2016 Graham Centre Sheep Forum
Contents

Program ...................................................................................................................................................................... 3
Our supporters ........................................................................................................................................................ 4
Welcome .................................................................................................................................................................... 5
Speaker biographies ............................................................................................................................................. 6

Research priorities and the Sheepmeat Industry Strategic Plan................................................................. 8
Mark Harvey-Sutton
Sheepmeat Council of Australia

Best practice worm control for prime lamb production in southern NSW ........................................ 10
Rob Woodgate
Charles Sturt University

Using second-generation annual, hard-seeded pasture legumes to ‘meat’ lamb production targets in the southern Australian mixed farming zone .............................................. 19
Lucinda Watt
Charles Sturt University

The cost of hitting lifetime ewe targets in scanned and un-scanned merino flocks
– a simulation using a dynamic model, AusFarm ................................................................................. 22
Shawn McGrath
Fred Morley Centre, Charles Sturt University

Management to improve lamb survival ........................................................................................................ 27
Susan Robertson
Charles Sturt University

Producer case study: Increasing lamb survival on-farm ........................................................................... 30
Tim Westblade
Lockhart

The Trouble with Sub project update .............................................................................................................. 32
Janelle Jenkins
Riverina Local Land Services
Graham Centre Sheep Forum
8 July 2016 - CSU Convention Centre, Wagga Wagga

8.30-8.55am  Registration and coffee
8.55-9.00am  Welcome and outline of the day  
Ms Toni Nugent  
(Industry Partnerships and Communications Manager, Graham Centre)
9.00-9.40am  Research priorities and the Sheepmeat Industry Strategic Plan  
Mark Harvey-Sutton  
(Sheepmeat Council of Australia)
9.40-10.00am  Best practice worm control for prime lamb production in souther NSW  
Rob Woodgate  
(Charles Sturt University)
10.00-10.20am  Using second-generation annual, hard-seeded pasture legumes to ‘meat’ lamb production targets in the southern Australian mixed farming zone  
Lucinda Watt  
(Charles Sturt University)
10.20-10.40am  Panel session (all session speakers)
10.40-11.15am  MORNING TEA
11.15-11.35am  The cost of hitting lifetime ewe targets in scanned and un-scanned merino flocks - a simulation using a dynamic model, AusFarm  
Shawn McGrath  
(Fred Morley Centre, Charles Sturt University)
11.35-11.55am  Management to improve lamb survival  
Susan Robertson  
(Charles Sturt University)
11.55-12.15pm  Producer case study: Increasing lamb survival on-farm  
Tim Westblade  
(Lockhart)
12.15-12.35pm  The Trouble with Sub project update  
Janelle Jenkins  
(Riverina Local Land Services)
12.35-12.55pm  Panel session (all session speakers)
12.55-1.10pm  Forum summary, wrap-up and evaluation  
Ms Toni Nugent  
(Industry Partnerships and Communications Manager, Graham Centre) and  
Professor Michael Friend  
(Director, Graham Centre)
1.10pm  LUNCH
In many respects, there has never been a better time to be in the sheep business. Strong meat and wool prices and continued high demand, improvements in our understanding of how management can improve profitability, combined with genetic gains and recent favourable seasons, has resulted in widespread optimism across the industry. However, significant challenges exist, which if not addressed, will threaten the future viability of the industry.

More than ever, the industry needs a strategy to address these threats and exploit opportunities. To set the scene for the day, Mark Harvey-Sutton from the Sheepmeat Council will outline the recently released Sheepmeat Industry Strategic Plan, and what this means for future R&D and marketing initiatives for the industry.

Our speakers will then drill down to some recent research that has implications for how we manage our sheep for improved productivity and profit. Worms can be a significant cost in our sheep enterprises, both in direct control costs and indirect costs in lost productivity. Rob Woodgate will discuss worm control, and how we should manage sheep in our region to reduce the onset of resistance, and at the same time, the impact of worms on our sheep. Similarly, reproductive wastage in our sheep enterprises can be a major lost opportunity and limit to profitability. Susan Robertson will summarise what we know regarding management to improve lamb survival, and offer some practical advice to improve it. This will be complemented by Shawn McGrath, who will discuss some of his recent whole farm modelling work that investigates the long-term impacts on productivity and gross margins of the sheep enterprise and managing the flock based on scanning results and feeding to meet condition score targets. Tim Westblade will round off the topic with a case study on how he approaches improving lamb survival on farm. Our final topic area relates to annual legumes in our pastures. Janelle Jenkins will discuss issues relating to maintaining sub clover in our pastures, while PhD student Lucy Watt will present her recent results on lamb growth rates from hard seeded legumes that offer an alternative to sub clover in our systems.

