Final report

PDS: Increasing production using containment areas

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Prepared by: Deb Scammell
Talking Livestock

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Meat & Livestock Australia Limited
PO Box 1961
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Abstract

With increasingly variable seasons, later autumn breaks and reduced rainfall, producers in the Barossa region of SA found that the seasons were having a detrimental impact on their pasture production. With larger feed gaps to fill, producers had recently adopted containment feeding of ewes as an alternative to de-stocking or supplementary feeding in dry paddocks. Throughout three consecutive seasons, three 'major' sites and eight 'minor' sites containment fed ewes and were monitored to determine the success and any cost or risk associated with the practice. Producers were wanting to maintain their stocking rate over the variable seasons rather than selling and buying stock back in. Removing a large proportion of ewes from the paddocks enabled improved ground cover and extra feed on offer to be available in lambing paddocks. Over the course of the project lamb marking percentage on the major sites improved by 12% compared to their long-term average prior to containment. This was associated with some improved feed on offer in the lambing paddocks but also improved ewe management while ewes were in containment. Ewe mortality increased on some sites at times, however with precise management ended up being similar to mortality averages on paddock run ewes.

Executive summary

Background

With the increasingly dry conditions in the Barossa region, sheep producers began implementing containment areas to preserve ground cover, provide supplementary feed and water, monitor welfare and for ease of management. The containment areas have allowed producers to maintain their stocking rate, rather than having to de-stock, and allowed them a quick recovery after the dry conditions. As producers commenced containment, they sought information about the clear benefits associated with containment feeding. They also wanted to ensure they were able to containment feed ewes successfully, keep ewes in adequate condition score while optimizing or increasing lambing rates and not have a negative impact on ewe health.

Core producers are in the Barossa region of South Australia. This project emerged as the producers in this region were finding that the increasing dry periods and late breaks meant that they were having to supplementary feed. In the paddock this was detrimental to their ground cover and pasture recovery when it did rain. Many producers in South Australia have commenced the practice of containment ewe feeding for similar reasons.

The results of this demonstration will be used to provide knowledge around the best methods of containment feeding ewes to reduce impacts on ewe health. It will also improve producer confidence statewide and nationally to utilize containment feeding in their own enterprise through learnings gained from the project. The gross margin figures generated will also show a full cost-benefit analysis of containment feeding versus continuing to supplementary feed in the paddock.

Objectives

Demonstrate and assess the use of on-farm 'containment areas' on major and minor properties within the Barossa to:

- maintain annual enterprise stocking rate
- maintain ground cover at 70% to 90% on any single property

- increase the reproductive rate (measured by pregnancy scanning) of ewes by 10%
- maintain condition score of the ewe and meet industry targets through mid and late pregnancy to increase lamb marking percentage by 10% and maintain wool cut.

Methodology

Three major sites containment feeding a large portion of the ewe flock were monitored over a three-year period for condition score, pregnancy scanning information, ground cover and feed on offer, fleece weight, lamb marking percentage, ewe mortality and feed and labour costs. In addition, 8 minor sites were monitored for two years. Sites worked with a livestock consultant to set up containment pens that met industry specification and rations were formulated to meet ewe energy requirements throughout pregnancy.

Results/key findings

- Marking percentage increased by an average of 12% compared to the pre – containment average on the three major sites. This was associated with better management of ewes associated with them being fed in containment pens.
- Ewes kept in containment (for a short period during pregnancy) vs paddock run ewes on a similar property had an average marking % increase of 8% over the three years. Ewes that were kept in containment for a short period of time were run at a much higher stocking rate over the rest of the year.
- Ewe mortality varied considerably across the years and sites. Many health issues were overcome as the knowledge and skill of containment feeding improved over the project. The ewe mortality in the final year of the project was equivalent to paddock run ewes at an average of 1.8%.
- Calcium and Magnesium levels during pregnancy could be optimised with a focus on effective supplementation and balanced rations, reducing the risk of metabolic disease over lambing.
- Feeding costs varied dependent on ingredients used and time in containment. The range was from $14 per ewe to $57 per ewe per year.
- Ground cover was well above the 70% target on any of the sites who locked up a high proportion of ewes, with the exception of two sites that had severe kangaroo grazing pressure during the drought. The major sites had groundcover between 90 and 100% across the three years of the project.
- Feed on offer was an average of 560kg DM/ ha higher across the year on the properties that contained all of their ewes compared to other properties within the region
- The economic analysis showed an advantage of between $5.30 and $8 per ewe associated with the more precise management and containment feeding of ewes.
- 11 Core producers were involved in the project.
- A total of 13 events were delivered in the form of workshops, webinars and field days with an attendance of 739 ‘observers’.
- 35 communication outputs were delivered across local, state and national networks.
- 11 core producers are routinely using containment as part of their standard management practice.

- There was an improvement in confidence in managing ewes in containment by both the core and observer producers.
- Knowledge, skill and practice change occurred over the project in both core and observer producers in recommended management practices.

Benefits to industry

Over the course of the project core producers in the Barossa region have had a significant improvement in confidence and knowledge in correctly feeding ewes in containment. This knowledge has been extended to a significant number of producers throughout South Australia and Victoria who have attended our events.

Some health issues arose as we were feeding ewes. These were overcome throughout the project by improving nutritional balance or making other changes to the containment methodology. This knowledge will be extended through a containment project that has just commenced. This has upskilled the private consultant involved in the project also which has meant it can be extended to many other producers and regions.

Extension material will continue to be available showing various containment set ups and the positives and negatives associated with different feeding methodology.

Future research and recommendations

During the gross margin calculations on the benefit of containment there was no quantifiable data on the dollar value associated with maintaining very high levels of ground cover and feed on offer – especially in unimprovable hills grazing; future research in this space would be an advantage.

Some of the health problems associated with containment, especially hypocalcaemia risk and appropriate supplementation and the risk of prolapse require more research to identify the cause and solutions.

Sharing of knowledge across consultants involved in containment feeding ewes and some consistency in containment feeding advice and extension material available would be an advantage for the industry. A simple ration formulation tool, specific to containment feeding would also allow producers to easily do their own balanced, correct rations and feed budgets.

PDS key data summary table

Project Aim:
To improve the reproductive rate of ewes through precise management in containment pens while maintaining ground cover and stocking rate on the property.

	Comments		Unit
Production efficiency benefit (impact) Animal production efficiency - kg LWT/ha; kg LWT/DSE, AE or LSU Pasture productivity – kg DM/ha Stocking rate – DSE, AE or LSU/ha Reproductive efficiency – marking %, weaning % Mortality rate (%)	*The stocking rate was able to be maintained on all the major sites through variable seasons with the use of containment.* *Reproductive efficiency improved. Marking % to ewes joined.*	12	%
Reduction in expenditure Reduction in labour i.e. DSE/FTE, LSU/FTE, AE/FTE; Reduction in other expenditure	There was a reduction in labour while ewes were in containment. This varied due to size of property but averaged at a saving of:	$1.86	DSE
Increase in income (12% increase in marking %)		$8.00	DSE
Additional feeding costs (to achieve benefits)		$1.81	DSE
Net $ benefit (impact)		**$8.05**	**DSE**
Number of core participants engaged in project		11	
Number of observer participants engaged in project		739	
Core group no. ha		19988	
Observer group no. ha		1215655	
Core group no. sheep		42600	hd sheep
Observer group no. sheep		1256300	hd sheep
Core group no. cattle			hd cattle
Observer group no. cattle			hd cattle
% change in knowledge, skill & confidence – core	*Successfully manage and feed ewes in containment to improve reproductive performance on property.*	41%	
% change in knowledge, skill & confidence – observer	*Ability to manage and feed ewes in containment to improve reproductive performance on property.*	7%	
% practice change adoption – core	*Improved management of ewes in containment.*	30%	
% practice change adoption – observers	*Improved management of ewes in containment.*	5%	

% of total ha managed that the benefit applies to	*Grazing land with improved ground cover and pasture for lambing.*	63%	
Key impact data			
Gross Margin / dse or AE	**$8.05/DSE**		

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1. Background

Climate change and seasonal variation, is having a significant impact on the profitability of livestock enterprises within the region. Bureau of Meteorology data demonstrates that Angaston has experienced a reduction in rainfall of 100mm per year over the past 20 years, from an average of 500mm back to 400mm, and temperatures are predicted to increase by at least 1^{o}C (BOM, 2021).

Producers within the Barossa region have been increasingly supplementary feeding stock to overcome feed gaps which were having an impact on lambing results. This has been detrimental to ground cover and feed on offer in the paddock. They found once it did rain the pasture recovery was slow in areas where pasture had been overgrazed.

On some properties water wasn't available in all paddocks as ground water had dried up. This meant labour was required not only to cart supplementary feed out to paddocks over the summer and autumn feed gap but to also cart water.

Some producers in the region commenced containment feeding to overcome some of these problems. However, during implementation, they lacked confidence in the best way to containment feed and didn't always find the resources they needed available. As identified by Dr Susan Robertson; currently, the recommendations to industry for management of ewes when containment-fed are conflicting, and some are not evidence-based. This lack of understanding increases the risk of unnecessary costs, sub-optimal reproduction, poor ewe health and inferior welfare outcomes (Robertson, S: 2020).

During the first year of containment, we found an increase in ewe mortality on a lot of the sites which was associated with often an increased risk of metabolic issues around lambing. This was reflected in older research done in the state with lower lambing rates and higher ewe mortality often associated with containment feeding (Morbey and Ashton, 1990).

The project sought to identify the best methodology to containment feed ewes to enable an improvement in lambing percentages, reduction in ewe mortality and improvement in ground cover.

The major and minor sites were within the Barossa region, many of them had experienced substantially lower than average rainfall over the previous few years which had encouraged them to try containment feeding a high proportion of their ewes.

The results of the demonstration will be used to improve confidence and knowledge for other producers in the region, state and nationally to improve containment feeding results. Throughout the project the extension outcomes have allowed us to upskill a substantial quantity of other producers and industry advisers.

2. Objectives

1. Demonstrate and assess the use of on-farm 'containment areas' on 15 properties to maintain annual enterprise stocking rate, maintain ground cover at 70% on 90% of any single property, increase the reproductive rate (measured by pregnancy scanning) of ewes by 10%, maintain condition score of the ewe through mid and late pregnancy to increase lambing marking percentage by 10% and maintain wool cut (measured in Kg/head).

Objective 1 was achieved, 75% of the core producers utilised containment areas over the project and achieved a successful result. The major site producers all maintained ground cover over 70% for the three years of the project and increased reproductive rate through maintaining condition score in containment. The 25% of the other core producers will use containment when the season requires or are planning to implement containment in the future.

2. Conduct a cost benefit analysis on 15 properties to determine the economic performance of the use of containment compared to non-containment areas and associated management practices.

A cost benefit analysis was conducted looking at the full results on the 3 major sites and also reinforcing the analysis with the data from the 8 minor sites. One major site had comparison data for stock kept in a paddock vs containment fed ewes, the other major sites containment fed all of their ewes. Satellite data was used to quantify the advantages to feed on offer and ground cover compared to other properties in each region.

3. Upskill at least 15 core producers to increase their confidence in the use of electronic identification, condition scoring, ground cover monitoring and feed budgeting to implement ewe management best practice.

Objective 3 was achieved successfully All of the core producers were upskilled in condition scoring, ground cover monitoring, feed rations and feed budgets due to their interaction with a livestock consultant throughout the project. They observed electronic identification (EID) and it's use however haven't all implemented EID to date.

4. Conduct extension activities including an annual field day, a bus tour, webinar series and video to showcase the results and encourage adoption of key practices by 400 producers.

Extension activities were successfully completed. Through the series of events and webinars 739 producers were directly exposed to the project and upskilled in key practices.

5. Increase the number of producers adopting on-farm containment areas by 15.

The number of producers adopting on farm containment associated with the project was substantial. There were core producers who adopted containment during the project. There were many other producers who adopted containment after the initial bus trip or through their interaction with webinars or field days. At many of our events producers from different regions travelled to view our containment set ups to enable them to build a new containment area or improve an existing one.

3. Demonstration Site Design

3.1.1 Methodology

When the project commenced 15 major and minor sites were identified throughout the Barossa region. Of these, 11 sites containment fed ewes throughout the project and collected results. These sites varied in climate, pasture type and enterprise type.

The sites were set up as 3 Major (Site 1,2,3) and 8 Minor sites (Site 4 – 11). The minor sites were monitored for the first two years of the project where the major sites had additional monitoring for the final year of the project.

Major sites were set up in 3 different areas, they all contained a high proportion of their total ewes, minor sites varied considerably in the proportion of ewes which were contained, the sites are shown in Table 1.

Table 1: Site Locations, Rainfall and average number of ewes contained over the course of the project.

Site Number	Region	Rainfall	Average number of ewes contained per year
1	Keyneton	400 – 500mm	2900
2	Angaston	500mm	1350
3	Springton	400mm	830
4	Keyneton	400 – 500mm	530
5	Keyneton	450mm	140
6	Koonunga	460mm	360
7	Truro	250mm	1200
8	Angaston	525mm	240
9	Australia Plains	325mm	1760
10	Kapunda	450mm	3300
11**	Moculta	400mm	40
		TOTAL	12650

**Data excluded from results section due to very small number contained for 1 year.

The sites all worked with a livestock consultant to ensure their sites and containment facilities met industry standards of containment pen space, shade, adequate trough space and feed access and water quality and supply was adequate. Ewes were then fed formulated containment ewe rations, appropriate mineral supplementation and condition scored throughout the containment periods.

Sites were monitored across the 3 years (major sites) or 2 years (minor sites) for:

- Condition score
- Pregnancy Scanning information to determine conception
- Ground cover and feed on offer
- Fleece weight
- Lamb marking percentage
- Ewe mortality
- Feed and labour costs

In year three due to some issues identified with ewe health in containment over the first two years, additional monitoring of blood mineral levels of ewes was carried out. Two sites were chosen to blood test a representative sample of old ewes and ewe hoggets and identify any mineral deficiencies occurring throughout the containment period. Methodology was:

2 major sites selected 10 older mixed age ewes (3.5 – 6.5 years old) and 10 ewe hoggets for blood testing.
Twins were selected, however on site 1 the first blood test was prior to scanning results so a random selection was chosen, and twins were blood tested at the second and third blood tests.
Blood was taken on the 15 March, 11 April and 2 May 2022.

Blood was analysed for Calcium and Magnesium levels.

3.1.2 Economic analysis

Data from the three major sites and analysis of the results of the minor sites was used to demonstrate a methodology for analysing the financial benefits that can be gained by utilising containment feeding. Results from a 5 year containment feeding experiment conducted at Kybybolite Research Station was compared and analysed to also quantify a value of containment feeding.

3.1.3 Extension and communication

The extension and communication activities enabled producers to interact and learn from the project. The extension that was undertaken included:

- Three major field days were held at containment sites and covering varying topics, some of these were held in conjunction with other organisations to ensure we could get producer attendance.
- A series of webinar's were presented covering areas identified throughout the project that were a priority for extra knowledge and upskilling. We covered summer feeding and supplementation, a discussion of containment results and learnings and a two-part webinar on feed budgeting held in conjunction with Sheep Connect SA.
- Workshops were held each year, the first one involved major and minor sites benchmarking and discussing their containment results from the first year. We held a feed budgeting workshop and had a results discussion workshop to finalise the results and get any final feedback of extra information or research required.
- Articles were published in the BIGG monthly newsletter, local newspapers and the Stock Journal.
- Case studies have been developed for all the major and minor sites.
- Producer guides and fact sheets have been developed and distributed.
- The final results will be presented at the BIGG conference in February 2023.
- An article on final results is scheduled for the MLA Feedback magazine in February 2023.
- There is a dedicated webpage on the BIGG website which will have a link to the final project results and resources.
- A video has also been developed with footage of two of the major sites and communicating the final results from the project.

