interaction between CS treatment and breed; the least significant differences for ewe mortality apply to the transformed data.

Treatment and ewe breed on lamb survival to marking

There was an effect of breed by CS treatment on lamb survival to marking, where triplet lambs born to Merino ewes in the High CS treatment had greater survival to marking than their counterparts born to ewes in the Low CS treatment (Table *5.10*). CS treatment had no effect on the survival of lambs born to Maternal ewes. Lamb survival to marking did not differ between Maternal and Merino ewes within the High CS treatment. However, Merino lambs born to ewes in the Low CS treatment had lower survival than their Maternal counterparts (Table *5.10*). The proportion of shelter available in the lambing paddocks and the average chill index during lambing had no effect on the survival of triplet-born lambs nor were there any interactions with ewe CS treatment.

CS at lambing and CS change between pregnancy scanning and pre-lambing on lamb survival to marking

There was a significant effect of breed by the average CS of ewes at lambing on lamb survival, where the survival of Merino but not Maternal lambs was higher when ewes were in greater CS at lambing ($P < 0.01$; Figure *5.1*). On average, survival of Merino lambs to marking was 6.7% higher when the average pre-lambing CS of mobs of triplet-bearing was 0.5 CS greater, within a range of CS 2.5 to 3.5 (Figure *5.1*).

There was a significant effect of breed by the average CS change of ewes between pregnancy scanning and pre-lambing on lamb survival, where gaining CS increased the survival of Merino lambs but not Maternals ($P < 0.01$; Figure *5.2*). On average, survival of Merino lambs to marking increased by 6.5% when the average CS change of ewes increased by 0.5 between pregnancy scanning and pre-lambing (Figure *5.2*).

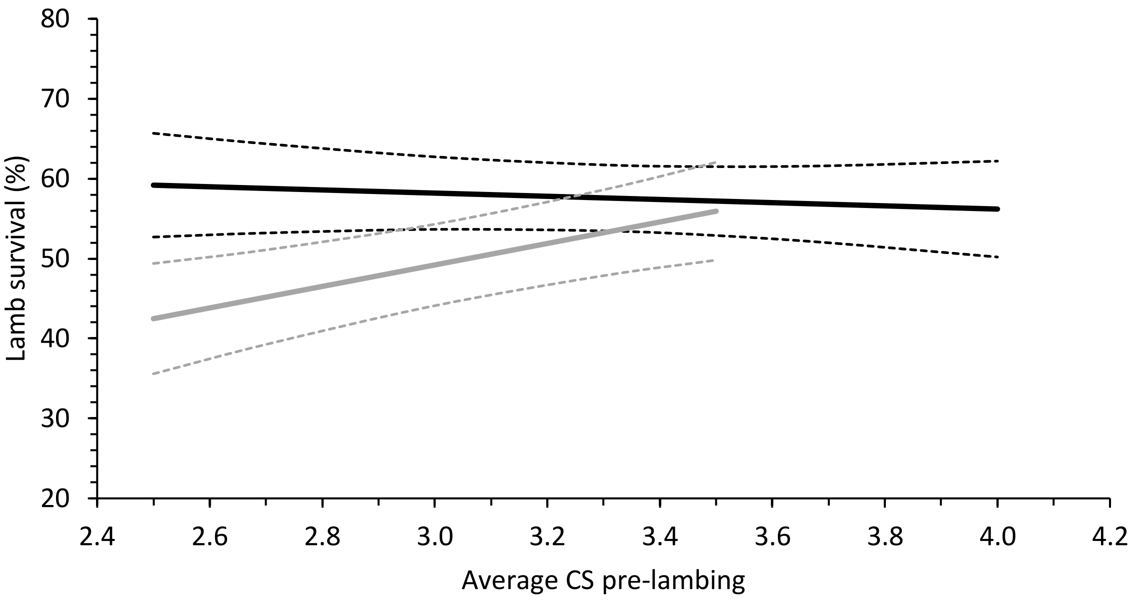

Figure 5.1. Effect (± 95% confidence intervals; dotted lines) of the average condition score (CS) of mobs of triplet-bearing Maternal (black lines) and Merino (grey lines lines) ewes pre-lambing (average of 136 days from the start of joining) on the survival of their lambs to marking at 19 commercial research sites across southern Australia between 2019 and 2021. The average CS at pregnancy scanning was 3.4 for Maternals and 3.3 for Merinos.

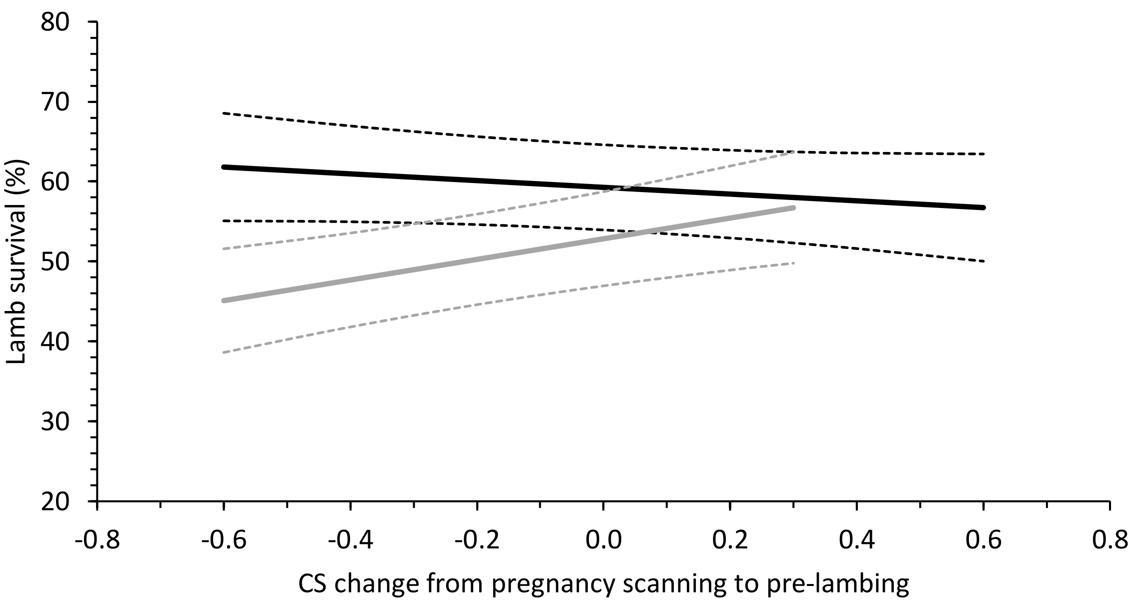

Figure 5.2. Effect (± 95% confidence intervals; dotted lines) of the average change in condition score (CS) of mobs of triplet-bearing Maternal (black lines) and Merino (grey lines lines) ewes between pregnancy scanning and pre-lambing on the survival of their lambs to marking at 19 commercial research sites across southern Australia between 2019 and 2021. The average CS at pregnancy scanning was 3.4 for Maternals and 3.3 for Merinos.