We look forward to some robust discussion about the opportunities, challenges and research needs facing our sheep industry.

Regards

Professor Michael Friend,
Director, Graham Centre for Agricultural Innovation
Mr Mark Harvey-Sutton
Mark is the Sheepmeat Council of Australia’s Chief Executive Officer. Prior to taking up this role, Mark was Policy Director of the Cattle Council of Australia. Mark has also worked for the Australian Government on a number of issues across rural and regional portfolios, including working closely with industry in developing policy for Australia’s red meat industries. Mark also most recently completed a 10-month stint at Parliament House working in a ministerial office as a Departmental Liaison Officer. Mark is admitted as a lawyer in the Supreme Court of the ACT and has spent time working in law firms specialising in rural law.

Ms Janelle Jenkins
Ms Janelle Jenkins works as a Senior Land Services Officer, Mixed Farming Systems, for the Riverina Local Land Services (Riverina LLS) based in Tumut. Her work involves providing advice to landholders on crop, pasture and livestock systems in the higher rainfall areas of the Murrumbidgee catchment.

Janelle previously worked with the Murrumbidgee Catchment Management Authority (CMA) for eight years prior to the formation of the Riverina LLS. Janelle worked on numerous environmental projects and native vegetation legislation. Many of these projects had a conservation farming focus, including the early development and implementation of the drought lot feeding facility and grazing management incentive projects. Prior to working with the Murrumbidgee CMA Janelle worked extensively in production agriculture and environmental positions within the Department of Primary Industries and other organisations.

Dr Shawn McGrath
Dr Shawn McGrath grew up on a beef / wool property near Tumbarumba. He completed a Bachelor of Science in Agriculture at the University of Sydney in 2001, before commencing work in corporate agriculture for Elders Ltd (2002-2009), predominantly in the beef supply chain with production and marketing of domestic beef and export Wagyu, and then in rural finance. In 2010 he returned to southern NSW and changed his career focus to research, with a wool industry-sponsored PhD into the utilisation of dual-purpose wheat followed by an MLA-sponsored project comparing Dorper and Merino production in mixed-farming systems at Wagga Wagga. In August 2015 he commenced in his current position as lecturer in Whole Farm Management in the Fred Morley Unit at Charles Sturt University (CSU), with a focus on applied research and undergraduate and postgraduate teaching in livestock production and consultancy.

Dr Susan Robertson
Dr Susan Robertson is a research fellow with the Graham Centre and a lecturer in Farming Systems with CSU. In her PhD, she evaluated nutritional management of ewes to improve staple strength of wool, before becoming a livestock officer in the Victorian Mallee, and joining CSU in 2006. Susan’s area of interest is sheep production. Previously she has been involved in projects investigating methods of increasing ovulation rate and lamb survival, and has most recently been using simulation models to compare sheep production systems.

Dr Rob Woodgate
Rob joined CSU and the Graham Centre as a Senior Lecturer in Veterinary Parasitology in January 2012. He is responsible for teaching animal, equine and veterinary science students and also supports the worm egg counting and other parasitology testing and research in CSU’s Veterinary Diagnostic Laboratory. He is a current member of the Paraboss national technical committee.

Prior to the move to Wagga Wagga, Rob spent 12 years with the WA Department of Agriculture and Food, responsible for state-wide research and extension about the control of sheep worms, blowflies and lice. He has also helped many of Australia’s animal health companies with product development and marketing research in western and eastern Australia and was the national coordinator of the Sheep CRC’s WormBoss website between 2008 and 2011.
Ms Lucinda Watt
Lucy has a background in farming, growing up on a prime lamb and cropping property in central western NSW. After completing a Bachelor of Animal Science (Honours) at CSU in Wagga Wagga and completing her Honours research year in 2014 at the WK Kellogg Biological Station Pasture Dairy Research Centre, Michigan State University in the US, Lucy began her PhD in livestock (sheep) production and ruminant nutrition at CSU. She is scheduled to complete her PhD at the start of 2018.