A full list of the extension and communication activities is shown in the appendix.

3.1.4 Monitoring and evaluation

Monitoring and evaluation was undertaken prior to and on completion of the project. A survey was developed which was filled out by the core producers and observer producers to show their knowledge prior to the containment ewe project. A separate survey was then filled out by the core producers and observer producers after the project was completed.

Monitoring and evaluation was done in the form of surveys at the completion of each major field day and webinar.

Performance metrics measured included pre and post knowledge, skills and confidence change. Productivity was measured by stocking rate and reproductive efficiency. Profitability was measured by gross margin per DSE and environmental impact was measured by ground cover % maintained. Practice change of core producers and observer producers was also measured.

4. Results

4.1 Demonstration site results

Results are collated below for all the sites which were monitored over the course of the project. In some cases where minor sites only contained a small portion of ewes, more focus has been put on the major sites.

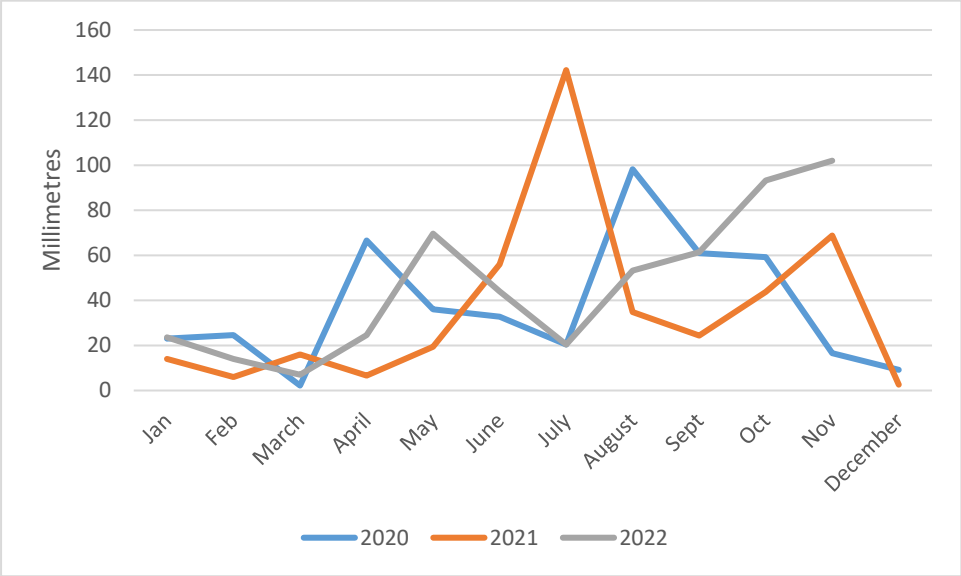
Major sites were running stock at varying stocking rates on each of the properties depending on grazing type. Even with the difficult seasons for lambing in 2020 and 2021 producers were able to maintain ewe numbers and marking percentages. Stocking rate and grazing type is shown in Table 2.

Table 2: Major sites showing stocking rate over the course of the project and grazing type.

Site Number	Region	Rainfall	Stocking rate (over the year)	Grazing Type
1	Keyneton	400 – 500mm	2.5 DSE/Ha	1000ha unarable native hills grazing, 1500ha improvable hills grazing, 250ha of arable sown for feed.
2	Angaston	500mm	13.7 DSE/Ha	255ha of improved pastures.
3	Springton	400mm	2.8 DSE/Ha	570ha of unarable native hills grazing, 30ha of arable sown for feed.

4.1.1 Seasonal conditions

Figure 1: Rainfall over the course of the project at the Keyneton weather station

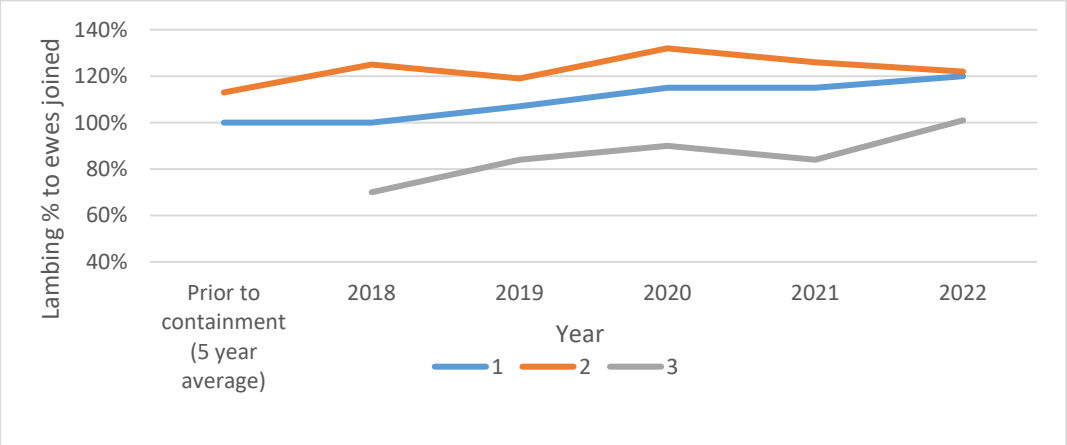


As shown in Fig. 1 the seasonal conditions varied considerably over the course of the project. Rainfall information was taken from the local BIGG weather station at Keyneton, the trend is very similar at the Koonunga and Flaxman Valley stations. Keyneton and Flaxman Valley both had below average rainfall for 2020 and 2021 seasons. Sites 7 and 9 situated at Australia Plains and Truro had less rainfall than average, over the growing season, during the 2020 and 2021 season. This was off the back of a very dry 2019 which demonstrated the advantage of containment feeding breeding stock in these areas, it allowed them to retain breeder numbers rather than sell off ewes as many producers around them did.

- 2020: A reasonable break but well below average rainfall through until late August.
- 2021: A very late break meant feed on offer and ground cover was marginal in many areas.
- 2022: A reasonable break in most regions (where containment sites are located). A very dry winter with higher-than-average rainfall in spring.

4.1.2 Lambing % over the course of the project

Figure 2: Marking % to ewes joined on each of the major sites. Pre-containment average compared to marking % each year over the project.



As shown in Fig. 2 in most cases the lambing percentage improved over the course of the project, particularly compared to a long-term average prior to ewes being contained. A key finding within the project was that as producers contained ewes often their management of ewes improved also. Across all the major sites the use of containment meant ewes could be split into better sized management mobs (between 250 and 400), as they were in smaller groups and being observed more readily any shy feeders were easily observed and could be separated. It also became easier to condition score ewes more readily and on major sites 1 and 2 ewes were put into pens based on condition score.

Site 2 had some severe weather events during both lambing cycles in 2022 which had an impact on lamb survival. In 2021 due to the late break ewes were slightly under condition score targets which was difficult to correct during the containment period, this meant that a proportion of the multiple bearing ewes lambed under the ideal condition score impacting on ewe mortality and lamb survival. Site 3 had a high proportion of maidens in 2021 and had a campylobacter issue with causing some foetal loss, maiden ewes were vaccinated in 2022. The increase in lambing percentage on major site 3 was associated with more careful nutritional management and ewes were monitored a lot more closely to feed to condition score targets in the final year 2022 which showed a large improvement in lambing percentage.

All the major sites worked closely with a nutrition consultant over the course of the project. Ewes were fed rations which were formulated to meet energy requirements at each stage of pregnancy also which gave lambs a higher chance of survival and meant ewes were usually in adequate condition score.

Major site 2 kept some mobs of ewes in the paddock, however as they locked up a high proportion of the breeding ewes it meant these ‘stocked’ paddocks still had high levels of feed on offer and were well above ground cover targets. Ewes fed in the paddock were supplemented with equivalent quantities of grain (as the containment fed ewes) and were fed 40% of the hay quantity. The difference in marking results is shown below in Table 3.

Table 3: Site 2 lamb marking % (to ewes pregnant), Containment fed ewes vs Paddock run ewes.

Year	Containment ewe numbers	Lamb Marking % (of ewes pregnant)	Paddock ewe numbers	Lamb Marking % (of ewes pregnant)
2020	1010	139%	85	132%
2021	1486	141%	500	130%
2022	1258	137%	590	131%

Over the three years the average increase in marking to ewes scanned pregnant was 8% in the containment ewes versus the paddock run ewes. The containment ewes were lambed on the Angaston property which was running a stocking rate of 13.7 DSE/ha over the year (destocked only during the containment period). The paddock run ewes were run all year round on the Craneford property at a stocking rate of 7.85 DSE/Ha.

Figure 3: Marking % to ewes joined on minor sites

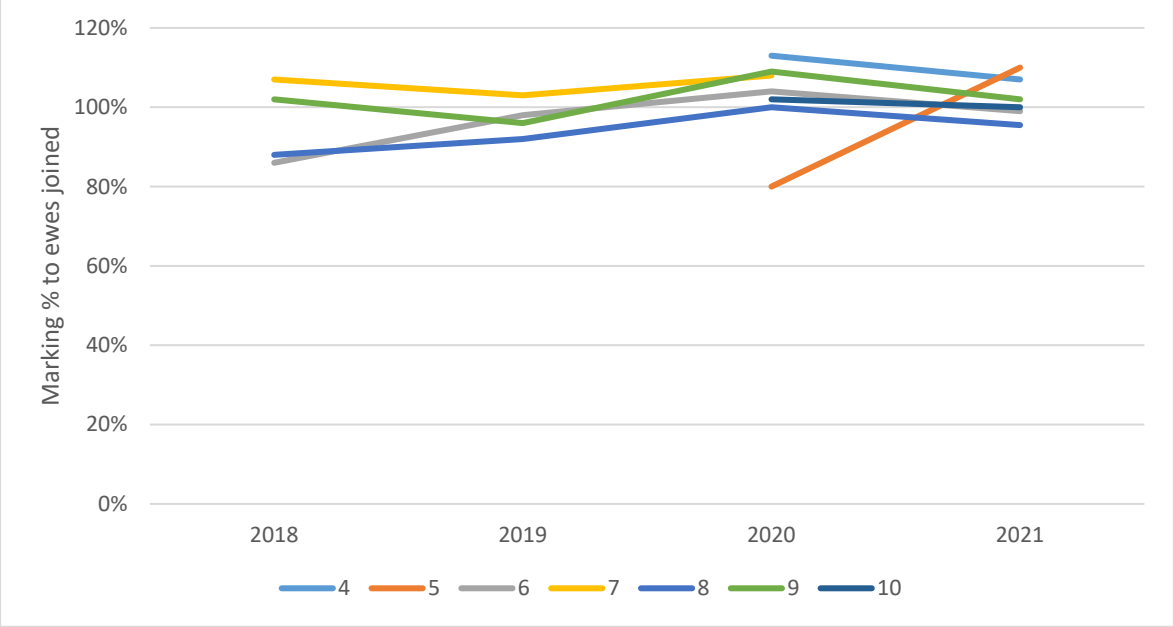
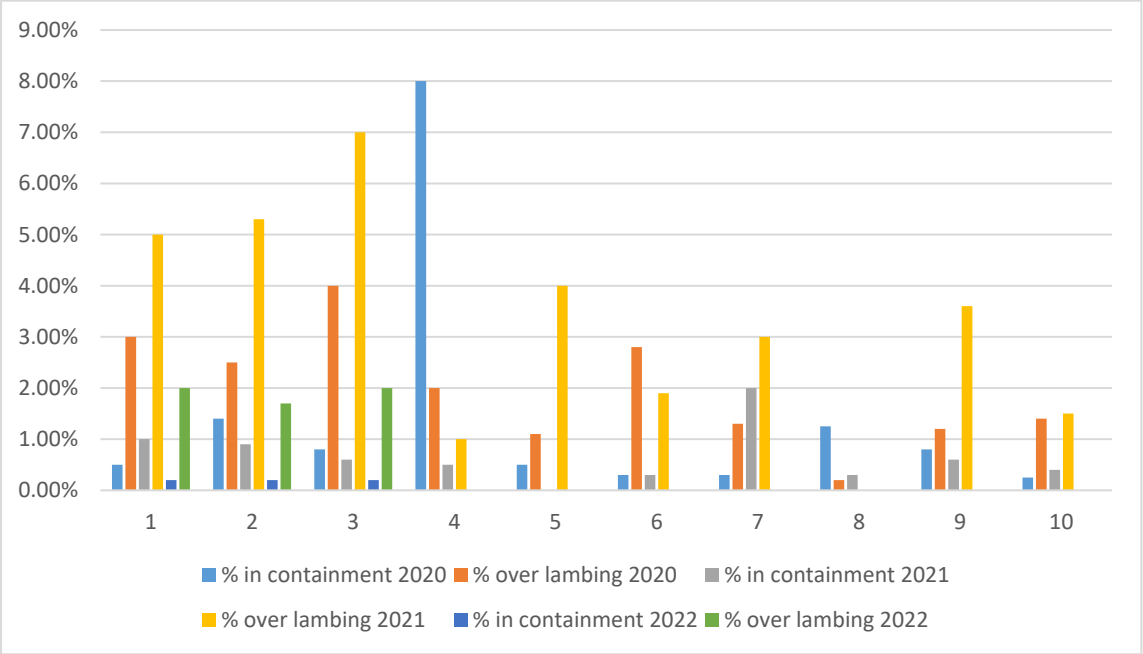


Fig. 3 shows the marking percentage to ewes joined on the minor sites. As mentioned above there was a large difference between the proportion of ewes that were contained on the minor sites. Some of the sites had a slight reduction in marking percentage, especially in 2021 with a very late break. On some of these sites only a small number of ewes were in containment, so it didn't have a significant effect on their overall results.

Sites 6,7,8,9 and 10 all contain a large proportion of their ewes. All of these sites were able to maintain or improve on their long-term marking percent average associated with the use of containment and improved ewe management.

4.1.3 Ewe mortality

Figure 4: Ewe mortality on each of the sites during the containment and pre-lambing period



As shown in Fig. 4 ewe mortality varied considerably across the containment sites and various health issues were overcome throughout the project.

Mortality in the containment pens was generally low with most sites being well under 1%. The common health issues which occurred in the pens included acidosis, pulpy kidney, campylobacter and vaginal prolapse. The largest issue we encountered in the containment pens was a large proportion of vaginal prolapse which occurred in twin bearing ewes contained on one of the minor sites (Site 4) in 2020. 8 percent of the twin bearing ewes prolapsed and had to be euthanised. All of the standard risk factors didn't appear to have occurred; ewes were fed to an energy and protein requirement with no excess and balanced nutrition, ewes were being fed to a condition score average of CS 3.5 and were only slightly over this target, tail length was adequate and calcium levels were sufficient. The ewes did have a major change in exercise regime as they were kept on hills for the majority of the time and then were moved to the smaller pens (10m2 per ewe). A similar issue had happened the previous year prior to the project commencing. During 2021 ewes were fed in small sacrifice paddocks in the foothills rather than in the purpose-built containment facility, this resulted in much lower ewe mortality and only 2 prolapses occurring across the 526 ewes. The overall ewe mortality on site 4 in 2021 was reduced considerably.

There was also a large variation in ewe mortality over the lambing period (once ewes were released from containment) with many of the sites being over the industry target of two percent. As ewes on most of the containment sites were fed high quantities of cereal grain (calcium deficient) this increased the risk of metabolic associated deaths. Some of the deaths were associated with pregnancy toxaemia however a higher proportion appeared to be due to hypocalcaemia. Ewes had all been provided a form of calcium in the pens mostly in loose lick form but this didn't always appear to be adequate.