Treatment and ewe breed on ewe mortality to marking

There was an effect of breed by CS treatment on ewe mortality, where Merino ewes in the Low CS treatment had greater mortality to marking than their counterparts in the High CS treatment (Table *5.10*). By contrast, CS treatment had no effect on the mortality of Maternal ewes. Ewe mortality to marking did not differ between Maternal and Merino ewes within the High CS treatment. However, Merino ewes managed at the Low CS had greater mortality than their Maternal counterparts (Table *5.10*).

CS change between pregnancy scanning and pre-lambing on ewe mortality to marking

Ewe CS at pregnancy scanning had no effect on ewe mortality (data not shown). There was no effect of breed by CS change between pregnancy scanning and pre-lambing on ewe mortality ($P = 0.290$; Figure *5.3*). Ewe mortality decreased as the CS change between pregnancy scanning and pre-lambing increased ($P < 0.05$). There was no significant difference in mortality between Merino and Maternal ewes due to CS change between pregnancy scanning and parturition ($P = 0.065$).

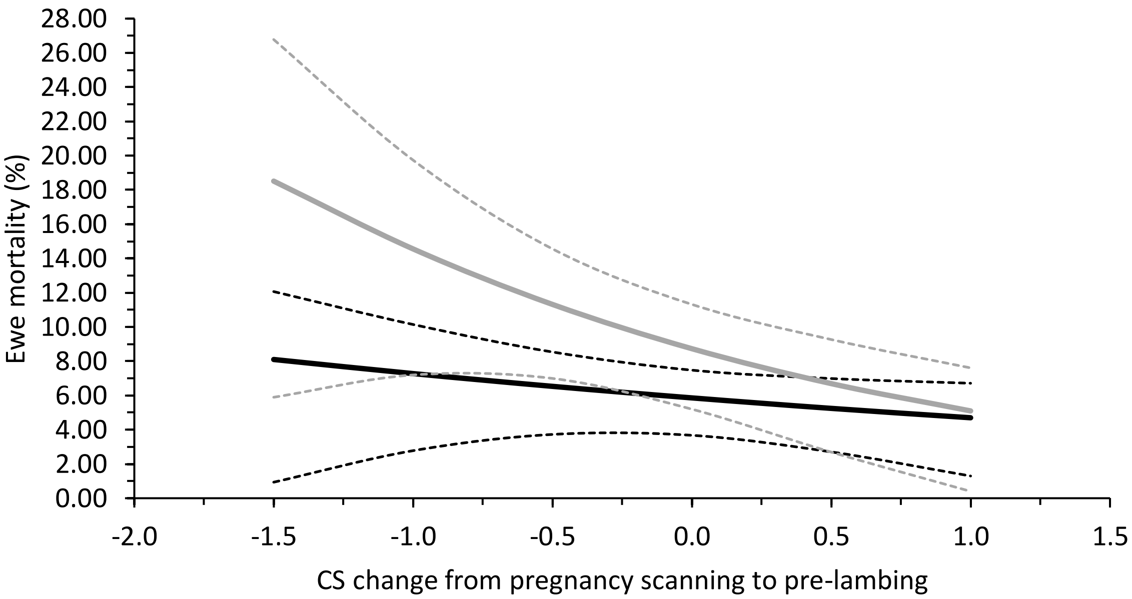

Figure 5.3. The effect (± 95% confidence intervals; dotted lines) of the change in condition score (CS) of triplet-bearing Maternal (black lines) and Merino (grey lines) ewes between pregnancy scanning and pre-lambing on their mortality to marking at 19 commercial research sites across southern Australia between 2019 and 2021. The average CS at pregnancy scanning was 3.4 for Maternals and 3.3 for Merinos.

CS change between pregnancy scanning and pre-lambing on the probability of the ewe lactating at marking

Ewe CS at pregnancy scanning, the change in CS between pregnancy scanning and pre-lambing, and ewe breed had no effect on the probability of those ewes alive at marking being non-lactating (data not shown). When ewes that died before marking were also considered as 'non-lactating' at marking, CS at pregnancy scanning and breed remained non-significant. However, there was a positive relationship between CS change between pregnancy scanning and pre-lambing, and the probability for a triplet-bearing ewe to be lactating at marking ($P < 0.01$; Figure **5.4**).