Lucy hopes to build her career in agricultural research and development working for a research company that has strong ties with industry members and hopes to make a valuable contribution to the agricultural industry by working to improve its productivity and sustainability. She also hopes to one day venture into the university sector and become a lecturer to encourage others to pursue a career in agricultural research.

Mr Tim Westblade
Tim Westblade is a 44-year-old, fifth-generation farmer, born and raised in the Riverina. Tim is married with five children, four boys and one girl. Tim completed his primary schooling and then attended St Francis College, Leeton until Year 10, before attending Assumption College, Kilmore. Deciding that school was not his thing, he left and became a full-time shearer for 10 years, working hard to save and purchase his first farm.

Tim purchased his first property in 1996, 800ha of unimproved land that no one wanted to buy. Tim was working alongside his father Peter after purchasing his property and they made a great team, with Peter’s skills with the stud, Tim assisting and concentrating on running the cropping enterprise. Peter became ill in 2006 and Tim took over the whole enterprise in 2007. By 2010, the stud had become the largest supplier of pol merino rams in NSW. The farm has grown to comprise 3,600ha, growing 1,450ha of barley, 350ha of vetch as a break crop, and running 4,600 breeding ewes.
Mark Harvey-Sutton  
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**Take home messages:**
- Sheepmeat Industry Strategic Plan 2020 provides a clear statement of where the industry wants to be by 2030 and how it proposes to get there.
- The 2030 vision for the sheepmeat industry is for Australian lamb to be a highly valued meal across the globe and recognised for its exquisite flavour, tenderness and consistency.
- The research, development and extension priority areas advanced in SISP 2020 by the Sheep CRC and MLA are production efficiency, optimising product quality, and animal wellbeing.

### The Sheepmeat Council of Australia

The Sheepmeat Council of Australia (SCA) is the peak industry council that represents producers by promoting the interest of all lamb and sheepmeat producers in Australia. The SCA’s core business is industry advocacy, industry strategic planning, and the oversight of levy-funded bodies such Meat and Livestock Australia (MLA), Animal Health Australia (AHA) and the National Residue Survey (NRS).

As part of SCA’s role within the industry, SCA are the custodians of the Sheepmeat Industry Strategic Plan (SISP). The successful global recognition of Australia as a provider of premium sheepmeat products can largely be attributed to the strong collaboration between industry organisations. Organisations across the whole supply chain have worked collaboratively to deliver goals set out in strategic plans since the mid 1990s. To ensure the continued development and success of the sheepmeat industry, last year SCA released the industry’s forward looking strategic plan, SISP 2020.

### SISP 2020

SISP 2020 provides a clear statement of where the industry wants to be by 2030 and how it proposes to get there. It serves as a blueprint and call to action to all parts of the industry, especially those charged with allocating resources towards research, development, extension, marketing and other industry services.

SISP 2020, developed under the guidance of the SCA, is strongly aligned to the overarching framework provided for the red meat industry through the Meat Industry Strategic Plan 2015-20 (MISP 2020). SISP 2020's core foundation is constructed from the comprehensive stakeholder consultation process that was undertaken in 2015. This consultation process included an industry-wide survey of priorities conducted in May to June 2015, direct engagement throughout the nation at producer forums, and close communication with industry groups such as state farming organisations and breeder groups. The engagement process has consequently ensured that SISP 2020 takes into account the various plans and strategies that guide individual agencies, corporations and entities servicing the sheepmeat industry.

The 2030 vision for the sheepmeat industry is for Australian lamb to be a highly valued meal across the globe and recognised for its exquisite flavour, tenderness and consistency. While it commands high prices, consumers know exactly how the product will perform under given cooking methods. Australian lamb and sheepmeat products are trusted for their safety and their integrity, and are known to have come from farms that care for their sheep and for the environment in which they are raised.