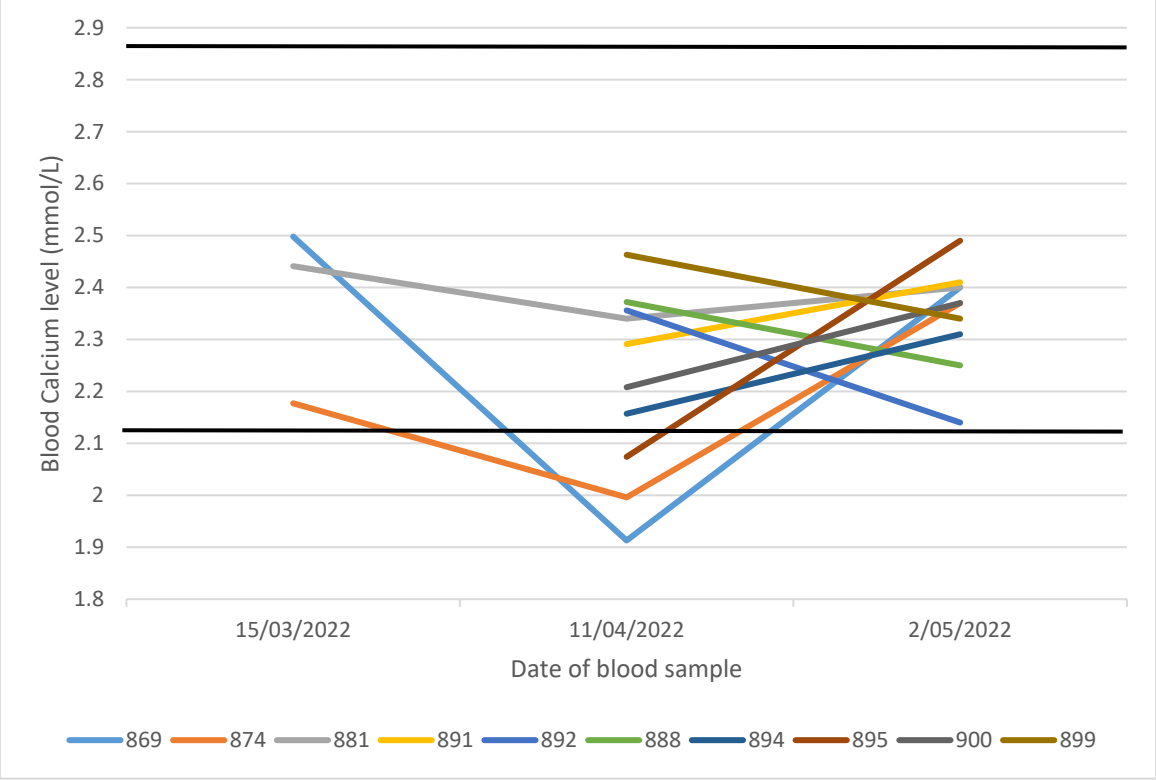
Ewe mortality increased in most of the containment sites in 2021, spring of 2020 was below average in many areas and combined with a later break in 2021 it meant ewes were heavily supplementary fed. Ewes were all fed large quantities of grain over a relatively long period of time, hay and straw

prices were also very high in 2021 which meant many rations were formulated using barley and straw, rather than hay. Even though ration costs are reduced by using straw for roughage this often had a negative impact on ewe mortality through increased requirement for barley (to reach energy targets) and increased risk of hypocalcaemia. The risk was also higher for twin bearing ewes or older ewes who had been supplementary fed heavily throughout their life. Site's 2 and 3 also had a proportion of twin bearing ewes below their condition score target in 2021 which increased overall mortality. The ewes on site 3 were fed a higher silage diet which had been formulated to meet energy requirements of the twin bearing ewes, however during the last trimester some ewes started to drop condition, reinforcing the importance of close monitoring and condition scoring.

4.1.4 Health project Calcium and Magnesium levels throughout containment

A small quantity of blood sampling was conducted in 2021, on site 1 we found from randomly selected ewes 21% had low blood calcium levels a month out from lambing. A small sample size were blood sampled at site 2 six weeks into lactation and we found 60% of these lactating ewes had inadequate blood calcium levels. Due to this we did more extensive blood testing in 2022.

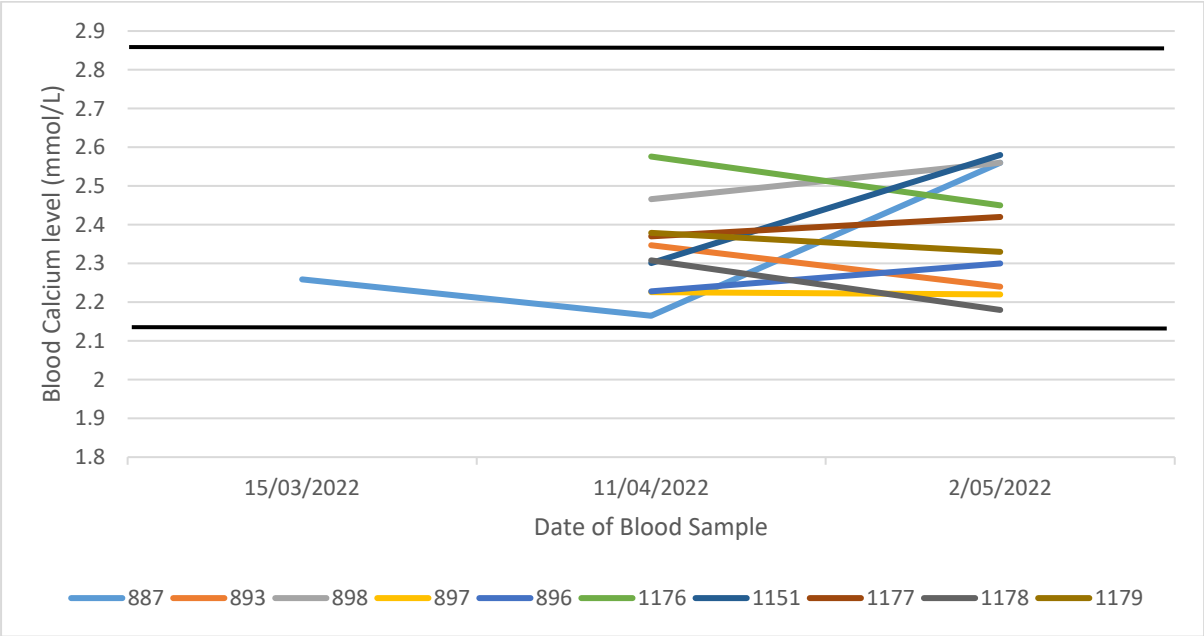
Figure 5: Site 1 mixed age older ewes blood calcium levels for 10 different ewes over three time periods in containment. Solid black lines show the normal range for Calcium blood levels.



Older mixed age ewes were blood tested at three time periods. The first blood testing was done prior to scanning on this site so only ewes that were sampled that ended up in the twin mob have been graphed in Fig. 5. By the second blood collection 30% of the ewes had inadequate blood calcium levels and at this point were being fed a straw and barley ration with a high calcium loose lick available ad-lib in the pen. Interestingly due to the increased cost of barley, site 1 then began feeding ewes a fully feed pellet which contained mineral additives (including 1% calcium) and also kept access to the ad-lib mineral in the pens. 70% of the ewes tested had an increase in Blood

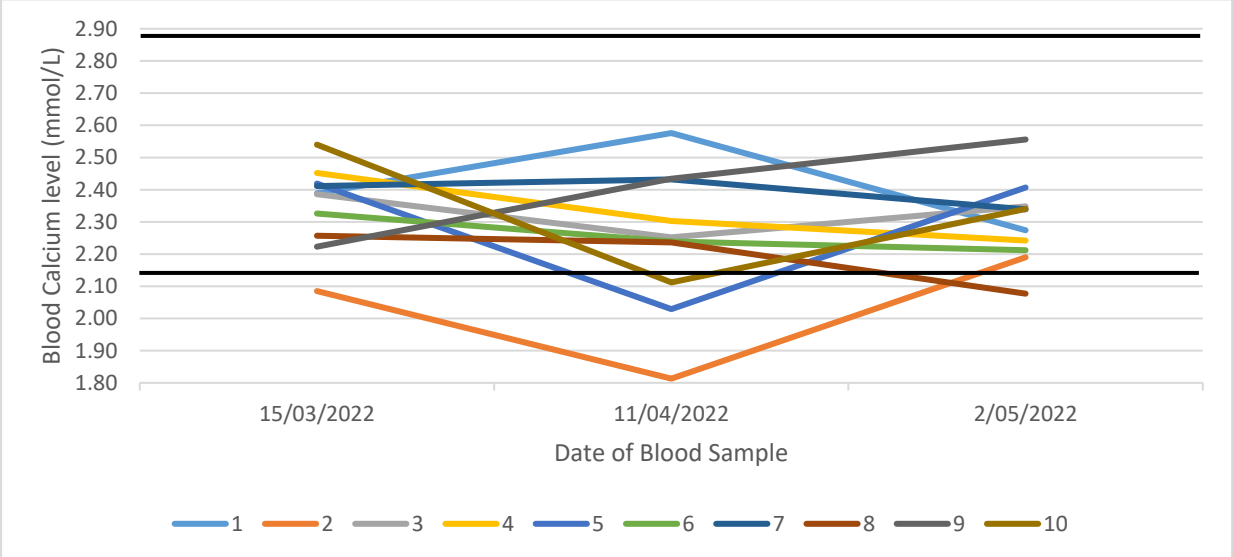
calcium over the following three weeks and all of them were in a normal blood calcium range a month prior to lambing. Ewe mortality in the twin mobs on site 1 was less than half of the previous year.

Figure 6: Site 1 ewe hogget blood calcium levels for 10 different ewes over three time periods in containment. Solid black lines show the normal range for Calcium blood levels.



The younger ewe hoggets blood sampled on Site 1, shown in Fig. 6 showed normal blood calcium levels right through pregnancy. They had the same change of feed to a well formulated full feed pellet just after the second blood sample was taken. 60% of the ewes sampled had a slight increase of blood calcium to a month out from lambing.

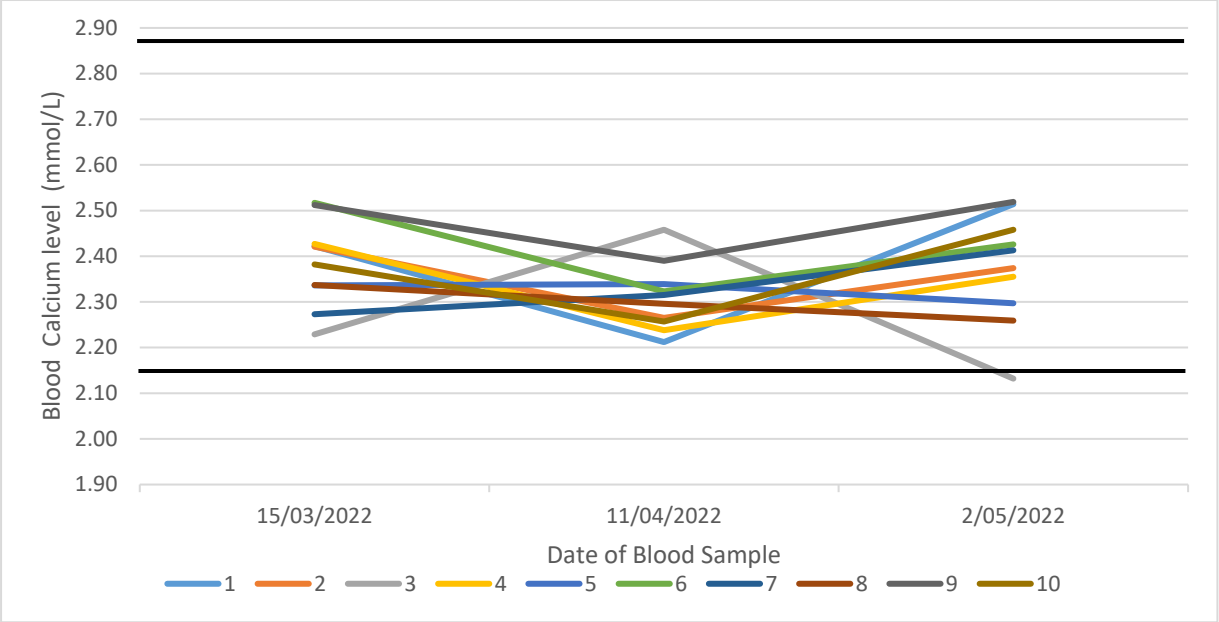
Figure 7: Site 3 mixed age older ewes blood calcium levels for 10 different ewes over three time periods in containment. Solid black lines show the normal range for Calcium blood levels.



As this site had scanning information by the first blood collection all 10 ewes were identified out of the twin mob, so they had blood samples taken over the 3 points in time. Fig. 7 shows a similar trend with 50% of the ewes having decreased blood calcium levels as they progressed through pregnancy.

The ewes on site 3 were fed a predominate silage-based ration with a small quantity of barley fed during the last trimester to meet energy requirements. They also had a loose lick available ad-lib in the pen the whole time. Even though their diet wasn't as calcium deficient 30% of the ewes still had low blood calcium levels at the second blood collection date before 90% of the calcium levels being in a normal range by a month out from lambing.

Figure 8: Site 3 ewe hogget blood calcium levels for 10 different ewes over three time periods in containment. Solid black lines show the normal range for Calcium blood levels.



Site 3 ewe hoggets shown in Fig. 8 had normal blood calcium levels throughout pregnancy at the three blood collection times.

Figure 9: Blood magnesium levels for the four different groups of ewes across two sites. The solid black lines show the normal magnesium range.

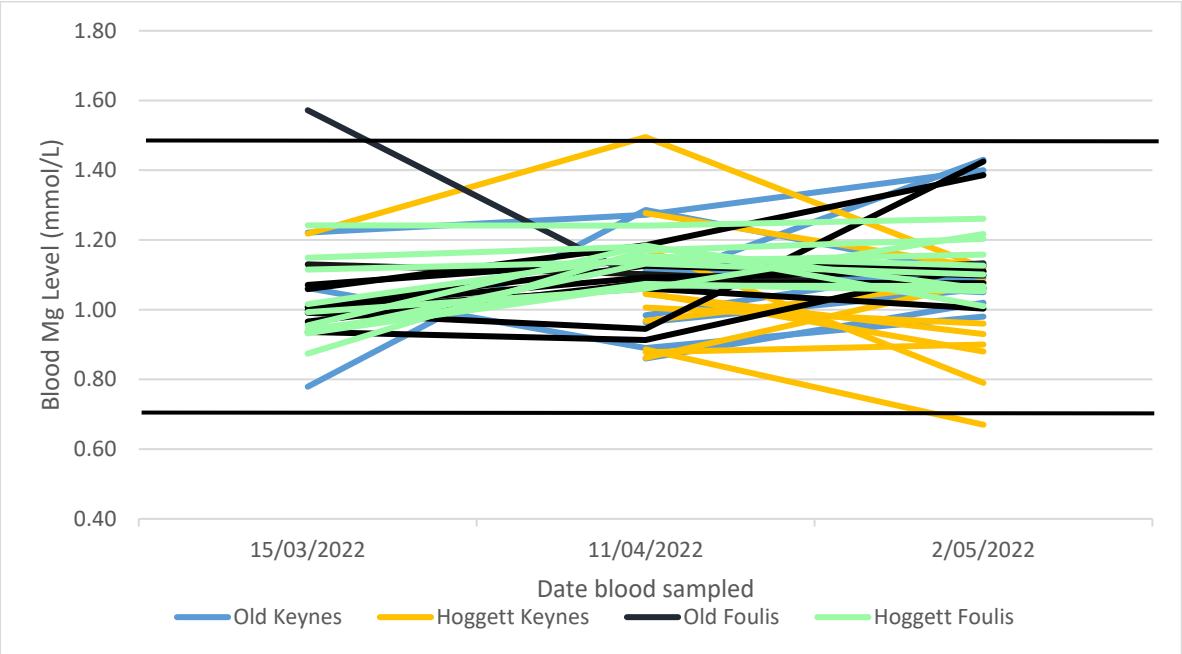


Fig. 9 shows blood magnesium levels all in the normal range with the exception of 1 ewe Hogget which showed a slightly lower level at the last blood collection prior to lambing. We expected from our hypocalcaemia related deaths in 2020 that calcium blood levels would have been more of an issue than Magnesium levels which is confirmed by these results.