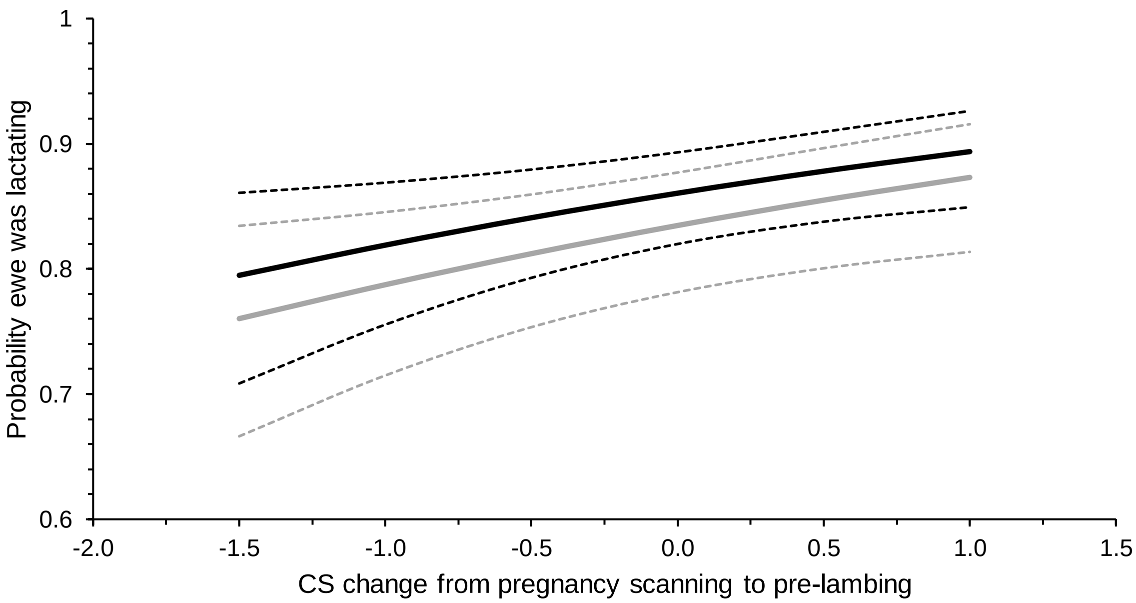

Figure 5.4. Prediction (± 95% confidence intervals; dashed lines) for the relationship between the change in ewe condition score (CS) between pregnancy scanning and pre-lambing and the probability of triplet-bearing Maternal (black lines) and Merino (grey lines) ewes to be lactating at marking at 19 commercial research sites across southern Australia between 2019 and 2021. Ewes whose entire litter died and ewes that died prior to marking were included in the analysis. The average CS at pregnancy scanning was 3.4 for Maternals and 3.3 for Merinos.

5.2.3 Mob size at lambing

Lamb survival was significantly greater for lambs born in the Low compared with the High mob size treatments (Table **5.11**). There was no effect of mob size at lambing on the mortality of triplet-bearing ewes (Table **5.11**). Analysis of the effect of the actual mob sizes showed that reducing mob size at lambing by 10 triplet-bearing ewes increased the survival of their lambs to marking by 1.51% (Figure 5.6; $P<0.001$). There was no effect of ewe CS at lambing, the stocking rate of ewes at lambing, FOO at lambing, the proportion of legume in the pasture at lambing, shelter availability in the lambing paddock or the average chill index during lambing on lamb survival or ewe mortality nor any interaction with treatment.

Table 5.11. Mortality (%) of triplet-bearing ewes of Merino and Maternal breed and survival (%) of their lambs to marking for the High and Low mob size treatments across Australia between 2019 and 2021.

	High mob size	Low mob size	l.s.d.	*P*-value
Ewe mortality	6.3	5.1	1.68	0.179
Lamb survival	56.6	65.6	3.62	<0.001

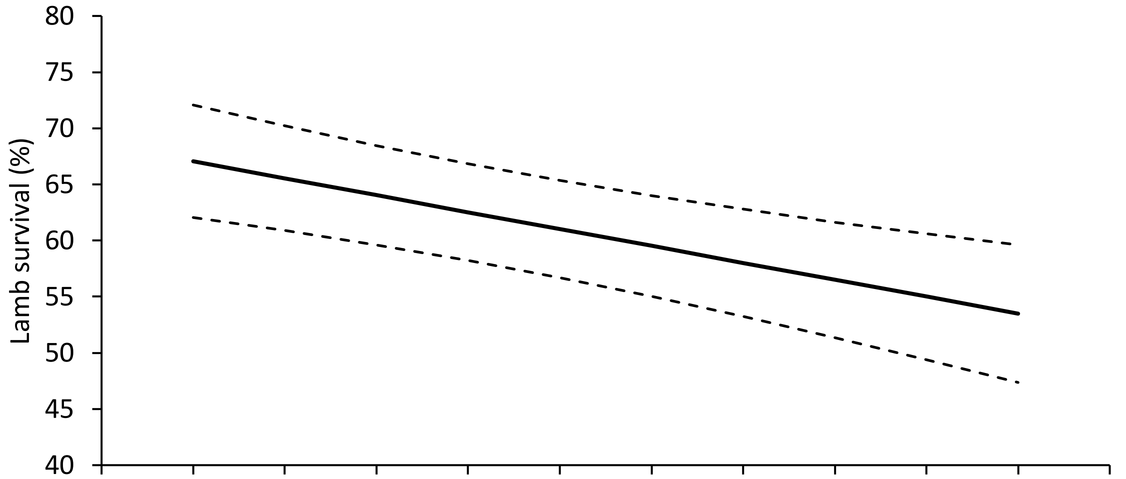

Figure 5.5. The effect (±95% confidence intervals) of the mob size of triplet-bearing ewes of Merino and Maternal breed at lambing on the survival of their lambs to marking at research sites across southern Australia between 2019 and 2021.

5.2.4 FOO and supplementary feeding during late pregnancy and lambing

The HFHS and HFLS treatments had greater FOO than the LFHS and LFLS treatments pre-lambing and at marking (Table ***5.12***). There was no significant difference in the proportion of legume in the pasture in the paddocks for each treatment.

Table 5.12. Mean feed-on-offer (FOO; kg DM/ha) at allocation to treatments in late-pregnancy (average of 124 days from the start of joining) and at lamb marking for triplet-bearing ewes in the High FOO and High Supplementary feeding (HFHS), High FOO and Low Supplementary feeding (HFLS), Low FOO and High Supplementary feeding (LFHS), and Low FOO and Low Supplementary feeding (LFLS) treatments at 10 commercial research sites across southern Australia between 2019 and 2021.

	HFHS	HFLS	LFHS	LFLS	*l.s.d.*	*P*-value[1]
Late-pregnancy	1,982	1,976	1,202	1,208	294.4	< 0.001

Marking	2,245	2,319	1,417	1,238	593.2	< 0.001

[1]*P*-value is for the interaction between FOO and supplement treatments

There was no significant effect of the FOO x supplementary feeding treatments on the survival of triplet-bearing ewes or their lambs (Table **5.13**). Ewe CS at lambing, shelter availability at lambing and the average chill index during lambing had no significant effect on lamb mortality.

Table 5.13. Mean mortality (%) of triplet-bearing ewes of Maternal and Merino breed and survival (%) of their lambs to marking for mobs allocated to the High FOO and High Supplementary feeding (HFHS), High FOO and Low Supplementary feeding (HFLS), Low FOO and High Supplementary feeding (LFHS), and Low FOO and Low Supplementary feeding (LFLS) treatments for lambing at research sites across southern Australia between 2019 and 2021.

	HFHS	HFLS	LFHS	LFLS	*l.s.d.*	*P*-value
Ewe mortality	6.8%	8.1%	4.9%	9.2%	3.5	0.099
Lamb survival	61.5%	63.7%	64.7%	63.1%	5.9	0.747

5.2.5 Mineral supplementation during late pregnancy and lambing

There was no significant effect of mineral supplementation on the survival of triplet-bearing ewes or their lambs (Table ***5.14***). Ewe CS at lambing, shelter availability at lambing and the average chill index during lambing had no significant effect on lamb mortality.