The SISP 2020 describes the priority activities that need to be undertaken over the next five years to ensure the industry’s long-term vision is achieved. From the SISP the following six outcomes are the most critical to ensure the vision’s full realisation:

1. Systems in place that allow information flowing up and down the value chain to aid decision-making and improve quality at all stages
2. Reduced losses in the national flock including marking rates increased by five percentage points and ewe mortality rates decreased by one percentage point
3. The successful definition and marketing of a yearling product: 1.39 million head underpinned by Meat Standards Australia (MSA) without compromising the lamb category
4. Improved access of Australian sheepmeat to key global markets: new market opportunities valued at $61 million by 2020 and $334 million by 2030
5. The establishment of a collaborative sheep innovation centre to succeed the Sheep CRC in 2019
6. Continuous improvement in product quality: quality increased by two MSA consumer points by 2020 whilst maintaining or improving lean meat yield.
Major economic modelling undertaken on the MISP 2020 estimates that if all the activities pertinent to the sheepmeat sector highlighted in the SISP 2020 occurred, at an annual investment of $58 million, the plan would deliver increased net industry income of $728 million by 2020 and $3.49 billion by 2030 on the baseline projection. The overall benefit cost ratio is 2.8:1 at 2020 and 5.7:1 at 2030.

Figure 1. SISP 2020 Industry benefits

Research priorities and the SISP

Research, development and extension (RD&E) forms the bedrock from which the industry will build from to reach the strategic vision outlined in SISP 2020. The RD&E priority areas advanced in SISP 2020 by the Sheep CRC and MLA are production efficiency, optimising product quality, and animal wellbeing.

Production efficiency

One of the targets from SISP 2020 is a reduction in the cost of on-farm sheepmeat production ($/kg liveweight) by 1.5 per cent. SISP 2020 activity level key performance indicators for increasing production efficiency are:

- marking rates are increased by five percentage points and ewe mortality rates are decreased by one percentage point
- the rate of genetic gain across the national flock is 2 per cent per annum
- there is a 12.5 per cent increase in average liveweight gain per day across the national lamb flock.

Optimising product quality

Product quality is integral to the success of Australian sheepmeat into the future. The activity level key performance indicators outlined in SISP 2020 to insure and develop Australian sheepmeat quality are:

- development of tools to provide objective and accurate measurement of all key attributes and, where required, relevant changes are made to the meat and livestock specification language
- improvements in sheepmeat eating quality are made whilst maintaining or improving lean meat yield
- commercial supply chains implement payment options that reflect real value differences across key quality, yield and integrity attributes.

Animal wellbeing

An annual investment of $7.6 million in SISP 2020 animal wellbeing initiatives is forecast to deliver a net increase in industry income of $148 million by 2020, resulting in a benefit cost ratio of 4.3:1. Key SISP 2020 animal wellbeing activities include:

- undertake RD&E to reduce the risk of compromised wellbeing of sheep and develop enhanced husbandry and management procedures
- deliver improved diagnostic methods, enhanced understanding of and/or improved control methods for emergency animal diseases
- reduce the cost of endemic diseases, including internal and external parasites, by $3 million by 2020 and $69 million by 2030.

Looking forward

The Australian sheepmeat industry has a remarkable and proud history of past achievements. Looking forward, the future for our industry looks just as promising, if not more so. SISP 2020 provides a credible strategic plan for the industry to ensure continued sustainability and profitability.
Best practice worm control for prime lamb production in southern NSW

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Take home messages:
• Avoiding costs to production due to worms in first cross ewes is a balance between ewe body condition, available nutrition and worm challenge from pasture contamination
• First cross ewes in good body condition are likely to be reasonably resilient to the effects of worms
• Observations, especially from NIL treated groups, suggested that despite low egg counts, first cross ewes, particularly twin bearing ewes, will benefit from an effective pre-lambing worm treatment
• Monitoring of faecal worm egg counts can provide additional confidence in your worm control program. This is also a useful guide to the level of worm contamination of different paddocks
• Knowledge of current drench resistance status is critical for Riverina sheep producers.