Time of containment varied across all the sites from 35 through to 120 days. There didn't appear to be any correlation between lambing results or increased risk of ewe mortality due to longer periods of containment. It appeared to be more correlated to how ewes were managed during this time.

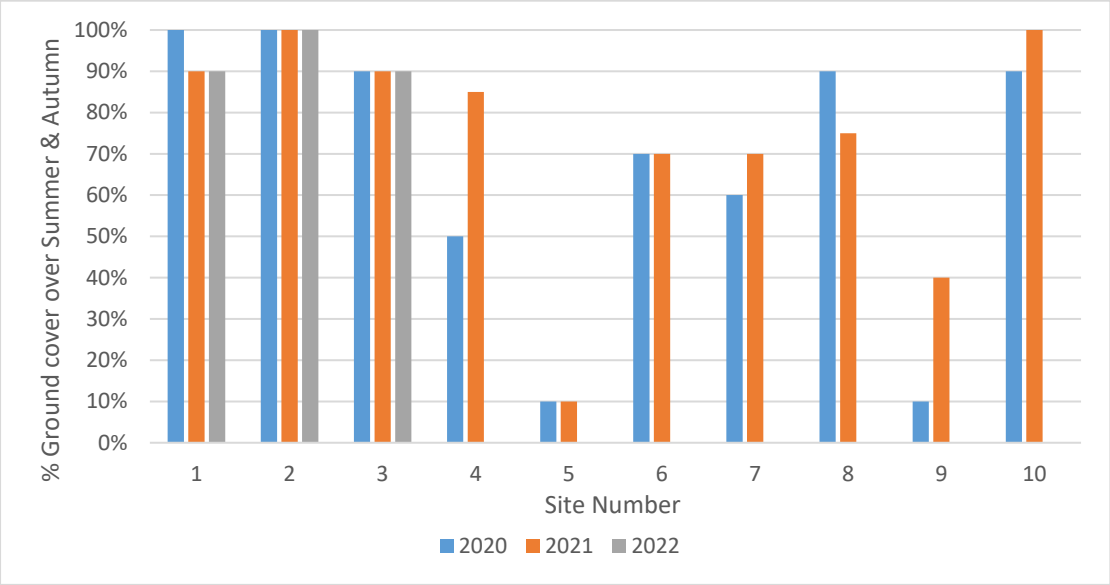
4.1.5 Feeding costs

Figure 10: Feeding cost variance across all sites and years

Feeding costs varied across all the sites as shown in Fig. 10. All the feed costs were calculated using standard commercial value for the season, so all site feed costs were equivalent. In 2021 roughage cost of hay and straw went up substantially which increased the cost of some rations depending on the percentage of roughage in their ration. Site 1 and 2 fed predominantly hay, straw and grain with site 1 swapping to full feed pellet at the end of 2022 due to barley price increase. Site 3 fed straw and barley in 2020 but swapped to silage-based rations in 2021 and 2022. Site 5 was able to keep ration costs down by using waste grain. Site 8 had a lower feed cost due to only containing single bearing ewes, with a lower energy requirement. Site 9 used a total mixed ration so can make use of any hay and grain balance to reduce overall ration cost where possible.

4.1.6 Ground cover % across the sites

Figure 11: Ground cover percentage over summer and autumn on the containment sites



Ground cover varied across all the sites as shown in Fig. 11. The three major sites all locked up a large proportion of the ewes on their property so as we expected they maintained ground cover well above the 70% industry target. Site 4 had reduced ground cover in 2020 with a late break and only had a small portion of ewes off the paddocks, they also had pressure from kangaroo's grazing. Site 5 has only recently commenced containment (in 2020) and so hasn't locked up enough ewes to improve property ground cover at this point. Site 6 and 10 both contained all of their ewes and run predominately cropping focused business and have managed ground cover at the target.

Site 7 locked up a high proportion of their ewes in 2020 but still struggled to maintain ground cover at the target with an extremely poor season, the 60% ground cover maintained did increase pasture recovery though once the break did come. Site 9 also had a very poor season in 2020, they contained most of their breeding ewes however huge kangaroo pressure meant their ground cover was much lower than they would have liked.

4.1.7 Feed on offer advantage with containment

Figure 12: Comparison between Site 1 feed on offer (FOO) over the course of the project vs comparison properties within 8km's of similar size. Feed on offer comparison from satellite imagery measurements.

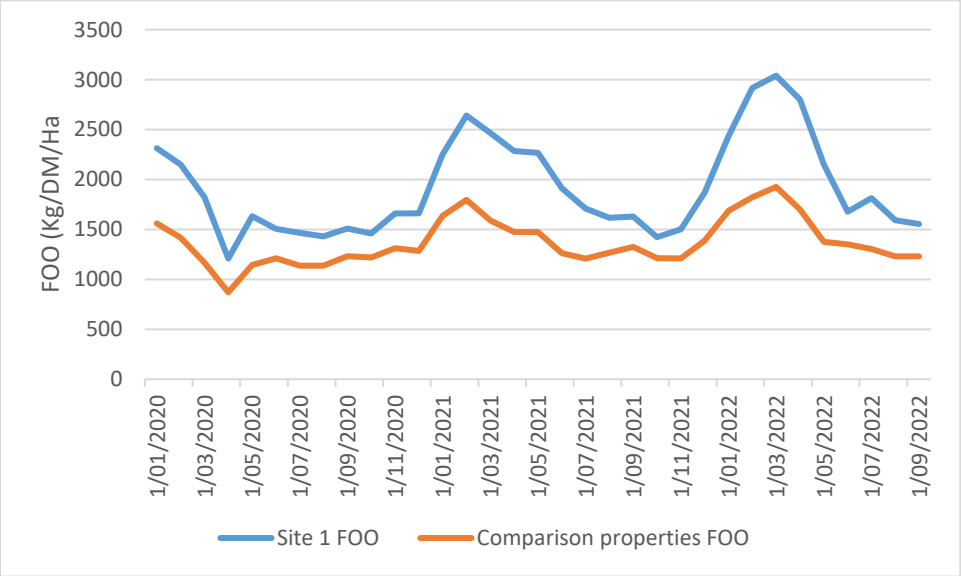
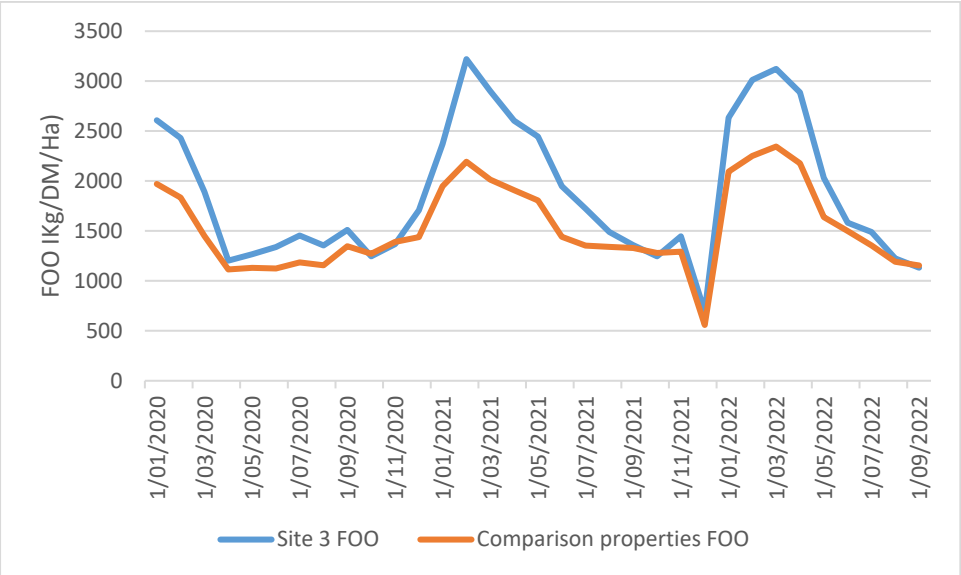


Figure 13: Comparison between Site 3 feed on offer (FOO) over the course of the project vs comparison properties within 8km's of similar size. Feed on offer comparison from satellite imagery measurements.



As shown in Fig. 12 and 13 both major sites 1 and 3 showed a considerable feed on offer advantage over the period of the project by destocking paddocks over the summer and autumn period as compared to other properties in the region.

4.2 Economic analysis

4.2.1 Differences in lambs weaned

Analysis of the PDS data from the three main sites showed that two sites had estimated FOO differences between continuously grazed (neighbouring farms) and the deferred grazing treatments areas over June and July (Table 4) consistent with those found in the 5-year comparison of a deferred grazing system and a continuously grazed system on annual pastures.

Table 4: Increased FOO over winter from deferred grazing and FOO levels of continuously grazed pastures.

	Site 1	Site 2	Site 3
Av. Difference in FOO (KgDM/HA) through June-July	435kg	263kg	-152kg
FOO Level of continuously grazed pastures (Jun-Jul)	1245kg	1327kg	1124kg
FOO Level of continuously grazed pastures (Jan-Apr)	1553kg	1941kg	2285kg

The third site had less dry matter available through June and July in the deferred grazing areas than the continuously grazed site. This result was confounded by very different stocking rates on the two different properties.

Lamb survival in merino ewes, and in particular twin lamb survival, has been shown to be influenced by ewe condition score at lambing and the FOO at lambing. The sites averaged ~1250 kgDM/Ha through the lambing months (range 1125 kgDM/Ha to 1325 kgDM/Ha) which was 182 kgDM/Ha higher (range from -152 KgDM/Ha to 435 kgDM/Ha) than surrounding farms (Table 4). These results are slightly lower than what was achieved in the Kybybolite experiment which may reflect ewes not being locked up for as long post the autumn break.

The impact of ~400kg additional dry matter available on lamb survival is also dependent on the average chill index at lambing. Using LTEM tables on predicted survival rates of twin born lambs with a chill index ranging from 900 to 1100 the impact of the additional feed on offer on twin lamb survival would be between 2% to 5% for 3.3 condition score merino ewes. For singles born lambs it is predicted to be 0.5% to 3%.Modelled chill index using Grassgro at Temora in NSW (similar latitude, rainfall, maximum and minimum temperatures for the month of June as Keyneton) with 39 years of weather records for the period from May through to October showed the median weekly chill index “rarely exceeding 1000 kJ/m2.h” (Broster et al 2012). The tablelands environments (higher altitude) commonly exceeded 1000 kJ/m2.h from June onwards. In most of the more susceptible Tableland’s environments the chill index could be substantially reduced by providing shelter to lower wind speeds.

Consideration of what benefits are likely therefore need to consider the amount of shelter in the lambing paddocks and the aspect of the paddock which can substantially reduce chill index by lowering wind speeds.

Average chill index data for the lambing period at each site, each year, is not recorded. The average of the 2014, 2015, 2016, and 2021 years, calculated for the Barossa Improved Grazing Group at Keyneton was 1090 KJ/m2.h.

This average is from a small number of years and does not take into account potential reductions in the chill index from available shelter on sites (i.e. twin lambing ewes put into the more sheltered paddocks).

In the calculations done on cost benefits of the containment ~1000 KJ/m2.h has been used for the lambing period in which case the increased twin lamb survival would be predicted to be ~3.5% for 400kg to 500kg additional dry matter available through lambing, and ~1.5% in single born lambs.

Care should be taken with the expectation that these outcomes will be achieved in practice given that experimental data at Kybybolite and other similar experiments have not recorded differences.

Using predicted impacts on lamb survival, the total predicted increase in lambs weaned where the outcome is 125% lambs weaned is 3% extra lambs weaned. If the outcome is 100% lambs weaned the total predicted increase in lambs weaned is 1.6% because there are far fewer twins.

The three sites analysed recorded 5% - 20% more lambs weaned in the mobs that were containment fed than they had achieved in previous two years before the PDS started. Most of the difference in weaning percentage are likely to have come from differences in condition scores of ewes at lambing rather than containment feeding and higher FOO on offer through lambing. This implies better management of the ewes.

4.2.2 Difference in cost of feeding

The differences in the management decision as to when ewes should go into containment meant that over the three years across the three analysed sites the average FOO on pastures that were destocked were between 2000kg FOO and 2600kg FOO. Across the 3 continuously grazed sites the FOO over the same period averaged between 1500kg DM to 2200kgDM (Table 4). The FOO availability in the continuously grazed sites will affect the cost to maintain ewes at a higher condition score.

4.2.3 Differences in annual carrying capacity of pastures

Given the findings of the Kybybolite experiment that total annual pasture production was not increased by containment feeding from the autumn break it is not possible to attribute the higher stocking rate on any property to the management practice of containment feeding and its impacts on pasture growth.

That does not rule out that containment feeding may give management more comfort that they can control nutrition at a higher stocking rate, thereby enabling the decision to run a higher stocking rate.

4.2.4 Differences in mortality rates in ewes

The Kybybolite experiment recorded low average annual death rates in ewes (<2.2%) but higher +~1% in the deferred grazing system than in the continuously grazed system. The additional deaths were largely incurred through the lambing period rather than the feeding period.

Amongst the PDS sites only one site in two years compared death rates of containment fed ewes to continuously grazed ewes. In this site there were 1% additional deaths in one of the years and 6% additional deaths in the other year.

The year where the difference was considerably higher was a year where all sites had high (>6% deaths in containment and over lambing)

It should not be assumed that higher death rates are inevitable, but it should be considered a risk.

4.2.5 Costs and benefits

The method of calculating the costs and benefits of containment feeding is via the following steps.

Step 1: Calculate the additional rations costs of using containment whilst above minimum target FOO levels remain on pasture.

Step 2: Account for any differences in operational costs associated with containment feeding versus feeding on pasture.

Step 3: Attribute benefits from more FOO over lambing

Step 1 – Additional Ration Costs

Down to a low level (500 to 1000kg of available dry matter depending on quality of the dry feed) there is an opportunity cost in not using available pasture dry matter as part of the ration.

Feed quality measurements of the paddock available FOO were not taken during this PDS. A guide as to the potential ration cost saving has been created using a simple GrazFeed comparison of required barley to maintain a 60kg ewe 45 days pregnant with twins on varying levels and digestibility of dry feed. The two levels of digestibility were 45% digestible (6.7 MJME/Kg DM) or 40% digestible (5.8 MJME/Kg DM).

Table 5: Estimate of additional ration requirement at different levels of pasture digestibility and availability.

Pasture Availability (KgDM/Ha)	**45% Dig. pasture**	Herbage Intake	Grain	% Of Full Ration Saved by Herbage	**40% Dig. pasture**	Herbage Intake	Grain	% Of Full Ration Saved by Herbage
	2000	0.74	0.34	39%	**2000**	0.54	0.46	18%
	1500	0.65	0.39	30%	**1500**	0.46	0.5	11%
	1000	0.52	0.47	16%	**1000**	0.37	0.55	2%
	500	0.31	0.56	0%	**500**	0.22	0.61	-9%

There was significant variation between sites and between years but the average dry matter available across three sites and three years was just shy of 2000kg of DM.