Table 5.14. Mean mortality (%) of triplet-bearing ewes of Maternal and Merino breed and survival (%) of their lambs to marking for mobs provided with no mineral supplementation, the standard mineral supplement for the farm or the mineral supplement produced in Western Australia for research sites across southern Australia between 2019 and 2021. Data for ewe mortality were angular transformed and values in brackets are presented in the back-transformed state.

	None	Standard mineral	WA mineral	*l.s.d.*	*P*-value
Ewe mortality	17.0 (8.5%)	21.0 (12.9%)	17.6 (9.2%)	5.0[1]	0.312
Lamb survival	57.5%	53.9%	59.9%	5.2	0.080

[1] Least significant difference applies to the transformed data

5.3 Discussion

5.3.1 Combined versus separate management of twin- and triplet-bearing ewes during late pregnancy and lambing ('Mixed *vs.* Managed')

Survival of triplet-born lambs was better when triplet-bearing ewes were managed separately from twin-bearing ewes during late pregnancy and lambing, but there was no impact on ewe survival. It has been reported that triplet-bearing ewes have similar feed intakes to twin-bearing ewes under pastoral conditions (Morris and Kenyon 2004), despite them having greater nutritional demands, and hence triplet-bearing ewes have been reported to be in negative energy balance during late pregnancy (Kenyon *et al.* 2019a). The average CSs of ewes at lambing were slightly higher for triplet-bearing ewes managed separately compared to when managed together with twin-bearing ewes. It is therefore possible that separate management of triplet-bearing ewes enabled better nutrition, contributing to improved lamb survival for the mobs of triplets managed separately in this study. Smaller mob sizes at lambing improve the survival of twin-born lambs (Lockwood *et al.* 2020a; Lockwood *et al.* 2020b) and this project has shown that smaller mobs improve the survival of triplet-born lambs, with the effect for triplets being 6-fold that of twins. Hence, optimum mob sizes at lambing are smaller for triplets than twins and thus differential management of twins and triplets during lambing also allows optimisation of mob size and hence lamb survival.

5.3.2 Ewe CS from pregnancy scanning to lambing

The average CS of the Merino ewes was 3.3 at pregnancy scanning. Merino ewes managed at the High CS maintained CS between pregnancy scanning and pre-lambing whilst those managed at the Low CS lost 0.4 CS. Both treatments lost CS between pre-lambing and marking, although those ewes managed at the High CS had greater CS loss. Late-pregnancy represents the greatest period of foetal growth (Mellor 1983; Kelly and Newnham 1990) and hence nutrition during this period dictates lamb birthweight (Roca Fraga *et al.* 2018). It is well known that lambs born to Merino ewes in poorer CS during late-pregnancy or that lose liveweight during late-pregnancy have lower birthweights and thus poorer survival (Oldham *et al.* 2011b; Paganoni *et al.* 2014). Our findings also showed that survival of lambs born to triplet-bearing Merino ewes was poorer when ewes had a lower CS pre-lambing or lost CS between pregnancy scanning and pre-lambing. Hence, the poorer survival of triplet lambs born to Merino ewes managed at the Low CS can be explained by the loss in ewe CS between pregnancy scanning and lambing, and the overall lower CS of these ewes compared with those managed at the High CS. It has been reported that triplet-bearing ewes have similar feed intakes to twin-bearing ewes under pastoral conditions (Morris and Kenyon 2004), despite them having greater nutritional demands, and hence triplet-bearing ewes have been reported to be in negative energy balance during late pregnancy (Kenyon *et al.* 2019b). Ewes in poorer condition have less ability to buffer any nutritional shortfalls through mobilising their body reserves and are subsequently at greater risk of metabolic disease, dystocia and death (Jacobson *et al.* 2020). The greater mortality of triplet-bearing Merino ewes managed at the Low CS compared with the High CS can therefore also be explained by their overall poorer CS and loss in CS during late-pregnancy, predisposing metabolic disease and dystocia.

The average CS of the Maternal ewes at pregnancy scanning was 3.4, which was similar to that of the Merino ewes. Maternal ewes managed at the High CS gained 0.26 CS between pregnancy scanning and pre-lambing whilst those managed at the Low CS lost 0.25 CS. Maternal ewes managed at the

High CS lost more CS between pre-lambing and marking resulting in similar average CS for the High and Low CS treatments at marking. CS treatment had no significant impact on the survival of triplet-born Maternal lambs. These findings suggest that Maternal ewes in CS 3.4 at pregnancy scanning which lose up to 0.25 CS, on average, to pre-lambing can compensate for the declining nutritional status resulting in no negative impact on the survival of their lambs. This may also suggest that a CS of 3.1-3.2 is within or near the optimal range for triplet-bearing Maternal ewes at lambing and thus their lambs may have been born within the optimal range for birthweight. This is supported by Behrendt *et al.* (2019) who found that undernutrition only decreased lamb birthweight when the CS of Maternal composite ewes at lambing was less than 3 and that lamb survival was near-maximum when ewes were managed to CS 3.2 to 3.5 at lambing. Similarly, Kenyon *et al.* (2011) observed no effect of the CS of triplet-bearing Romney ewes on the survival of their lambs, when the average CS of ewes ranged from 2.8 to 3.4 in late-pregnancy. However, Kenyon *et al.* (2013) found survival of triplet lambs born to ewes that were managed to CS 2.5 during pregnancy (CS 2.5 at lambing) was poorer than those born to ewes managed to CS 3 during pregnancy (CS 2.7 at lambing). On average, the CS of Maternal ewes was greater in our study and therefore further exploration of the impacts of lower CS profiles on ewe and lamb survival are warranted. Our findings also suggest that allowing Maternal ewes to lose significant CS between pre-lambing and marking could compromise ewe and lamb survival and hence further work is required to investigate this relationship.

The impact of CS treatment on lamb survival differed between Merinos and Maternals in our study. Survival was poorer for lambs born to Merino ewes managed at the Low CS, who lost 0.4 CS in late-pregnancy compared to those managed at the High CS which maintained CS, whereas lamb survival was not compromised when Maternal ewes managed at the Low CS lost 0.25 CS during late pregnancy compared with those managed at the High CS which gained 0.26 CS. Furthermore, our results show that lambs born to triplet-bearing Merino ewes that are in greater CS pre-lambing or which gain CS between pregnancy scanning and lambing have better survival to marking, whereas this was not observed for Maternals. This contrasts the findings of Hocking-Edwards *et al.* (2019) who suggested that similar coefficients for liveweight change in late pregnancy predict the birthweight and survival of single- and multiple-born crossbred and Merino lambs, noting that most multiple-bearing ewes in the Hocking-Edwards study were twin-bearing ewes with few triplets.