Nematodes (or ‘worms’) remain the most significant endemic disease with regard to Australian sheep production. The most recent estimates suggest an annual cost to the sheep industry in excess of $400 million (Lane et al., 2015). However, despite sheep meat production becoming a significant contributor to sheep and mixed farming enterprises in many parts of Australia, there is relatively less information known about the impact of sheep worms on prime lamb production, compared with Merino wool enterprises.

Therefore, in 2012, Meat and Livestock Australia instigated the Lifting the Limits imposed by worms on sheep meat production project. This project was designed to develop and evaluate integrated worm control programs for sheep meat enterprises, by investigating the differences between ‘best practice’ (LTL) worm control and ‘typical’ (TYP) worm control in prime lamb flocks. The project involved a range of commercial sheepmeat farms in Victoria and the south-west, central tablelands and northern tablelands of New South Wales and continued for three years.

Two TYP flocks were also to be identified and monitored for the second and third years of the project, and then comparisons were to be made between LTL and TYP practice, under potentially different seasonal conditions. However, due to a variety of reasons, a total of eight flocks were involved in the southern NSW trials at various times during the project.

On each property, a total of 240 twin-bearing prime lamb ewes were identified at pregnancy scanning each year, individually numerically tagged and enrolled in the project. The mobs monitored in southern NSW were predominantly winter lambing first cross ewes. The aim for most producers was to sell the majority of lambs off their mothers at 14-16 weeks of age, with the remaining lambs sold by early to mid-summer.

Tagged trial ewes were randomly divided to run in one of two larger separate ewe mobs (120 trial ewes within each larger mob of ewes). Within each mob, half the trial ewes were treated regularly to keep them ‘worm free’ (SUP ewes) and the other half were only treated for worms according to either their LTL or TYP plan (NSUP ewes).

The SUP ewes had regular sequential treatments with long-acting anthelmintics and short-acting primer treatments, to act as a baseline for sheep production without worms in each mob, allowing comparisons between different flocks. This is not a strategy for routine worm control as it would prove extremely expensive and has the potential to increase the rate of development of drench resistance. Therefore it is important not to equate the use of SUP worm treatments in this trial to the use of a single capsule.

During the project, no advice was given by the researchers to farmers on the TYP allocated farms. These NSUP ewes were treated as normally occurs on each farm.

Given the variability in climate across the Riverina region, it was decided to assess ‘lower rainfall’ and ‘higher rainfall’ farms, with a LTL and a TYP farm for each rainfall zone. In the higher rainfall region in Year 2 NSUP ewes on the TYP farm were treated with the same long-acting capsules as the SUP ewes. In Year 3, the treatments on both the LTL and TYP farms were similar (a short-acting oral pre-lambing drench). For the ‘lower rainfall’ farms, no drenches were given on the TYP farms.

The overall MLA Lifting the Limits trial design did not involve any totally un-drenched groups of ewes (as a negative control). However, in Years 1 and 3 in the Riverina, in one mob in one flock, an additional NIL treatment group was monitored (this extra information is provided in this paper).

Ewes from SUP and NSUP groups were identified following udder painting of trial ewes on each farm. A sample of lambs from each ewe treatment group was weighed at lamb marking, and half the lambs were subjected to monthly drenching (suppressive worm treatment), while the remaining lambs were not drenched, with group allocation stratified for ewe treatment. Lambs born from the trial ewes were weighed...
at or shortly after lamb marking and again prior to the sale of
the first draft of lambs on all but one of the farms (no lamb
data was collected for SW9 in Year 3).

The critical questions associated with this research were:

1. What is ‘best practice’ (LTL) worm control in prime lamb
   flocks in the Riverina?
2. What productivity gains and profits can be attained by
   adopting best practice?

It was decided that ‘best practice’ (LTL) would initially involve:

- an effective short acting pre-lamb drench
- monitoring using worm egg counts to determine if any
  additional drenches were necessary
- faecal egg count reduction trial to establish drench efficacy
  at the start of the project.

It was also decided this would be regularly reviewed and
altered if necessary.

Results for southern NSW

While there were variations in seasons, the three years where
monitoring occurred were characterised by above average
autumns and winters, and adequate but short springs.
This potentially affected the trial in a number of ways. The ewes
were generally in good condition going into lambing, and
surprisingly in all years ewes were grazing pastures that had
more feed available than expected. Sheep were not grazing
the more typical short winter pastures, as occurred the year
after the trial finished, and it was only in summer / autumn in
Years 1 and 3 that sheep required feed supplementation.