On all three of the sites dry mater levels fell from Jan through to April in the first year indicating senesced pastures. In the second year FOO levels did not start falling until March and in the third year it was not until April. This indicates that there was some pasture growth in the 2nd and third years through summer which would have meant that the pasture quality was better until later in those year on those sites.

It is not possible to know exactly what the difference in feed cost was from the results of these demonstrations. Given the amount of feed on offer in both the destocked pastures and the pastures that were not destocked a conservative estimate of ~18% is used to allow a demonstration of the methodology.

In practice it would be worth feed testing to understand exactly what the containment feeding is adding to costs of feeding when residual dry matter levels are above 1250 kgDM/Ha.

The actual ration costs per head per year varied between $14 per head and $57 per head (Table 6) and therefore the gross additional cost of feeding in containment over in the paddock varied between $2.45 per head and $10.19 per head if the containment cost 18% more in ration costs.

Table 6: Ration costs per ewe fed and marginal ration cost from being containment fed over fed on pasture ($/Ewe Fed).

	Total Ration Cost			Marginal Ration Cost @ 18%		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
2020	$37	$24	$23	$6.75	$4.40	$4.12
2021	$57	$24	$22	$10.19	$4.33	$3.87
2022	$27	$14	$21	$4.86	$2.45	$3.76

Step 2: Account for differences in operational costs

There are however also some savings from containment feeding in the feeding operation. Estimated time saved varied from 2hrs per week to 12 hours per week which is in part dependent on the number of sheep and the size of farm. At a cost of $45 per hour this translated to a difference in labour of between $0.85 per ewe to $4.05 per ewe which was dependent on the number of days fed as well.

The marginal vehicle costs saved from containment feeding versus feeding in the paddock varied between $60 per week in fuel to $100 per week in fuel and wear and tear on vehicles. This translated to between $0.25 per head to $0.80 per head saved on vehicles costs. Fuel estimates were given by each site owner and where kilometres differences were given a $1.20 per kilometre rate was applied to each kilometre.

Table 7: Estimates of labour and vehicle cost savings from containment feeding ($/Ewe Fed)

	Labour Saved from Containment Feeding			**Vehicle Costs Saved from Containment Feeding**		
	Site 1	**Site 2**	**Site 3**	**Site 1**	**Site 2**	**Site 3**
2020	-$4.05	-$1.17	-$3.21	-$0.49	-$0.81	-$0.81
2021	-$3.45	-$0.85	-$2.00	-$0.42	-$0.59	-$0.51
2022	-$2.05	-$0.89	-$2.40	-$0.25	-$0.62	-$0.61

The estimated marginal cost of feeding from containment (extra ration cost less savings in labour and vehicle costs) averaged over the three years for each site came to $0.74 per head per year to $3.70 per head per year.

Table 8: Marginal cost of containment feeding ($/Ewe Fed)

	Marginal Cost of Feeding		
	Site 1	**Site 2**	**Site 3**
2020	$2.21	$2.41	$0.10
2021	$6.32	$2.89	$1.36
2022	$2.57	$0.94	$0.75
Average	**$3.70**	**$2.08**	**$0.74**

Step 3: Work out the net benefit in production from additional FOO at lambing

Unless all additional lambs weaned are sold at weaning, increasing reproduction rates in a wool flock changes flock structure. Where a farm is already optimally stocked, increased lambing percentages will decrease ewes joined as more replacement ewe weaners (and possibly wether weaners) are retained through to 1 year of age.

The extra lambs also incur extra costs associated with marking, animal health, shearing and crutching and selling costs. The gross benefits of additional lambs as a % of ewes joined do not correlate directly to a value on those lambs.

In a flock model where the farm is optimally stocked and it costs $14.60 to run a lamb from marking through to one year of age inclusive of (marking, shearing, crutching, and animal health treatments) then if wether lambs are sold for $100 off shears at 6 months of age, but ewe weaners are run through to 1.5 years of age before the cull portion is sold for $160, the increase in gross margin per ewe joined is only ~$5.65 for every 5% increase in lambs weaned. This allows for flock structure changes, and additional costs incurred on lambs and finally selling costs.

On a gross income basis where flock structure is not changed and 50% of extra lambs are wethers with 50% ewes (av. sale price of $130) the increase in income per ewe joined would be $6.50 for every 5%.

A 1% increase in survival would therefore be worth $1.13 per ewe joined. If 3% extra lamb survival is obtained, then it would have offset the marginal cost of feeding at each of the sites.

4.2.6 Consider risks

Attention should be paid to the risks around mortality. If as per the Kybybolite experiments deaths of contained ewes. Where the sale price of CFA ewes is $120 then every 1% increase in mortality is a cost of ~$1.70 per ewe joined. Where the sale price of CFA ewes is $180 it is ~$2 per ewe joined. If mortality rates in ewes are not controlled consistently then they could easily swamp potential benefits from lamb survival.

4.2.7 More accurate management of sheep

Increased production from containment feeding may not come from containment feeding, but rather from improved management of the sheep (more accurate management allowing ewes to be in better condition through hitting target levels of nutrition). For instance, had the sheep not been contained and monitored as closely the target condition score may have been missed.

High condition score ewes at lambing will have better lamb survival, and those lambs will have a higher lifetime fleece value.

In this analysis the assumption is that the benefits of additional fleece weight in the ewe fed to a higher condition score will either be largely, or wholly, offset by the increased fibre diameter of the fleece. The impact on the fleece value of the ewe is subsequently ignored.

More significant benefits of maintaining higher condition score of ewes through mid to late pregnancy will come through better lamb survival and then the lifetime fleece value of merino progeny.

If we assume 5% more lambs weaned because of being +0.5 condition score, then @ $100 per wether lamb weaned lamb and $160 per extra ewe lamb weaned that is $5.60 of additional gross margin per ewe joined from the additional lambs weaned as per the analysis in the previous section.

The progeny would also have 100g heavier fleece weights that are 0.2 micron finer at each shearing. The value of this will be very varied according to fibre diameter of the sheep and the markets at the time. For this analysis, we have used a base fleece weight of 3.5kg clean and $20 per kilogram clean as the price. We have then assumed a $1.50 per micron premium as the fleece get finer.

The value attributed to the ewe that is fed depends on how many times the progeny is shorn. For the purposes of this calculation, we have used 3 full fleeces per lamb (1 for wether progeny and 5 for the ewe progeny). Calculating that out equates to a nominal ~$10 for lifetime fleece value of progeny.

The additional 0.5 of a CS has therefore yields ~$15.60 of increased income from progeny.

At a ration cost of $400 per tonne and 3.5kg of ration per 1kg of liveweight maintained the additional feed cost is ~$5 per ewe. The net benefit is then ~$10.60 per ewe after the feed cost to maintain the extra condition on the ewes.

Containment feeding, allowing more control over the feeding process and more frequent monitoring of the sheep may be a more reliable way to ensure that the CS objectives are met. If that is the case, then for it to be profitable, the marginal costs of feeding in containment need to be less than the net benefit from being in better condition at lambing. It also requires that the same average result cannot be achieved out of containment.

Based on the 3 main PDS sites, and an assumed 40% digestibility of pasture from Jan to April, the marginal cost of containment was $0.74 to $3.70. Under the assumption that the containment fed ewes were 0.5 of a CS better off than had they not been fed, and that containment feeding was going to be a more reliable way to achieve that outcome, the net benefit of the additional CS maintained in ewes from the progeny would therefore be between ~$8 per ewe and ~$5.30 (deduct the additional cost of containment feeding from the net benefit of ewes being 0.5 of a CS better at lambing).

The economic analysis has not attempted to quantify any additional benefits to pasture persistence or soil preservation that may also accrue from containment. If these are going to occur it will be a very low dry matter levels and will be particular to soil types, soil fertility and pasture species.

4.3 Extension and communication

4.3.1 Extension Activities

2019			
Webinar: Summer feeding: Managing summer feed and pre-joining nutrition webinar recording - YouTube	November	A webinar discussing supplementary feeding	90
		Total	90
2020			
BIGG conference: containment ewe producer panel	February	4 producers answered containment questions and explained the fit in their enterprise	84
Annual Field Day: Bus Tour	March	Visited Major and minor sites: Angaston, Keyneton, Point Pass and Bagot Well	42
Field Day: BIGG pasture walk – minor containment site visit	September	Minor site visit and producer discussed his set up. Camplylobacter update from Coopers Animal Health.	27

Workshop: Benchmarking results	October	Workshop for core producers benchmarking results & discussion	8
Webinar: Containment results and discussion with panel: BIGG Containment Ewe Results and Discussion Webinar November 2020 - YouTube.	November	Containment results and collected information from panel and attendees re gaps in knowledge	97
		TOTAL	258
		2021	
Annual Field Day: Containment site visits and health talk	March	Visited Milendella to view automatic feeding set up for ewes and lambs, Health and disease in containment talk with Dr Colin Trengove and visited major site at Springton.	14
Webinar: Feeding with the late break	June	Webinar covering ewe pregnancy and lactation requirements and the best way to feed (with late break in SA)	92
Webinar: Feed budgeting – a closer look	July	Webinar having a closer look at how to make a feed budget	131
Workshop: Feed assessment and budgeting	November	Started with a practical assessment of pasture, quantity and ground cover. Followed by a feed budgeting workshop and discussion of containment results	15
		TOTAL	252
		2022	
Annual Field Day: Keyneton station in conjunction with Technology Day	June	Spoke on ewe health in containment as part of the 'Keyneton Station' technology field day. Georgie Keynes (Major site) also spoke on her containment pens and successes, there was also an update on the condition score and pregnancy scan project that was done as part of our containment ewe project	45
Workshop: Discussion around final results	October	What worked? What didn't? What information do you need to improve. Final discussion workshop with core producers	14
		Total	59
		2023	
BIGG conference – Final Results presented	February	Presentation of Final results	80
		TOTAL 2019,2020,2021,2022, 2023	739

4.3.2 Communication Activities

		Internal	x 300 Members
		BIGG Newsletter are available: Newsletters - Barossa Improved Grazing Group (biggroup.org.au)	
2019	1	BIGG Project introduction article - September	
	2	BIGG Newsletter Update - October	
	3	BIGG Newsletter- November	
2020	4	Tech Article "Feeding minerals in containment"	
	5	BIGG Newsletter – September: Containment ewe and pasture walk field day article.	
	6	BIGG Newsletter – September: Containment project update & Case Study	
	7	BIGG Newsletter – October: Summary of results workshop and initial project results.	
	8	BIGG Newsletter – November: Article advertising containment summary result and webinar	
2021	9	BIGG Newletter – March: Article advertising upcoming containment feeding systems and health field day	
	10	BIGG Newsletter – April: Sheep feeding and health field day – pictures and media release of the day	
	11	BIGG Newsletter – May: Containment project update	
	12	BIGG Newsletter – June: Webinar advertising	
	13	BIGG Newsletter – August: Containment project update	
	14	BIGG Newsletter – October: Advertising for Feed Budget workshop	
	15	BIGG Newsletter – November: Containment ewe workshop summary and results update	
2022	16	BIGG Newsletter – March: Containment ewe result and health project update	
	17	BIGG Newsletter – April: Article and field day advertising	
	18	BIGG Newsletter – May: Containment ewe case study and update article on southeast producer who has implemented a containment lot after visiting our sites in 2021	
	19	BIGG Newsletter – June: Field Day report	
	20	BIGG Newsletter – September: Producer Case Study	
	21	BIGG Newsletter – October: Producer Case Study	
		Local	x 20,000
2020	1	Leader newspaper: March – Media article on containment bus trip "All aboard the BIGG bus"	
	2	Leader newspaper: September – media article on pasture walk and containment ewe site visit	

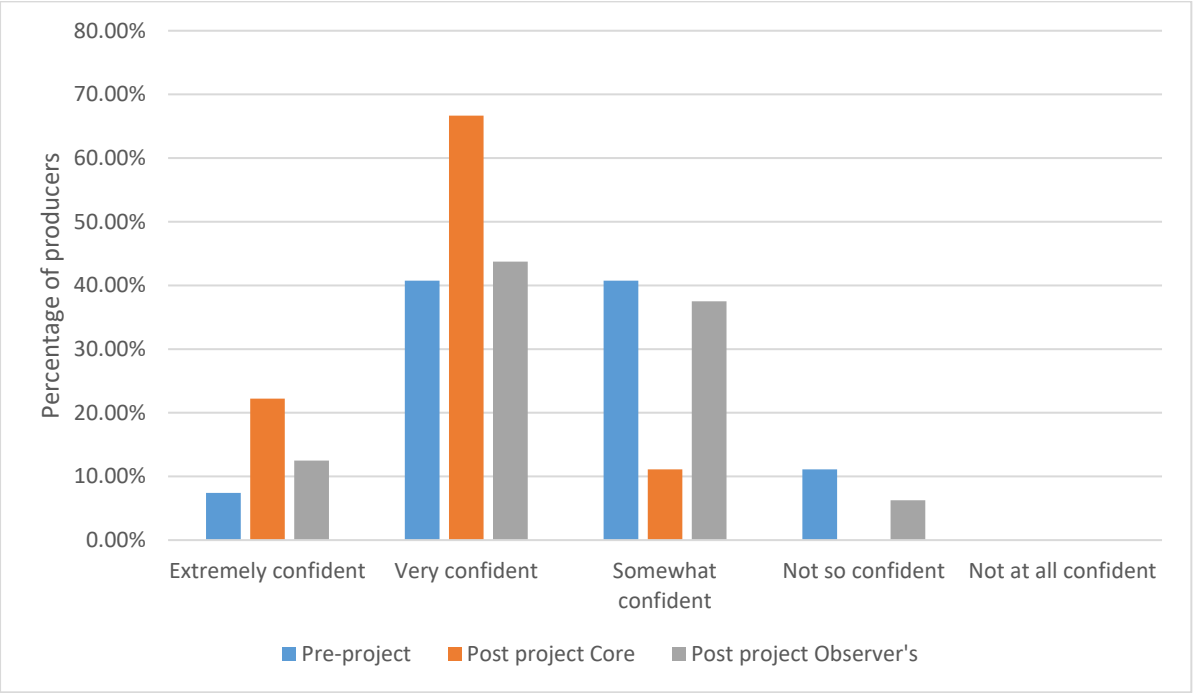
2021	3	Leader Newspaper: March - Advert and editorial advertising containment field day	
	4	Leader Newspaper: March – Media release and photos published after containment ewe field day	
		State	x 52,000
2020	1	Stock Journal: March – Media article on containment bus trip and photos.	
	2	Stock Journal: May – Article on Loffler family (minor site): Lambing onto standing crop aids Loffler family | Stock Journal | SA	
2021	3	Stock Journal: March - Media release after containment field day: Ewe care centre for BIGG field day | PHOTOS | Stock Journal | South Australia	
	4	Stock Journal: June – Article advertising upcoming feed budgeting webinar: Graziers invited to attend BIGG events | Stock Journal | SA	
	5	Stock Journal: November – containment ewe feature – two articles written by Deb Scammell combining learnings from the project	
2022	6	Stock Journal: July – Field day feature: Focus field day attracts graziers and farmers in the Barossa | PHOTOS | Stock Journal | SA	
		National	
2019/20	1	MLA Website project description and update	2116520
2020/21	2	Facebook posts x 20	350
	3	Feedback Magazine – final results article. Scheduled for Feb 2023	50000

4.4 Monitoring and evaluation

Knowledge of containment feeding, ground cover, feed on offer and ewe management improved substantially as shown in the survey results.