In addition to the treatment effects, analysis of data from individual ewes showed that there was a negative relationship between the change in CS between pregnancy scanning and pre-lambing, and mortality of Maternal and Merino ewes. Mortality of Merino ewes was more sensitive to CS change compared with Maternals, with mortality of Merino ewes increasing considerably when ewes lost more than 0.5 CS between pregnancy scanning and pre-lambing. Given that ewe deaths cause lamb deaths, this would indicate that triplet-bearing ewes should be managed to ensure that they don’t lose more than 0.5 CS during late pregnancy. Overall, the paddock- and individual-level analyses from our study demonstrate that producers should manage the nutrition of triplet-bearing Merino ewes so that ewes are in greater CS at lambing and/or to gain CS between pregnancy scanning and lambing to improve ewe and lamb survival. Triplet-bearing Maternal ewes should be managed to gain CS between pregnancy scanning and lambing to improve ewe survival.

5.3.3 Mob size at lambing

Reducing mob size at lambing by 10 triplet-bearing ewes increased the survival of their lambs by 1.51%, when mob size ranged from 10 to 139 triplet-bearing ewes and stocking rate ranged from 0.7

– 13.4 ewes/ha. Therefore, our hypothesis was accepted. The magnitude of the impact of mob size on the survival of triplet-born lambs was 4- to 8-fold greater than that observed for twin-born lambs in Australia by Lockwood *et al.* (2020a) and Lockwood *et al.* (2020b). Albeit the average mob size examined in the current study was much smaller and covered a lower range than in the studies of Lockwood *et al.* (2020a) and Lockwood *et al.* (2020b). Limited adoption of pregnancy scanning for triplets means that there is little data available for the mob size at which triplet-bearing ewes are lambed at commercial enterprises in Australia. However, it appears that the range in mob size and stocking rate assessed in our study reflects commercial management (Hancock *et al.* 2019; Thompson *et al.* 2023). The ewes in our study were mostly of non-Merino breeds and therefore further experimentation using Merino ewes is warranted to investigate whether there is an impact of ewe breed on the relationship between the mob size of triplet-bearing ewes at lambing and the survival of their lambs. Triplet-bearing ewes may only represent a small proportion of pregnant ewes within the enterprise, particularly for Merinos, and therefore balancing the allocation of resources, mob sizes and paddocks for twin- and triplet-bearing ewes will be important in improving overall marking rates for the enterprise.

5.3.4 FOO and supplementary feeding, and mineral supplementation

Management achieved a significant difference in FOO between the High and Low treatments, but there was no effect of FOO on ewe or lamb survival, regardless of supplementary feeding. It has been suggested that intake by triplet-bearing ewes is not adequate to meet their nutritional requirements even when FOO is unlimited (Kenyon *et al.* 2019a). It is therefore likely that pasture intake by the triplet-bearing ewes did not differ between the FOO treatments in this study. Additionally, variable impacts of supplementary feeding of triplet-bearing ewes have been reported for lamb birthweight and survival, depending on the type of supplementary feed and whether FOO was restricted (Kenyon *et al.* 2019a). Further work could establish the minimum FOO that enables maximum pasture intake by triplet-bearing ewes to inform FOO targets and management guidelines for producers.

Mineral supplementation had no impact on ewe or lamb survival in our study. Similarly, Robertson *et al.* (2022) reported no effect of supplementing twin-bearing ewes with calcium and magnesium on survival of their lambs when ewes grazed pasture. However, the authors report that the lack of effect was partly due to inadequate voluntary intake of the mineral supplement by the ewes and indicate that variation in supplement intake may be associated with the type and quantity of pasture grazed by the ewes. Ewes from each treatment in our study, on average, grazed pastures of similar FOO and legume content. Whilst mineral intake was not measured in our study, it is therefore possible that the ewes in our study did not consume adequate mineral supplement to induce impacts on ewe and/or lamb survival. The mineral status of ewes in our study was also not recorded and therefore it is not possible to determine the initial mineral status of the ewes and whether supplementation improved the mineral status of the ewes. Further research with triplet-bearing ewes should therefore monitor ewe mineral status before and during the period of supplementation, and measure intake of the supplement by ewes within the mob. Ideally, intake of the mineral supplement would be measured for individual ewes to enable correlation with ewe status and survival outcomes, however this is not currently possible under extensive, paddock-scale conditions.

5.4 Conclusion

Results from the experimental work showed that best-practice management of triplet-bearing ewes to improve ewe survival should include managing nutrition of Merino ewes so that they are in a greater CS at lambing and managing the nutrition of both Maternal and Merino ewes so that they gain CS between pregnancy scanning and lambing. Best-practice management of triplet-bearing ewes to improve the survival of their lambs should include managing triplet-bearing ewes separately to twin-bearing ewes between pregnancy scanning and lambing and allocating triplet-bearing ewes to lamb in smaller mobs. For Merinos, this should also include managing triplet-bearing ewes so that they are in greater CS at lambing and/or to gain CS between pregnancy scanning and lambing to increase the survival of their lambs, granted it will be more challenging to achieve under commercial conditions. Further work is required to determine CS and FOO targets for triplet-bearing ewes, and to understand the relationship between ewe CS, timing of death and cause of death to inform management guidelines. The impacts of mineral supplementation during late-pregnancy and lambing on ewe and lamb survival also requires further investigation.

6. Collaborator workshops

Collaborator workshops were held at the same locations as the initial consultation workshops that were held at the beginning of the project. The focus of these workshops was to re-engage with producers and advisors that attended the original consultation workshops, plus directly invite producers that hosted research trials on their farms during the project and those who contributed benchmark surveys. The overall aim of these workshops were to expose collaborators to the outputs of the research to witness the interpretation of what the research findings mean for collaborators at a production system level and identify the key practices they are likely to adopt and how to best aid the adoption of these practices. This exchange has further informed the content and design of the best-practice guide developed by this project, plus highlighted additional research and demonstration activities that producers and advisors regard as a priority for triplet-bearing ewes in the future.