From a worm challenge point of view, this meant that while
conditions were suitable for worm larval survival and
development, the combination of a high level of nutrition
and grazing of longer pastures meant the worm challenge,
particularly over lambing, appeared to be relatively minor
during the three-year trial period. In addition, feed was
so plentiful during autumn and winter in 2014 that many
producers who normally pregnancy scanned their ewes opted
not to scan. This resulted in one trial participant not being able
to re-enrol (due to not scanning), and the loss of the scanning
information in the year the producer was enrolled. It was also
difficult to identify replacement flocks due to fewer producers
utilising scanning in autumn 2014.

Sampling dates

Faecal worm egg counts, bodyweight and condition scores were
recorded for both SUP and NSUP ewes on up to six
occasions during the 12-month trial period for each mob on
each farm for each year:

- the first measurement was conducted after pregnancy
  scanning, with the aim of ewes being 50-80 days pregnant.
  This typically occurred in April or May
- visit 2 (pre-lamb) was conducted approximately 2-4 weeks
  before lambing, usually in late May or June. On some farms
  ewe enrolment in the trial also occurred at this time
- visit 3 (lamb mark) was conducted at 2-3 weeks after lamb
  marking in August / September
- visit 4 (weaning) occurred at or shortly after weaning,
typically in November / December
- visit 5 (pre-joining) occurred prior to re-joining of ewes in
  December / January
- visit 6 (post join) occurred post joining in March / April
- an additional visit on some farms occurred following the
  second scanning in April / May.

Worm egg counts

Worm egg counts (WEC) for most groups were low to
moderate when monitored during the course of this project
(Table 1 and Figure 1). Generally the SUP groups had low or
zero egg counts. On several occasions the counts in these
capsuled sheep were positive as the interval between capsules
slightly exceeded their payout period. Where low egg counts
were recorded in capsuled sheep, it was difficult to recover any
larvae on faecal culture, suggesting the small numbers of eggs
were not viable.

Worm egg counts in the NSUP groups (both LTL and TYP mobs)
were consistently higher over the lambing period (WEC2 to
WEC3) and generally fell after weaning (WEC3 to WEC4) and
during the summer before rising in the late summer / autumn
(WEC5 to WEC6).

Table 1. Average worm egg counts (eggs per gram) for different sampling times.

<table>
<thead>
<tr>
<th>Year</th>
<th>Farm type</th>
<th>NSUP/ SUP</th>
<th>WEC1</th>
<th>WEC2</th>
<th>WEC3</th>
<th>WEC4</th>
<th>WEC5</th>
<th>WEC6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LTL</td>
<td>NSUP</td>
<td>87</td>
<td>284</td>
<td>265</td>
<td>155</td>
<td>209</td>
<td>104</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUP</td>
<td>111</td>
<td>50</td>
<td>24</td>
<td>6</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>LTL</td>
<td>NSUP</td>
<td>920</td>
<td>251</td>
<td>151</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUP</td>
<td>727</td>
<td>119</td>
<td>32</td>
<td>143</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TYP</td>
<td>NSUP</td>
<td>217</td>
<td>208</td>
<td>186</td>
<td>139</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>SUP</td>
<td>233</td>
<td>117</td>
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<td>54</td>
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<td></td>
</tr>
<tr>
<td>3</td>
<td>LTL</td>
<td>NSUP</td>
<td>181</td>
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<td>337</td>
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<td></td>
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<td></td>
<td></td>
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<td>279</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td>71</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1. Average worm egg counts (eggs per gram) for different sampling times.
Given that summer across the Riverina is typically hot and reasonably dry, most worm problems are associated with ‘scour worms’ (*Teladorsagia* and *Trichostrongylus* species). Barber’s pole worm (*Haemonchus contortus*) is only seen very occasionally. However, the sometimes wet summers, early autumn breaks and milder winters during the LTL trial period resulted in the regular detection of *Haemonchus* in larval cultures, particularly in Year 2 (Table 2).