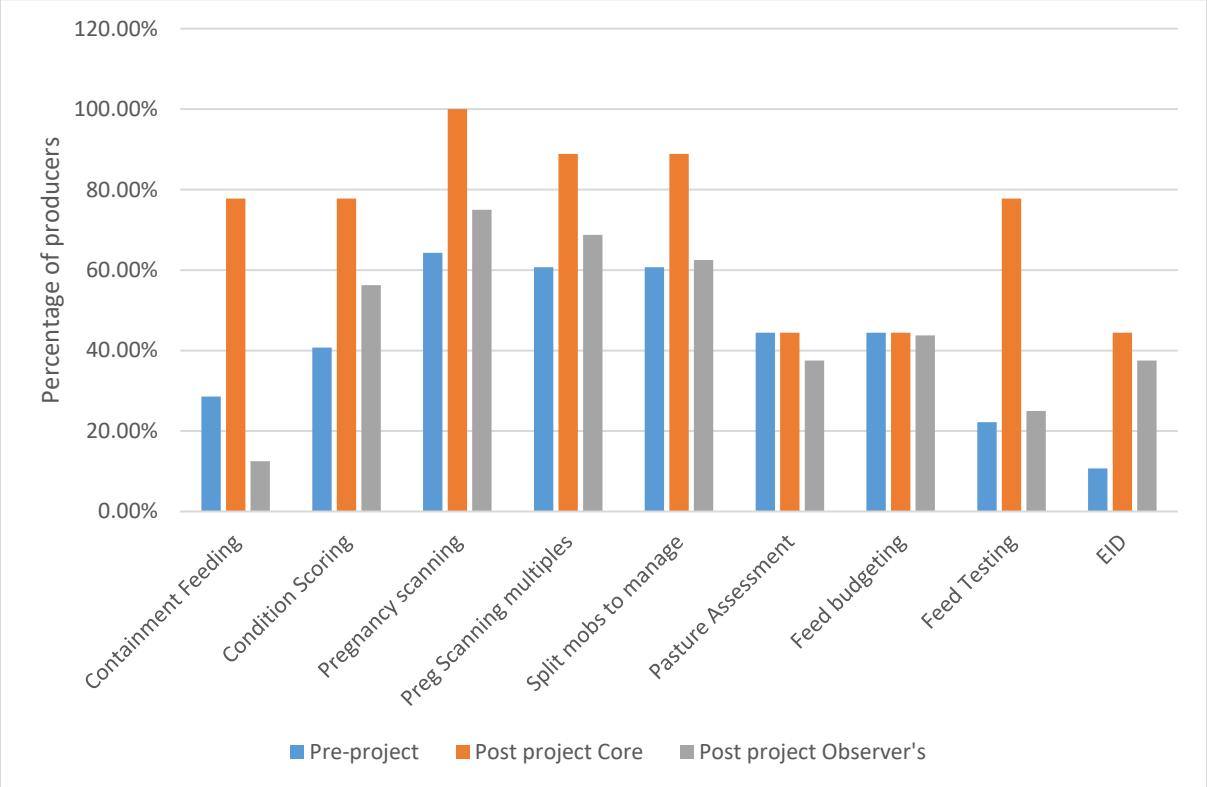
The confidence in managing ewes in containment improved substantially for all producers since the project commenced. Observer producers had an increase in confidence over the project, however core producers had a much larger improvement with 89% being extremely or very confident to manage ewes in containment. Fig. 14 shows the shift in confidence over the project.

Figure 14: Confidence managing ewes in containment from before the containment project, compared to confidence in Core producers and in Observer producers post - project.



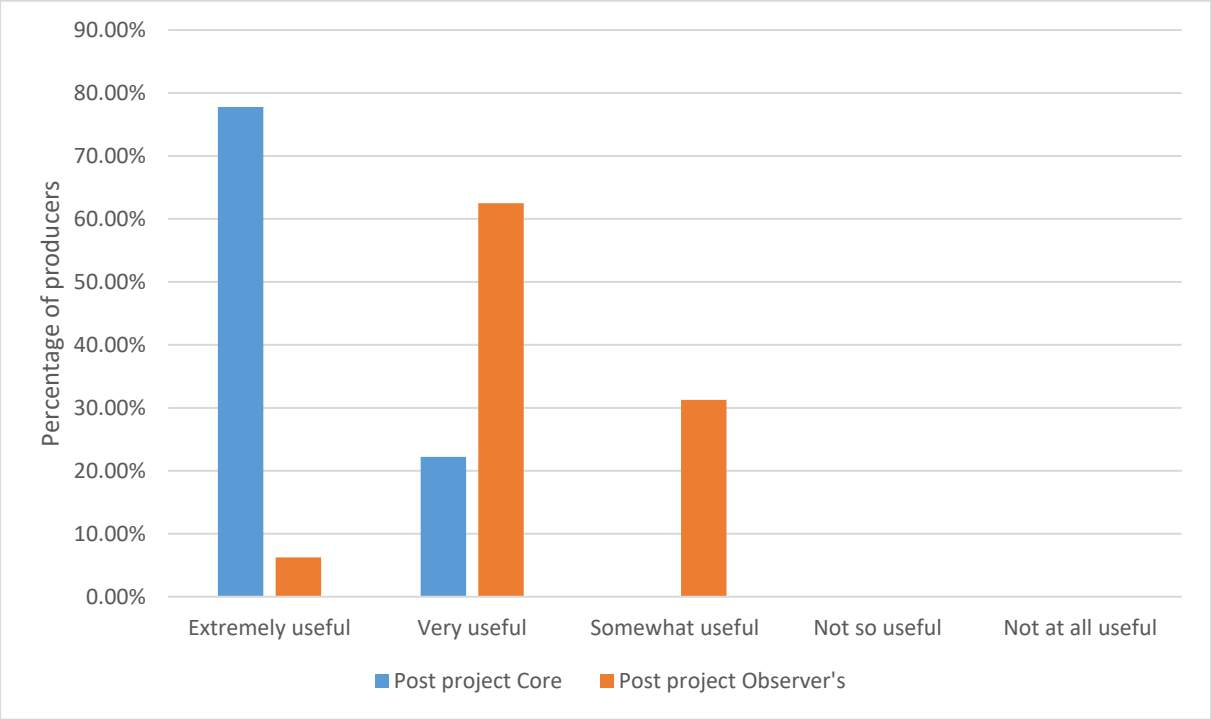
Adoption and practice change was also substantial throughout the project. Fig. 15 shows the percentage of producers adopting improved management practices pre-project. There was a 30% improvement in core producers adopting improved management practices over the project, and there was a 5% improvements within observer producers.

Figure 15: Practice change throughout the project.



Both core and observer producers highly rated their involvement with the containment ewe project. As expected, the core producers rated this a lot higher than the observers that had attended events and these are shown in Fig. 16.

Figure 16: Core and Observer producers rated how they felt being involved in the project improved their confidence and knowledge to containment feed ewes.



Other event surveys and webinar scores are summarised in the attached survey data document.

Eleven of the core producers identified initially adopted containment areas. Of the other four core producers initially identified to be involved one has a containment area and will continue to use when the season requires as he's running quite a low stocking rate. Two still have plans to build containment areas but haven't yet and one had a major business shift and has moved to a different property.

Many observer producers have implemented containment with producers travelling from northern SA, Southeast SA and Victoria to attend events and look at our containment pen set ups. Through my private consulting work I have run many external workshops, worked one on one with producers and spoken at conferences on containment feeding which has often incorporated learnings from this project.

5. Conclusion

Due to seasonal variation across the sites and some experiencing below average rainfall throughout the project, containment was extremely successful in allowing the producers to maintain their annual stocking rates. Ground cover and feed on offer advantage was clearly visible compared to neighbouring properties who kept paddocks stocked. This was even more apparent in areas with unarable native pasture hills which couldn't be re-sown or quickly improved after dry times. All the

sites that contained a high proportion of ewes were able to keep ground cover percentage over the industry target of 70%. Pasture recovery after the season break and feed on offer available at lambing was significantly higher than surrounding properties. The environmental outcomes of reduced erosion, less run off, improved soil structure and more nutrients and organic matter in the soil are all positives associated with maintaining ground cover over summer and autumn.

Lambing percentages were maintained or improved over the course of the project on all the sites which contained a high proportion of ewes on their property. All the major sites showed a significant improvement in lamb marking percentage compared to their pre-containment average. The improvement was associated with not only the containment pens and improved feed on offer at lambing but also as a result of improved ewe management. Throughout the course of the project, it became clear that utilising containment pens meant that producers were able to sort ewes into more appropriately sized management mobs and draft ewes based on condition score. Nutrition was more precise as they often followed a formulated ration where paddock supplementation can often be relatively ad-hoc. Producers were more inclined to pregnancy scan as they could visually see the condition score of multiple bearing ewes decreasing if they weren't separated from singles. Shy feeders were more likely to be identified in a pen where sometimes they are missed in the paddock. Over the course of the project most of the producers overcame some problems with a variance in condition scores in mobs. In most cases the improvement in lambing results could be correlated with an improved ability to manage ewes to a condition score target.

The comparison data between paddock run ewes and containment fed ewes showed the extra value in locking ewes up. The containment ewes were able to produce more lambs and also were run at a substantially higher stocking rate over the rest of the year without having a negative impact on feed on offer or ground cover.

Excessive ewe mortality across some of the sites was an issue throughout the project. In most cases we were able to overcome the issues and mortality was drastically reduced on the major sites during the third year. The mineral blood testing project added a lot of value to some of the unknowns on avoiding metabolic associated deaths when feeding large quantities of grain. Due to the change in feed type over the course of the final year feeding a more balanced ration throughout the containment period i.e silage based, or a balanced full feed pellet appeared to reduce the risk of metabolic associated deaths. With plenty of producers still relying on very high proportions of cereal grain in containment rations, more studies on effective supplementation and avoiding hypocalcaemia associated deaths (especially in older ewes) is required.

A low percentage of prolapse seemed to occur in most of the containment sites without it being associated with any of the obvious known risk factors. The extreme case of vaginal prolapse in twin bearing ewes which had moved from very hilly paddocks highlighted the need for more research in this area. The following year with a much larger 'sacrifice paddock' containment area appeared to resolve the problem with no change to nutrition, condition score or genetics. Verbal communication with other experts seemed to reinforce the theory that the change in exercise regime can have a major impact on muscle structure and increase the risk of vaginal prolapse. Further research is required in reducing the risk of prolapse in containment ewes.

Shy feeders were an issue on most sites but if enough pens were available, they could be effectively identified and separated quickly. In one case we had a line of ewe hoggets which were put into containment on a barley and straw ration. However, they hadn't been introduced to grain prior to weaning with the rest of the line of ewe hoggets. A large proportion of these animals became shy feeders and wouldn't go to the grain feeder, they ended up 0.5 of a condition score lower than the

mob average. This led to the conclusion that for any replacement ewe lambs imprinting on grain, feeders and troughs early in life is invaluable when they come back as pregnant ewes.

Mob size worked well on most sites at a maximum of 350 – 400 ewes. Most producers reported an increasing spread of condition score and a higher incidence of shy feeders if mobs got too much larger than this. Producers using self-feeders even though they were easy to use and required less labour all reported difficulty with ensuring ewes were getting the right quantity of grain.

Feeding costs varied significantly across sites depending on the ingredients used in the rations. The ability to do a total mixed ration (TMR) meant ingredients could be mixed at exact proportions and fed ad-lib to stock which was the most accurate way to feed all ewes the same. Containment rations are often formulated on a 'least cost' basis however we found on many sites that ad-lib straw rations, which then required high quantities of cereal grain to meet energy targets increased the risk of metabolic associated deaths over lambing.

Feed on offer was higher than district average for the major sites monitored. This was particularly during the containment period and over the lambing period as the feed was able to get away immediately once the season broke, without the grazing pressure. The conclusion is that the extra feed on offer contributed to successful lambing results but also the improved management of ewes while they are in containment areas.

The industry resources and information around containment feeding is often conflicting, in most cases producers benefit from working closely with a consultant which can allow them to overcome any issues and achieve a successful result more quickly. Throughout the project it became clear that extra resources available to producers would be a benefit when they are utilising containment. Consultants or tools available to assist with pen set up, successful feeding, separating into pens, mob sizes and ration formulation would be invaluable.

5.1 Key Findings

- Containment allowed improved ground cover, extra feed on offer and improved lambing percentage.
- The use of containment enables producers to manage ewes more effectively with more precise nutrition, appropriately size mobs, to feed to condition score targets which results in improved lambing percentages.
- Access to containment gave producers confidence to consider keeping ewes over a drought period rather than immediately de-stocking.
- The use of containment can allow a higher stocking rate as it allows pasture to get away quickly after the break prior to lambing.
- Labour cost was considerably lower providing supplementary feed in containment pens compared to feeding in paddocks over the drier months especially on larger properties.
- Marking percentage increased by an average of 12% compared to the pre – containment average on the three major sites. This was associated with better management of ewes associated with them being fed in containment pens.
- Ewes kept in containment (for a short period during pregnancy) vs paddock run ewes on a similar property had an average marking % increase of 8% over the three years. Ewes that were kept in containment for a short period of time were run at a much higher stocking rate over the rest of the year.

- Ewe mortality varied considerably across the years and sites. Many health issues were overcome as the knowledge and skill of containment feeding improved over the project. The ewe mortality in the final year of the project was equivalent to paddock run ewes at an average of 1.8%.
- Calcium and Magnesium levels during pregnancy could be optimised with a focus on effective supplementation and balanced rations, reducing the risk of metabolic disease over lambing.
- Feeding costs varied dependent on ingredients used and time in containment. The range was from $14 per ewe to $57 per ewe per year.
- Ground cover was well above the 70% target on any of the sites who locked up a high proportion of ewes, with the exception of two sites that had severe kangaroo grazing pressure during the drought. The major sites had groundcover between 90 and 100% across the three years of the project.
- Feed on offer was an average of 560kg DM/ ha higher across the year on the properties that contained all of their ewes compared to other properties within the region
- The economic analysis showed an advantage of between $5.30 and $8 per ewe associated with the more precise management and containment feeding of ewes.
- 11 Core producers were involved in the project.
- A total of 13 events were delivered in the form of workshops, webinars and field days with an attendance of 739 'observers'.
- 35 communication outputs were delivered across local, state and national networks.
- 11 core producers are routinely using containment as part of their standard management practice.
- There was an improvement in confidence in managing ewes in containment by both the core and observer producers.
- Knowledge, skill and practice change occurred over the project in both core and observer producers in recommended management practices.

5.2 Benefits to industry

The three years of the project have allowed practical demonstrations of the different containment set ups, feeding methodology and positives and negatives of each. Through the field days, webinars and external communications this has been extended to many other producers looking to set up containment. Further video's, costs and benefits of each feeding system and gross margins will be extended as part of a national containment feeding project which has just commenced.

Core producers involved in the project had extensive interaction with a livestock consultant which improved their knowledge and confidence of how to correctly feed ewes locked in containment. The improvement in reproduction rate was substantial, however this was also associated with the improved management of ewes to feed to a condition score target and provide correct nutrition. The information gained from this project, especially in avoiding increased ewe mortality and health problems associated with containment feeding has been and will continue to be extended to the wider red meat industry.