Collaborator workshops led by Dr Andrew Thompson and Dr Jason Trompf were held in Struan, South Australia (SA), on 13th October 2022, and Hamilton and Ballarat, Victoria, on 14th October 2022. A collaborator workshop led by Dr Jason Trompf was held in Holbrook, New South Wales, on 9th December 2022. The workshops were attended by 13 producers in Struan, 16 producers in Hamilton, 14 producers in Ballarat and 7 producers in Holbrook. Additional producers had registered for the Ballarat workshop however were unable to attend due to impacts of extensive flooding. These producers who advised they were unable to attend the workshops in-person but were interested in participating have been shortlisted for the webinars to be held between June and September 2023.

There was excellent engagement from producers who attended the workshops held in late 2022 and several significant topic areas of discussion arose at the workshops. Key discussions are outlined in sections 6.1 to 6.6. These discussions have informed development of the best-practice guidelines and factsheets. They will also assist with conveying key extension messages to producers via extension programs and presentations.

The project findings were extended to non-collaborating producers and industry members at three events in eastern Australia during June 2023 by Dr Jason Trompf. Further workshops and webinars to extend the project findings and engage with industry are scheduled between July and September 2023 as reported in Table ***6.1***.

Table 6.1. Dates and locations for project workshops and webinars engaging collaborating and non-collaborating producers/industry members between June and September 2023 across New South Wales (NSW), Queensland (QLD), Victoria (VIC) and Western Australia (WA).

Workshop type	Date	Invitees	Location	Attendees
Face-to-face	13th June 2023	Open to industry	Super Borders conference, Wagga Wagga NSW	30
	16th June 2023	Open to industry	'Karbullah Merino', Goondiwindi QLD	45
	20th June 2023	Open to industry	BestWool BestLamb conference, Bendigo, VIC	160
	July 2023	Open to industry	'Northgate Park', Glenrowan VIC	
Face-to-face or webinar	July 2023	WA collaborating producers	Regional WA or online	
Webinar	July 2023	Lambs Alive producer network	Online	
	July to September 2023	Open to industry	Sheep Genetics webinar	
	October 2023	Open to industry	Sheep Reproduction Strategic Partnership webinar	

6.1 Optimising the privacy of triplet-bearing ewes for lambing

Discussion was held about interpretation of the research finding that reducing mob size significantly improved lamb survival, and how best to adopt and integrate this into the existing farm layout and in varying farming environments, particularly on mixed farms typically with much larger paddocks. Discussion was also held about alternative ways to mimic the benefits of smaller mobs, such as blending triplet-bearing ewes with single- and/or twin-bearing ewes for lambing. On cropping farms there were suggestions of splitting triplets into small numbers of ewes spread across numerous large cropping paddocks or using temporary fencing to graze crops more intensively with smaller mob sizes.

According to feedback from mixed sheep and cropping producers who farm in medium to lower rainfall environments, where their primary focus is cropping, engagement and adoption will require demonstration of practical ways to improve the privacy of triplet-bearing ewes for lambing on their farms. This demonstration must show that it can be achieved on farms with much bigger paddocks, predominantly under crop, that typically run fewer mobs of ewes that are larger in size. The demonstrations would need to highlight benefits like easier shepherding during lambing (so less time spent away from cropping enterprise), that temporary fencing is a cost-effective way to create privacy for triplets and results in better lamb survival on mixed farms, or alternatively that small groups of ewes can be grazed in large cropping paddocks that already exist across the farm.

6.2 Importance of shelter for triplets at lambing and options to provide/use shelter on-farm

A lot of discussion took place on the topic of shelter for lambing among producers attending the Struan, Hamilton and Ballarat workshops but to a much lesser degree at Holbrook, which probably reflects the greater risk of lamb mortality due to high chill conditions in those southern locations compared to the Holbrook region. Producers had differing opinions about the best types of shelter; some felt open paddocks with distinct tree-line areas that enabled ewes to maintain visual contact with their lambs were best whereas others believed scattered trees were much more effective than shelter belts. There were also contrasting opinions of how much pasture was advantageous for sheltering newborn lambs, with some producers advocating high volumes of pasture for lamb protection, combined with strategically placed slashed strips to provide shelter for ewe/lambs without compromising bonds. This was contracted in other production zones were others cautioned against this due to concerns about mismothering lambs in long pasture. In fact, some producers prioritised shelter in the form of trees, rock barriers, gullies and protected areas over FOO, preferring shorter pastures for triplet-bearing ewes to lamb on.

6.3 Survival of triplet-bearing ewes and the perceived importance of ewe fitness

A lot of discussion took place around the research findings related to ewe CS, in particular that Maternal ewes that were fatter pre-lambing (higher CS) didn't have a higher death rate than ewes in moderate CS. This led to wider discussion about risk factors for ewe mortality, with many producers suggesting ewes of older age (>5 years) were more prone to death when carrying triplets than younger ewes and that more older ewes seemed to conceive triplets, which led to further discussion about how this could be limited by management. Producers also felt that aside from CS, the fitness of triplet-bearing ewes in late pregnancy was critical to their survival and even aided better presentation of lambs. Limiting ewe mortality was widely recognised as a key pillar for success with triplets and any wider insights would be very helpful, in particular ways to limit death due to pregnancy toxaemia. Producers suggested that extension messages could include strategies to limit the number of triplets conceived in older age ewes, such as limiting ewe CS in older ewes for joining, joining older ewes earlier, not flushing older ewes and avoid using stimulants such as Ovastim and Regulin on older age ewes. Many producers highlighted lameness as a precursor for ewe mortality.

The primary interest of producers attending the workshops in future research and development related to investigation of ewe fitness (ability to of ewe to remain mobile in late pregnancy and up to the point of lambing) and its links with ewe and lamb survival and needs for shepherding during lambing. Many producers felt that ewe mobility/fitness was critical for successful outcomes with triplets.

6.4 Hierarchy of importance for improving triplet lamb survival

Producers referred to the multiple components of this research project and consolidating the messages to aid cut through in producers' awareness and adoption. A hierarchy of importance was suggested around the big-picture issues related to mortality of triplet-born lambs such as animal welfare, production, economic, labour and social (peace of mind for producers). In this context, producers encouraged the project to maintain a strong welfare focus in its extension messaging and emphasis, which is consistent with the auspice of the project funding and the project work undertaken to date. However, a delicate balance will need to be struck between being overt about the welfare challenges and opportunities with triplets to ensure engagement with producers, and the concern of raising the wider publics' awareness of this issue in the sheep industry. Producers were encouraging us to be clear in our communication on the significance of the current wastage and future opportunity with triplet dams and their lambs. A separate context where the producers suggested a matrix of importance might be useful, related to the outcomes of the various components of this research project. This was to help simplify project messages and aid adoption of key practices.

6.5 Milk production versus triplet lamb survival

A discussion was held with producers in the context of interest being shown in more intensive lambing systems such as lambing indoors and that Paul Kenyon (*pers. comm.*) stated that even when neonatal survival of triplet-born lambs is improved there is a subsequent death spike of lambs around 10-14 days of age because ewes rearing triplets only produce about 10% more milk than ewes rearing twins, and when milk becomes limiting often one triplet dies. It was suggested that it would be interesting to examine the sheep genetics database for the relationship between survival of triplet-born lambs and milk production (Maternal Weaning Weight) and maternal behaviour score.

6.6 Repeatability of ewes conceiving triplets

A discussion was held with producers in the context of trying to limit the number of triplet-bearing ewes year on year. A query was made regarding the utility of the Lifetime Maternals dataset to shed any light on ewes that conceived triplets two to three years in a row; how repeatable is it, and if a ewe conceives triplets one year are there any opportunities between late pregnancy and post-lactation recovery to restrict the likelihood of the ewe conceiving triplets again the next year? Some producers currently cull ewes that conceive triplets; is this a useful strategy for limiting the future proportion of the flock that conceives triplets?

7. Economic modelling

Economic modelling is ongoing. Preliminary reports are attached:

Economic modelling as at Jun

Mob size analysis

The economic modelling conducted to date has shown that the value of an extra triplet-born lamb surviving to weaning ranges from $27 – 75 for Merinos and $46 – 171 for Maternals across a range in lamb price of $4 – 11/kg. The value of an extra triplet-bearing ewe surviving to lambing across this range in lamb price ranges from $105 – 225 for Merinos and $180 – 545 for Maternals.

The profitability of scanning for triplets is dependent on ewe breed, time of lambing, reproductive rate and meat price. Profit can be increased if flocks are scanned for litter size and the information is used to optimise management of the triplet-bearing ewes. With standard prices and standard reproduction levels, scanning for litter size and managing the Maternal flocks increased profit by up to $18.50/triplet ewe or $1.60/total ewe. The $1.60/ewe compares with $2.75/ewe for scanning wet and dry and an additional $3/ewe for scanning for multiples. Differential management of the Merino flocks did not increase profit with standard reproductive rates.

The optimum nutritional profile for triplet-bearing ewes across all scenarios is to have them 0.2 – 0.5 condition score higher at lambing than twin-bearing ewes. The current best estimate is that differential management of the triplet-bearing ewes increases profit by about $1.60 per ewe scanned or $20 per triplet-bearing ewe after paying the extra costs associated with scanning and the extra labour for managing the feed supply and supplementary feeding.

The optimum mob size at lambing varies depending on enterprise-specific factors such as the target return-on-investment, stocking rate of the ewes, breed and lamb price. The optimum mob size for triplet-bearing ewes is approximately 30% that for twins if ewes are allocated to existing paddocks. The optimum mob size for triplet-bearing ewes is between 20 and 38 ewes when paddocks are subdivided in half using permanent fencing with lamb price at $7/kg and a target return-on-investment of 5%. This optimum mob size is approximately 35% that for twins, which reflects the greater response in lamb survival for triplets compared with twins. The indication from the preliminary analysis is that scanning and identifying triplet-bearing ewes, costing an extra $0.40/ewe scanned, is justified purely from the benefits of differential paddock allocation even if the scanning percentage is only 150%.

8. Best-practice guidelines and factsheets

Best-practice guidelines for the identification and management of triplet-bearing ewes have been drafted for extension to industry. There are 7 sections to the Triplet Best Practice Guide (BPG), including:

- Section 1 - Background
- Section 2 - Your triplet dams and their lambs - how many you have and how many survive
- Section 3 - Your triplet opportunity - the value of triplet dams and their lambs
- Section 4 - The identification of triplets - what’s happening, when, why and how to address
- Section 5 - Triplet ewe loss - what’s happening, when, why and how to mitigate the risks
- Section 6 - Triplet lamb loss due to low birth weight and miss mothering - what’s happening, when, why and how to mitigate the risks
- Section 7 - Summary of BPG actions and next steps.

These guidelines will be finalised by the end of July 2023. The draft best-practice guidelines can be found here:

Best-practice guide

The following factsheets have been drafted for extension to industry:

- Identification of triplet-bearing ewes at scanning
- The impacts of condition score on the mortality of triplet-bearing Maternal ewes
- The impacts of condition score on the mortality of triplet-bearing Merino ewes
- Combined versus separate management of twin- and triplet-bearing ewes
- Mob size at lambing for triplet-bearing ewes

These will be finalised by the end of July 2023. The draft factsheets can be found here:

Identifying triplets | CS of Maternal ewes | CS of Merino ewes | Separate management of trip | Mob size

9. Conclusion

9.1 Key findings

- Consultation with sheep producers across southern Australia in 2017 and/or 2018 revealed that:
  - On average, 5.9% of all ewes joined were identified as carrying triplets (6.6% of non-Merino ewes and 2.9% of Merino ewes).
  - The average mortality of triplet-bearing ewes was 6.4% and this did not differ between breeds.
  - The average survival of triplet-born lambs was 59% and survival was significantly higher for lambs from non-Merino compared to Merino ewes (60.1 vs 52.9%).
  - The key strategies adopted by producers to reduce the mortality of triplet-bearing ewes and their lambs were management of ewe CS, FOO, mob size at lambing and the use of shelter, but significant variation existed between producers for targets for CS at lambing (2.8 – 3.5), mob size at lambing (10 – 150 ewes) and FOO (800 – 2500 kg DM/ha).
  - The highest priorities for further research were ewe CS, mob size at lambing, FOO at lambing and mineral supplementation.
- On-farm research across southern Australia between 2019 and 2021 found that:
  - The survival of triplet-bearing Merino ewes and their lambs was greater when ewes were managed at a High compared with a Low CS between pregnancy scanning and lambing, but this was not observed for Maternals.