The improvement in ground cover and feed on offer was substantial across the properties that contained a high proportion of their ewes. The benefits of this were seen as improved feed on offer that was available at lambing. However, more research is required in this space to quantify what the extra dollar benefit is of maintaining ground cover and additional dry feed on offer – especially on

areas with native grasses and hill country that can't be improved if it is overgrazed. Additional dollar value for long term environmental outcomes like improved soil structure, reduced erosion etc would be useful also as there are more dollar benefits than we can quantify accurately in a gross margin calculation at this point.

Various health issues were overcome throughout the project by making nutritional and management changes within the containment pens. However more investment is required to further research some of the issues associated with prolapse in containment, hypocalcaemia risk and appropriate supplementation and other health issues.

There was a lot of variance with when producers let ewes out of containment, as this often varied also due to the distance that was required to move them to lambing paddocks. Extra investment in trigger point of the best time to put ewes in and out of containment would be useful also.

Sharing of resources between consultants involved in the containment feeding space, upskilling of extra consultants and simple ration formulating tool (specifically for containment feeding) would all be useful to ensure producers can access the information they need to feed correctly and ensure a successful result while ewes are in containment.

6. References

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7. Appendix

7.1 Communication outputs

7.1.1 Tech article "Feeding minerals in containment"

TALKINGLIVESTOCK
NUTRITION • PRODUCTION • HEALTH

The value of supplementing minerals to pregnant ewes in containment

The increase in supplementary feeding ewes, over the last few dry seasons, has meant feeding in containment, has been an effective tool for managing pregnant ewes. It has the added benefits of maintaining ground cover and minimising energy wastage from sheep wandering around large, bare paddocks. However, to ensure a successful lambing result it is critical to meet the ewe's nutritional requirements with balanced nutrition during this time.

Ewes in late pregnancy through to lambing have high energy requirements and to meet these energy needs many producers feed cereal grain, cereal hays and straws. High grain and hay supplement levels can upset the mineral balance of pregnant ewes, especially close to lambing. These supplementary feeds contain high levels of potassium, which can interfere with the mobilisation of calcium and magnesium. Both calcium and magnesium are critical minerals for a ewe in the pre-lambing and lactation period. Cereal grains and often hay are also high in phosphorus and low in calcium. The calcium phosphorus ratio is often closer to 1:1 which isn't high enough to meet the ewe's calcium requirements during late pregnancy and into lactation.

During pregnancy and the first few weeks of life the lamb is entirely dependent on the ewe to provide calcium to build strong bones. Ewes can utilise calcium, stored in their bones, throughout pregnancy and lactation to provide a percentage of the required calcium levels to the lamb. The extra must be provided in feed types or mineral supplements. The bone development of the lamb determines its future bone calcium storage capacity. So, if for example, a ewe lamb gets inadequate levels of calcium from its mother during the early growth stages as an adult it will be more at risk of developing hypocalcaemia (a deficiency of calcium which can often cause death) when lambing and lactating themselves due to inadequate calcium stored in their bones.

The requirement for Calcium and Magnesium increases significantly in the 4 – 6 weeks prior to lambing and as detailed above ewes often can't consume enough from dry paddocks or supplementary feeds to meet their requirements during this critical time. Magnesium assists with smooth muscle function, transfer of nervous impulses and stress. As such providing Magnesium prior to lambing assists with the ease of lambing as well as preventing ewes going down with a magnesium deficiency. Trials have shown that "Ewes supplemented with calcium and magnesium regulated their energy more efficiently than ewes not supplemented, which has many implications for the prevention of pregnancy toxaemia and the improvement of ewes reproductive performance."

Other critical vitamins for lambing, like Vitamin A and E, come from green feed. When ewes have been grazing dry feeds, hays and grains for more than six weeks they may become deficient. These vitamins and other microminerals (which may become deficient when relying totally on supplementary feeding) play a crucial role in lamb development and aid in maximising colostrum production and immunity in newborn lambs.

An average cost of feeding a ewe, in containment, with a combination of cereal grain, hay and straw can range from $1.40 - $3.50 / week depending on their stage of pregnancy. A well-balanced pre-lambing mineral lick, containing all the essential macro minerals, micro minerals and vitamins for the later stages of pregnancy, can be added from 21 – 42 cents per ewe per week. A relatively low cost on top of the feeding costs to ensure the ewes is fed a balance diet throughout pregnancy and to ensure a successful lambing result.

7.1.2 Newspaper articles

On The Land

25/3/20 Leader

Group tours to learn more about ewe containment

Forty-five farmers from across the Barossa, Mid North and Adelaide Hills attended the Barossa Improved Grazing Group (BIGG) Containment Ewe Tour on March 4 at various locations around the Barossa Valley.

The event showcased how local producers in this area have set up containment ewe areas, as well as provided informative sessions on containment nutrition, condition scoring ewes and soil ground cover assessments.

Deb Scammell, Talking Livestock Consultant, who facilitated the event, said the day was a great way to highlight some of the advantages and benefits of containment ewe management on location.

"We visited four different landowners over the course of the day, where we were able to see first hand the benefits of containment ewe management," she said.

"The take home messages from the demonstration sites were that containing ewes reduces overgrazing, soil erosion and wind erosion, and allowed pregnant ewes to be fed a more efficient ration as they weren't wasting energy walking around a dry paddock."

Presenters and farmers spoke about different topics, including nutrition, effective management of ewes in containment and land management.

Brian Hughes from PIRSA also spoke of the importance of soil ground cover in the paddock to prevent erosion and reduced growth when there was a break.

William Hurn from Angaston, spoke of better lambing percentages and control over nutrition from managing ewes in containment.

"I have found lambing percentages have improved as a result of using containment and we now have better management of rations due to mob segregation," he said.

"Containment also provides an ideal quarantine opportunity where required."

Georgie Keynes and Toby Rosenzweig from Keyneton currently manage 2,500 ewes in confinement. For them, ground cover is key.

"We aim to maintain (at all times if possible) around 1t/ha of ground cover as reserve for turning out stock prior to lambing," Georgie said.

"Barley is the main grain fed so we make sure we include salt and lime in their ration."

Bruce and Paul Schutz from Point Pass currently run 1,860 merino ewes and 400 wethers.

"We use a feed mixer for mixing a high roughage and barley mixed ration and this is put out into our own design feed bins in containment," Paul said.

"We have the option to move stock to different regions for finishing, so this is an advantage in maintaining balance in our overall farming enterprise.

"We recommend using bio-start (ruminant) and nutri-mol to condition guts as an induction step to moving stock out of containment."

Kym Mosey from Bagot Well was the final producer the attendees visited on the day. He said feeding cereal hay in containment pens and then letting ewes out to consume grain in a separate pen has been the easiest way for him to feed large numbers of ewes.

"We have found proximity to feed source and yards was important when deciding where to put pens," he said.

"It was handy to have some other small paddocks with shelter to put sheep into if weather turns. We also have protected trees so that they continue to provide shade in pens."

Emma Peters and Nic Dawes.

BIGG are please with success of ewe project

The Barossa Improved Grazing Group report their MLA PDS containment ewe project is tracking well.

The majority of the sites have ewes in containment with a few later lamber's due to bring them in over the next few weeks.

The first of the major sites, Neil and Russell Loffler have successfully lambed down over half of their ewes after having them in containment since December.

The Lofflers had standing cereal crops saved from last year (that weren't harvested) which made very successful lambing paddocks for an early lambing.

SA Police given power to stop harvesting during dangerous weather

The Marshall Government has passed legislation to ensure lives, homes, properties, crops and livestock are further protected during dangerous bushfire conditions.

The Fire and Emergency Services Miscellaneous Amendments Bill gives South Australia Police the power to direct grain growers to cease harvesting on days when weather conditions may cause a grass or bushfire.

The amendments were passed following recommendations from a bipartisan select committee that looked at whether legislation around power to direct was needed and if so who should be responsible for enforcing it.

Minister for Police and Emergency Services, Mr Corey Wingard, said the historic legislation is years in the making.

"The issue was first raised back in 2013 when the Hon. Paul Holloway undertook a review of the Fire and Emergency Services Act 2005 and flagged the need for a power to direct," the Minister said.

"The Marshall Government has got on with the job and we're pleased to finally have delivered a really important piece of potentially life-saving legislation.

"Before this year's bushfire season SAPOL ...

On the land

Zander success a highlight for BIGG Pasture Walk

By Mel Jaunay

A 150 percent improvement in arable land at Ben Zander's Mengler's Hill property was the highlight of Barossa Improved Grazing Group's Spring Pasture Walk held on September 25.

About thirty people braved wintery conditions on the day to attend three key sites, Zanders' at Mengler's Hill, a ewe containment lot at Browns' property in Keyneton, and an annual forage variety demonstration site set up by Coopers Farm Supplies, Mount Pleasant.

Attendees heard how Zanders converted a relatively unproductive paddock at Mengler's Hill through use of a rock picker and effective pasture management, significantly increasing the productivity of the land.

"Previously the paddock was only about 40 percent arable, and over the last three year period Ben's taken out 1,000 tonnes of rock across a 22 hectare paddock," explained BIGG's Technical Facilitator, Brett Nietschke.

"It was a lot of hard work, a lot of commitment and basically now it's about 90 percent arable, so it's an incredible turnaround and a real commitment from him."

The second key site visited was Brown family enterprises at Keyneton, who are involved with BIGG's ewe containment project.

... containment lot, so we were able to observe some of the key things to consider, like the importance of having it near shelter, and the amount of area for each pen."

The walk began with the annual forage variety demonstration site set up by Coopers Farm Supplies at Mount Pleasant, which provided the group with valuable information and examples of various mixes of species.

"We were able to see both some high production mixes and also good quality mixes at Coopers' demonstration site at Mount Pleasant," said Brett.

"The mix is important because it gives hopefully good production with a variety of species over the course of the season."

Bruce Hancock acknowledged at BIGG AGM

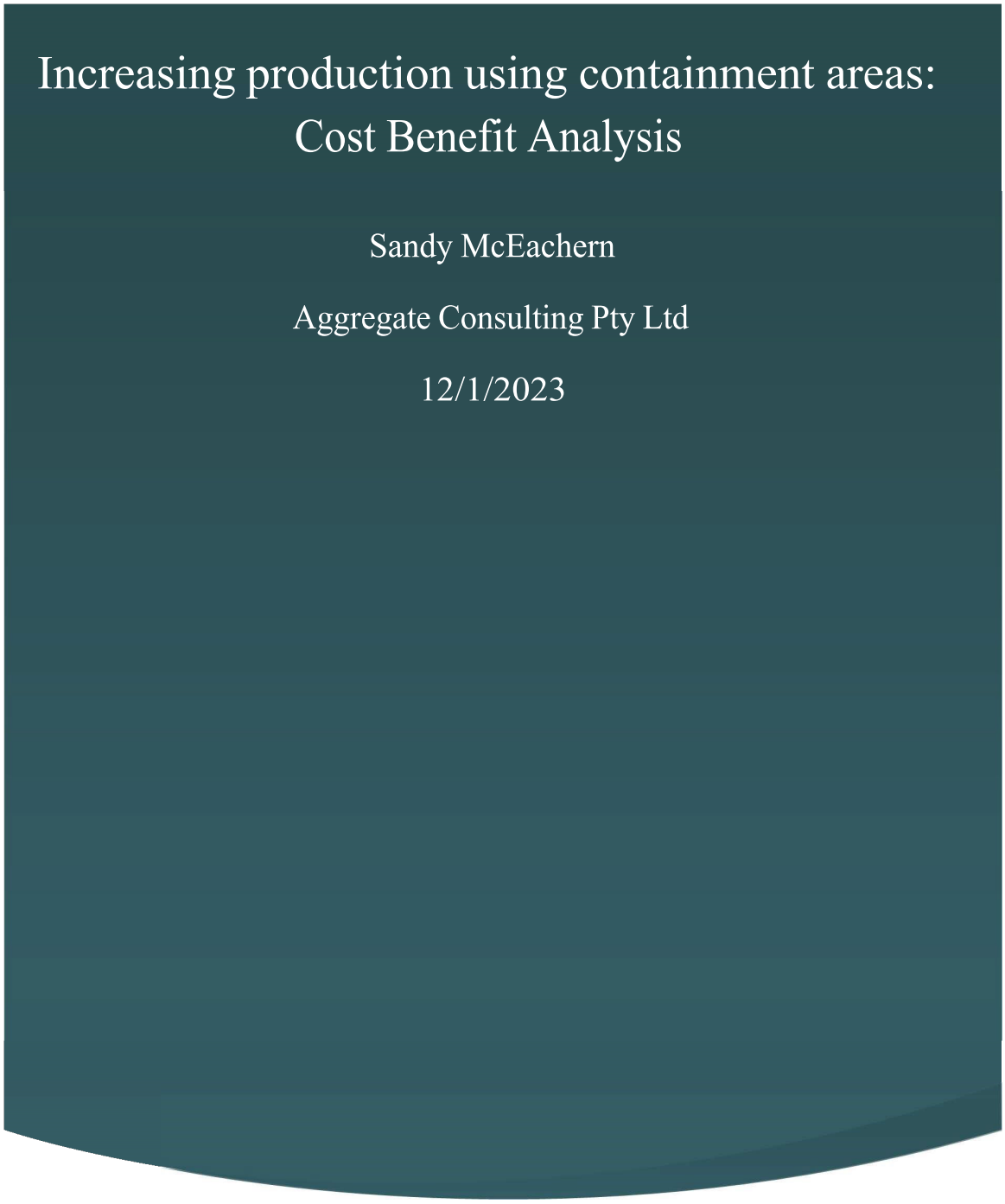
BIGG's Spring Pasture Walk was followed by its second AGM, held at Wanera Wine Bar, Angaston, where the group celebrated its first year as an incorporated body.

The evening was attended by more than 20 producers, with a notable highlight being the presentation of a BIGG Lifetime Membership Award to Bruce Hancock.

"Bruce has been instrumental in the development of BIGG when the group first started back in 2012," said Brett Nietschke.

Felicity Wills from Coopers' Animal Health, Deb Scammell from BIGG and Tim Brown of Keyneton at the Spring Pasture Walk.

7.1.3 Full economic Analysis



Data from the three major sites has been used to demonstrate a methodology for analysing the financial benefits that might be gained by using containment feeding over summer and autumn for a June lambing merino ewe flock.

Consistent with PDS aims, the sites were not set up as experiments but rather to demonstrate the practices and the outcomes from containment feeding and allow discussion of the benefits that should arise.

As is reported in the results producers maintained higher ground cover and reported higher individual animal production that had been achieved in previous years. The difficulty for economic analysis is how to attribute the changed outcomes to the confinement feeding practices that were employed.

To help attribute likely benefits to their source, expected differences in animal production from the containment feeding were taken from the 5-year experiment at the Kybybolite Research Station in the early 1970's (Brown 1977).

The Kybybolite deferred grazing experiment was run on annual pastures, using ewes at 13 different stocking rates (from 4.9 ewes per hectare to 19.8 ewes per hectare).

The key findings of the Kybybolite experiment were

1) Whilst deferred grazing created ~500kg of extra dry matter availability over the winter period it did not lead to increased annual pasture production.
2) The extra dry matter available from deferred grazing "had little or no effect on wool production in ewes and lambs, on the number of lambs born and weaned, or on lamb growth rates." (Brown 1977). This occurred at levels of dry matter available like the PDS sites.
3) "Although the quantities of dry pasture residue ranged from 100 to 4000 kgDM/ha at the break of the season, there was no significant relationship in any year between the quantities of dry pasture residue present and the pasture growth rate."

The Kybybolite experiment results were that deferred grazing and the subsequent increase in dry matter available over the winter did not enable higher stocking rates through addition pasture production over the whole year and did not lead to any additional production from ewes at any given stocking rate.