  - Survival of Merino but not Maternal lambs was greater when mobs of triplet-bearing Merino ewes had a greater average CS at lambing or on average gained CS between pregnancy scanning and lambing.
  - Survival of triplet-bearing Maternal and Merino ewes was greater when ewes gained CS between pregnancy scanning and lambing, when the average CS of ewes at pregnancy scanning was 3.4 and 3.3 respectively.
  - Managing triplet-bearing ewes separately from twin-bearing ewes between pregnancy scanning and marking improved the survival of their lambs.
  - Reducing mob size at lambing by 10 triplet-bearing ewes increased the survival of their lambs to marking by 1.5% when mob size ranged from 10 – 139 triplet-bearing ewes and stocking rate ranged from 0.7 – 13.4 ewes/ha.
- The economic modelling conducted to date has shown that:
  - The value of an extra triplet-born lamb surviving to weaning ranges from $27 – 75 for Merinos and $46 – 171 for Maternals across a range in lamb price of $4 – 11/kg. The value of an extra triplet-bearing ewe surviving to lambing across this range in lamb price ranges from $105 – 225 for Merinos and $180 – 545 for Maternals.
  - The profitability of scanning for triplets is dependent on ewe breed, time of lambing, scanning percentage and meat price. With standard prices and standard reproduction levels, scanning for litter size and managing the Maternal flocks increased profit by up to $18.50/triplet ewe or $1.60/total ewe. Differential management of the Merino flocks did not increase profit with standard reproductive rates.
  - The optimum nutritional profile for triplet-bearing ewes across all scenarios is to have them 0.2 – 0.5 condition score higher at lambing than twin-bearing ewes. The current best estimate is that differential management of the triplet-bearing ewes increases profit by about $1.60 per ewe scanned or $20 per triplet-bearing ewe after paying the extra costs associated with scanning and the extra labour for managing the feed supply and supplementary feeding.
  - The optimum mob size at lambing varies depending on enterprise-specific factors such as the target return-on-investment, stocking rate of the ewes, breed and lamb price. The optimum mob size for triplet-bearing ewes is approximately 30% that for twins if ewes are allocated to existing paddocks. The optimum mob size for triplet-bearing ewes is between 20 and 38 ewes when paddocks are subdivided in half using permanent fencing with lamb price at $7/kg and a target return-on-investment of 5%. This optimum mob size is approximately 35% that for twins, which reflects the greater response in lamb survival for triplets compared with twins. The indication from the preliminary analysis is that scanning and identifying triplet-bearing ewes, costing an extra $0.40/ewe scanned, is justified purely from the benefits of differential paddock allocation even if the scanning percentage is only 150%.

9.2 Benefits to industry

This research has demonstrated that a mixed-method approach involving more than 200 sheep producers from across southern Australia was effective at establishing the research needs and priorities of producers to improve the survival of triplet-bearing ewes and their lambs. The experimental work has identified that differential management of twin- and triplet-bearing ewes from pregnancy scanning to marking, managing ewe CS between pregnancy scanning and lambing, and lambing ewes in smaller mobs can improve the survival triplet-bearing ewes and/or their lambs. Best-practice guidelines and factsheets have been developed for extension to industry and these will assist producers to improve productivity, profitability and animal welfare. Reduced deaths and improved animal welfare will also (i) improve the wellbeing and satisfaction of producers, and (ii) help meet consumer demands for ethical sheep meat and wool.

10. Future research and recommendations

The following research, development and extension is recommended based on the outcomes from the experimental sites and consultation with producers:

- Recording and emphasis should be placed on ewe age and collection of additional data of its relationship with ewe death as part of any demonstration and/or future research and development with triplets.
- Recording of the exact timing of death and post-mortem of ewes to better understand the relationship between the management factors identified to impact ewe survival and the cause of death (e.g. CS and pregnancy toxaemia)
- The primary future research and development interest of producers attending the collaborator workshops related to investigation of ewe fitness (ability of the ewe to remain mobile in late pregnancy and up to the point of lambing) and its links with requirement for shepherding during lambing, and ewe and lamb survival. This novel research would involve the use of sensor technology that records tri-axial movement and imposing interventions that may lead to divergent fitness levels in triplet-bearing ewes at the point of lambing. This research would enable the impacts of factors such as paddock size, paddock shape, paddock aspects, FOO, prevailing weather conditions, containment feeding or the level of interaction on ewe/mob behaviour to be quantified. Some preliminary research undertaken by La Trobe University indicated a link between ewe morbidity (period of little or no movement) and lower survival of twin-born lambs.
- Producer demonstration sites related to the impact of reducing mob size at lambing and optimising privacy for lambing ewes on triplet lamb survival, including the economics of paddock subdivision. This should clearly outline the value proposition and practicalities for mixed-farming enterprises in the low to medium rainfall zones where the primary focus is cropping, and mobs and paddocks are larger. A demonstration project led by Murdoch University that targets mixed-farming enterprises in the low-medium rainfall regions of Western Australia would be a logical progression of this project. A decision-support tool would also help producers determine the optimum mob size at lambing for their enterprise, and the economics of allocating ewes to existing paddocks or paddock subdivision and hence aid adoption of smaller mob sizes and paddock subdivision.
- Further research is required to understand the impacts of shelter availability at lambing on the survival of triplet-born lambs. A demonstration project on the benefits of shelter and evaluating different approaches to the provision of shelter to improve triplet survival,

conducted in high chill index regions of southeast Australia, would be a logical progression of this project in that region. The same project could demonstrate the benefits of developing triplet nursery areas on-farm that combines the benefits of shelter and smaller mob sizes. A collaborating producer suggested that this could include studying wind-flows on farms using similar technology to that used to design the layout of wind farms and thus targeting the most protected areas for lambing triplet-bearing ewes.

- There was also interest from producers for further research to understand:
    - The relationships between ewe CS at lambing, age, fitness and mortality, including management strategies to reduce mortalities due to age and pregnancy toxaemia. This could also examine the impacts of over-conditioning ewes on ewe and lamb mortality, especially for Maternals.
    - The relationship between triplet lamb survival and genetics for maternal weaning weight (partly reflecting milk production) and maternal behaviour score.
    - The repeatability and heritability of conceiving triplets to determine whether culling triplets is a useful strategy to limit the future proportion of the flock that conceives triplets, where producers don't want triplets in their flock.

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12. Acknowledgements

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The project would also like to acknowledge the contribution of all of the collaborating producers and the consultants who assisted with the surveys and on-farm research.

13. Appendix

13.1 Literature review

The following literature review has been published in the *New Zealand Journal of Agricultural Research.*

Literature review

13.2 Scientific publication – initial industry consultation

The following manuscript has been published in *Animals* which reports the findings from the initial industry consultation.

Thompson et al. (2023) - initial indus

13.3 Scientific publication – condition score

The following manuscript has been published in *Animals* which reports the findings from the condition score experiment.

Triplets - CS

13.4 Scientific publication – mob size

The following manuscript has been published in *Animals* which reports the findings from the mob size experiment.

Triplets - mob size.pdf