There are some confounding factors when comparing the results of the Kybybolite research station to the animal and pasture conditions at the PDS sites.

Most obviously is that the locations are different and therefore you might expect slightly different weather outcomes and risks.

The percentage of ewes bearing twins was higher at two of the main PDS sites with the Kybybolite experiment ewes averaging ~98% lambs weaned to ewes joined whereas two of the three sites analysed averaging ~125%. This means that there would have been substantially more twin lambs born at these sites.

The Kybybolite experiment locked sheep up from the opening rains for six weeks.

This translated into locking pastures up from mid-April to early June in most years.

In the Kybybolite experiment (whether contained or continuously grazed on pasture) sheep were fed for 'survival only' which meant ewes were getting down to 45kg liveweight before feeding commenced with supplements increased if they fell below these levels. The rules however meant that except for the driest year (1972) and the heaviest stocking rates (>17 ewes per hectare) the continuously grazed sheep did not receive any supplementary feed.

By contrast, the three main PDS sites had sheep enter containment as early as November (but more typically entry in January or February) and no later than March in any of the

three years. Also, sheep were fed to maintain much higher condition scores (>CS 3) than those in the Kybybolite experiment.

Whilst the PDS site ewes had more twin bearing ewes they also maintained ewes in higher condition score which would have increased survival of the twin born lambs independent of feed on offer through lambing.

The PDS did not measure differences in FOO between containment feeding and a comparable continuously grazed pasture. Estimates of the differences in FOO for the three main sites were made by using satellite imagery comparisons of the host farms and surrounding farms.

Differences in lambs weaned

Analysis of the PDS data from the three main sites showed that two sites had estimated FOO differences between continuously grazed (neighbouring farms) and the deferred grazing treatments areas over June and July (Table 1) consistent with those found in the 5-year comparison of a deferred grazing system and a continuously grazed system on annual pastures.

Table 1: Increased FOO over winter from deferred grazing and FOO levels of continuously grazed pastures.

	Site 1	Site 2	Site 3
Av. Difference in FOO (KgDM/HA) through June-July	435kg	263kg	-152kg
FOO Level of continuously grazed pastures (Jun-Jul)	1245kg	1327kg	1124kg
FOO Level of continuously grazed pastures (Jan-Apr)	1553kg	1941kg	2285kg

The third site had less dry matter available through June and July in the deferred grazing areas than the continuously grazed site. This result was confounded by very different stocking rates on the two different properties.

Lamb survival in merino ewes, and in particular twin lamb survival, has been shown to be influenced by ewe condition score at lambing and the FOO at lambing. The sites averaged ~1250 kgDM/Ha through the lambing months (range 1125 kgDM/Ha to 1325 kgDM/Ha) which was 182 kgDM/Ha higher (range from -152 KgDM/Ha to 435 kgDM/Ha) than surrounding farms (Table 1). These results are slightly lower than what was achieved in the Kybybolite experiment which may reflect ewes not being locked up for as long post the autumn break.

The impact of ~400kg additional dry matter available on lamb survival is also dependent on the average chill index at lambing. Using LTEM tables on predicted survival rates of twin born lambs with a chill index ranging from 900 to 1100 the impact of the additional feed on offer on twin lamb survival would be between 2% to
5% for 3.3 condition score merino ewes. For singles born lambs it is predicted to be

0.5% to 3%.

Modelled chill index using Grassgro at Temora in NSW (similar latitude, rainfall, maximum and minimum temperatures for the month of June as Keyneton) with 39 years of weather records for the period from May through to October showed the median weekly chill index "rarely exceeding 1000 kJ/m2.h" (Broster et al 2012). The tablelands environments (higher altitude) commonly exceeded 1000 kJ/m2.h from June onwards. In most of the more susceptible Tablelands environments the chill index could be substantially reduced by providing shelter to lower wind speeds.

Consideration of what benefits are likely therefore need to consider the amount of shelter in the lambing paddocks and the aspect of the paddock which can substantially reduce chill index by lowering wind speeds.

Average chill index data for the lambing period at each site, each year, is not recorded. The average of the 2014, 2015, 2016, and 2021 years, calculated for the Barossa Improved Grazing Group at Keyneyton was 1090 KJ/m2.h.

This average is from a small number of years and does not take into account potential reductions in the chill index from available shelter on sites (i.e. twin lambing ewes put into the more sheltered paddocks).

In the calculations done on cost benefits of the containment ~1000 KJ/m2.h has been used for the lambing period in which case the increased twin lamb survival would be predicted to be ~3.5% for 400kg to 500kg additional dry matter available through lambing, and ~1.5% in single born lambs.

Care should be taken with the expectation that these outcomes will be achieved in practice given that experimental data at Kybybolite and other similar experiments have not record differences.

Using predicted impacts on lamb survival, the total predicted increase in lambs weaned where the outcome is 125% lambs weaned is 3% extra lambs weaned. If the outcome is 100% lambs weaned the total predicted increase in lambs weaned is 1.6% because there are far fewer twins.

The three sites analysed recorded 5% - 20% more lambs weaned in the mobs that were containment fed than they had achieved in previous two years before the PDS started. Most of the difference in weaning percentage are likely to have come from differences in condition scores of ewes at lambing rather than containment feeding and higher FOO on offer through lambing. This implies better management of the ewes.

Difference in cost of feeding

The differences in the management decision as to when ewes should go into containment meant that over the three years across the three analysed sites the average FOO on pastures that were destocked were between 2000kg FOO and 2600kg FOO. Across the 3 continuously grazed sites the FOO over the same period averaged between 1500kg DM to 2200kgDM (Table 1). The FOO availability in the continuously grazed sites will affect the cost to maintain ewes at a higher condition score.

Differences in annual carrying capacity of pastures

Given the findings of the Kybybolite experiment that total annual pasture production was not increased by containment feeding from the autumn break it is not possible to attribute the higher stocking rate on any property to the management practice of containment feeding and its impacts on pasture growth.

That does not rule out that containment feeding may give management more comfort that they can control nutrition at a higher stocking rate, thereby enabling the decision to run a higher stocking rate.

Differences in mortality rates in ewes

The Kybybolite experiment recorded low average annual death rates in ewes (<2.2%) but higher +~1% in the deferred grazing system than in the continuously grazed system. The additional deaths were largely incurred through the lambing period rather than the feeding period.

Amongst the PDS sites only one site in two years compared death rates of containment fed ewes to continuously grazed ewes. In this site there were 1% additional deaths in one of the years and 6% additional deaths in the other year.

The year where the difference was considerably higher was a year where all sites had high (>6% deaths in containment and over lambing)

It should not be assumed that higher death rates are inevitable, but it should be considered a risk.

Costs and benefits

The method of calculating the costs and benefits of containment feeding is via the following steps.

Step 1: Calculate the additional rations costs of using containment whilst above minimum target FOO levels remain on pasture.

Step 2: Account for any differences in operational costs associated with containment feeding versus feeding on pasture.

Step 3: Attribute benefits from more FOO over lambing

Step 1 – Additional Ration Costs

Down to a low level (500 to 1000kg of available dry matter depending on quality of the dry feed) there is opportunity cost in not using available pasture dry matter as part of the ration.

Feed quality measurements of the paddock available FOO were not taken during this

PDS. A guide as to the potential ration cost saving has been created using a simple GrazFeed comparison of required barley to maintain a 60kg ewe 45 days pregnant with

	45% Dig. Herbage pasture	Intake	Grain	% Of Full Ration Saved	40% Dig. Herbage Herbage pasture	Intake	Grain	% Of Full Ration Saved by Herbage
twins on varying levels and digestibility of dry feed. The two levels of digestibility were 45% digestible (6.7 MJME/Kg DM) or 40% digestible (5.8 MJME/Kg DM).								

Table 2: Estimate of additional ration requirement at different levels of pasture digestibility and availability.

Pasture Availability KgDM/Ha								18%
	2000	0.74	0.34	39%	2000	0.54	0.46	
	1500	0.65	0.39	30%	1500	0.46	0.5	11%
	1000	0.52	0.47	16%	1000	0.37	0.55	2%
	500	0.31	0.56	0%	500	0.22	0.61	-9%

There was significant variation between sites and between years but the average dry matter available across three sites and three years was just shy of 2000kg of DM.

On all three of the sites dry mater levels fell from Jan through to April in the first year indicating senesced pastures. In the second year FOO levels did not start falling until March and in the third year it was not until April. This indicates that there was some pasture growth in the 2nd and third years through summer which would have meant that the pasture quality was better until later in those year on those sites.

It is not possible to know exactly what the difference in feed cost was from the results of these demonstrations. Given the amount of feed on offer in both the destocked pastures and the pastures that were not destocked a conservative estimate of ~18% is used to allow a demonstration of the methodology.

In practice it would be worth feed testing to understand exactly what the containment feeding is adding to costs of feeding when residual dry matter levels are above 1250 kgDM/Ha.

The actual ration costs per head per year varied between $14 per head and $57 per head (Table 3) and therefore the gross additional cost of feeding in containment over in the paddock varied between $2.45 per head and $10.19 per head if the containment cost 18% more in ration costs.

Table 3: Ration costs per ewe fed and marginal ration cost from being containment fed over fed on pasture ($/Ewe Fed).

	Total Ration Cost			Marginal Ration Cost @ 18%		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
2020	$37	$24	$23	$6.75	$4.40	$4.12
2021	$57	$24	$22	$10.19	$4.33	$3.87
2022	$27	$14	$21	$4.86	$2.45	$3.76

Step 2: Account for differences in operational costs

There are however also some savings from containment feeding in the feeding operation. Estimated time saved varied from 2hrs per week to 12 hours per week which is in part dependent on the number of sheep and the size of farm. At a cost of $45 per hour this translated to a difference in labour of between $0.85 per ewe to $4.05 per ewe which was dependent on the number of days fed as well.

The marginal vehicle costs saved from containment feeding versus feeding in the paddock varied between $60 per week in fuel to $100 per week in fuel and wear and tear on vehicles. This translated to between $0.25 per head to $0.80 per head saved on vehicles costs. Fuel estimates were given by each site owner and where kilometres differences were given a $1.20 per kilometre rate was applied to each kilometre.

Table 4: Estimates of labour and vehicle cost savings from containment feeding

($/Ewe Fed)

	Labour Saved from Containment Feeding			Vehicle Costs Saved from Containment Feeding		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
2020	-$4.05	-$1.17	-$3.21	-$0.49	-$0.81	-$0.81
2021	-$3.45	-$0.85	-$2.00	-$0.42	-$0.59	-$0.51
2022	-$2.05	-$0.89	-$2.40	-$0.25	-$0.62	-$0.61

The estimated marginal cost of feeding from containment (extra ration cost less savings in labour and vehicle costs) averaged over the three years for each site came to $0.74 per head per year to $3.70 per head per year.

Table 5: Marginal cost of containment feeding ($/Ewe Fed)

	Marginal Cost of Feeding		
	Site 1	Site 2	Site 3
2020	$2.21	$2.41	$0.10
2021	$6.32	$2.89	$1.36
2022	$2.57	$0.94	$0.75
Average	$3.70	$2.08	$0.74

Step 3: Work out the net benefit in production from additional FOO at lambing

Unless all additional lambs weaned are sold at weaning, increasing reproduction rates in a wool flock changes flock structure. Where a farm is already optimally stocked, increased lambing percentages will decrease ewes joined as more replacement ewe weaners (and possibly wether weaners) are retained through to 1 year of age.

The extra lambs also incur extra costs associated with marking, animal health, shearing and crutching and selling costs. The gross benefits of additional lambs as a % of ewes joined do not correlate directly to a value on those lambs.

In a flock model where the farm is optimally stocked and it costs $14.60 to run a lamb from marking through to one year of age inclusive of (marking, shearing, crutching, and animal health treatments) then if wether lambs are sold for $100 off shears at 6 months of age, but ewe weaners are run through to 1.5 years of age before the cull portion is sold for $160, the increase in gross margin per ewe joined is only ~$5.65 for every 5% increase in lambs weaned. This allows for flock structure changes, and additional costs incurred on lambs and finally selling costs.

On a gross income basis where flock structure is not changed and 50% of extra lambs are wethers with 50% ewes (av. sale price of $130) the increase in income per ewe joined would be $6.50 for every 5%.

A 1% increase in survival would therefore be worth $1.13 per ewe joined. If 3% extra lamb survival is obtained, then it would have offset the marginal cost of feeding at each of the sites.

Consider risks

Attention should be paid to the risks around mortality. If as per the Kybybolite experiments deaths of contained ewes. Where the sale price of CFA ewes is $120 then every 1% increase in mortality is a cost of ~$1.70 per ewe joined. Where the sale price of CFA ewes is $180 it is ~$2 per ewe joined. If mortality rates in ewes are not controlled consistently then they could easily swamp potential benefits from lamb survival.

More accurate management of sheep

Increased production from containment feeding may not come from containment feeding, but rather from improved management of the sheep (more accurate management allowing ewes to be in better condition through hitting target levels of nutrition). For instance, had the sheep not been contained and monitored as closely the target condition score may have been missed.

High condition score ewes at lambing will have better lamb survival, and those lambs will have a higher lifetime fleece value.

In this analysis the assumption is that the benefits of additional fleece weight in the ewe fed to a higher condition score will either be largely, or wholly, offset by the increased fibre diameter of the fleece. The impact on the fleece value of the ewe is subsequently ignored.

More significant benefits of maintaining higher condition score of ewes through mid to late pregnancy will come through better lamb survival and then the lifetime fleece value of merino progeny.

If we assume 5% more lambs weaned because of being +0.5 condition score, then

@ $100 per wether lamb weaned lamb and $160 per extra ewe lamb weaned that is $5.60 of additional gross margin per ewe joined from the additional lambs weaned as per the analysis in the previous section.

The progeny would also have 100g heavier fleece weights that are 0.2 micron finer at each shearing. The value of this will be very varied according to fibre diameter of the sheep and the markets at the time. For this analysis, we have used a base fleece weight of 3.5kg clean and $20 per kilogram clean as the price. We have then assumed a $1.50 per micron premium as the fleece get finer.

The value attributed to the ewe that is fed depends on how many times the progeny is shorn. For the purposes of this calculation, we have used 3 full fleeces per lamb (1 for wether progeny and 5 for the ewe progeny). Calculating that out equates to a nominal ~$10 for lifetime fleece value of progeny.

The additional 0.5 of a CS has therefore yields ~$15.60 of increased income from progeny.

At a ration cost of $400 per tonne and 3.5kg of ration per 1kg of liveweight maintained the additional feed cost is ~$5 per ewe. The net benefit is then ~$10.60 per ewe after the feed cost to maintain the extra condition on the ewes.

Containment feeding, allowing more control over the feeding process and more frequent monitoring of the sheep may be a more reliable way to ensure that the CS objectives are met. If that is the case, then for it to be profitable, the marginal costs of feeding in containment need to be less than the net benefit from being in better condition at lambing. It also requires that the same average result cannot be achieved out of containment.

Based on the 3 main PDS sites, and an assumed 40% digestibility of pasture from Jan to April, the marginal cost of containment was $0.74 to $3.70. Under the assumption that the containment fed ewes were 0.5 of a CS better off than had they not been fed, and that containment feeding was going to be a more reliable way to achieve that outcome, the net benefit of the additional CS maintained in ewes from the progeny would therefore be between ~$8 per ewe and ~$5.30 (deduct the additional cost of containment feeding from the net benefit of ewes being 0.5 of a CS better at lambing).

The economic analysis has not attempted to quantify any additional benefits to pasture persistence or soil preservation that may also accrue from containment. If these are going to occur it will be a very low dry matter levels and will be particular to soil types, soil fertility and pasture species.

References

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