Table 2. Mobs with *Haemonchus* species.

<table>
<thead>
<tr>
<th>Mobs with larval culture</th>
<th>Mobs (and % mobs) with <em>Haemonchus</em> as dominant species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>9 (11%)</td>
</tr>
<tr>
<td>Year 2</td>
<td>16 (63%)</td>
</tr>
<tr>
<td>Year 3</td>
<td>17 (35%)</td>
</tr>
</tbody>
</table>

The presence of *Haemonchus* probably resulted in higher than typical WEC being recorded in NSUP sheep during this trial. However, given the regular presence of *Haemonchus*, it is surprising that WEC were generally below 600 epg per gram (epg) in untreated sheep, and often well below this.

The average WEC of the NIL treatment group in Year 1 remained relatively low (< 160 epg) until ewes were under nutritional stress and losing weight post-weaning. Counts rose to 300-350 epg during January to March. In contrast, in Year 3, the NIL treatment group WEC rose between lambing and lamb marking (100 epg to 375 epg) but fell again to 140 epg at weaning and 50 epg pre-joining, before rising again to 180 epg post-joining in March. Despite these variations, it is reasonable to note that at all times these untreated sheep had relatively low WEC, suggesting that with the possible exceptions of the period January to March in Year 1 and the lambing period in Year 3, worms were not a major issue for the sheep.

**Ewe bodyweights**

Ewe bodyweight data was collected for all mobs pre-lambing (BWT2), at lamb marking (BWT3) and weaning or shortly afterwards (BWT4). Pre-joining (BWT5) and post-joining weights (BWT6) were recorded for all mobs in Year 3 and for two of the four mobs in Year 1. Post-scanning weights (BWT1) were recorded for all mobs in Year 1 and on one farm (two mobs) in each of Years 2 and 3. Pre-joining weights (BWT5) were recorded on one farm (two mobs) in Year 2.

Overall, bodyweight differences between groups were relatively small and not consistent. As expected, despite the overall background of only a low to moderate worm challenge, based on the WEC data, the nutritional status and condition of the sheep, the SUP ewes generally gained or maintained higher bodyweights compared to the NSUP ewes of the same mobs. Thus, for the 20 mob comparisons between SUP and NSUP ewes, SUP ewes were relatively heavier by at least 0.5kg in 13 mobs, while in only three mobs NSUP ewes were heavier by at least 0.5kg (there was less than a 0.5kg difference in four mobs). For six of the 13 mobs the weight advantage occurred over the lambing period and was maintained for the remainder of the trial. For the remaining seven flocks the gains were relatively small during the lambing period but accumulated over the duration of the trial.

Weight differences between NSUP and SUP ewes for LTL and TYP farms are shown in Table 3. This table highlights a small but consistent disadvantage in weight gain for NSUP ewes. In Year 2 the difference was more marked on TYP farms. In Year 3, differences were less and more variable. Year 3 was associated with an exceptional autumn and winter period, with abundant feed in both autumn and winter.

Table 3. Weight differences between NSUP and SUP ewes.

<table>
<thead>
<tr>
<th>Weight changes over lambing (kg)</th>
<th>Weight changes from initial to last weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td></td>
</tr>
<tr>
<td>LTL</td>
<td>-4.2</td>
</tr>
<tr>
<td>SUP</td>
<td>-2.3</td>
</tr>
<tr>
<td>Difference</td>
<td>-1.9</td>
</tr>
<tr>
<td>NSUP</td>
<td>-9.0</td>
</tr>
<tr>
<td>SUP</td>
<td>-5.6</td>
</tr>
<tr>
<td>Difference</td>
<td>-3.4</td>
</tr>
<tr>
<td>Year 2</td>
<td></td>
</tr>
<tr>
<td>LTL</td>
<td>-9.3</td>
</tr>
<tr>
<td>SUP</td>
<td>-8.1</td>
</tr>
<tr>
<td>Difference</td>
<td>-1.2</td>
</tr>
<tr>
<td>NSUP</td>
<td>0.7</td>
</tr>
<tr>
<td>SUP</td>
<td>2.0</td>
</tr>
<tr>
<td>Difference</td>
<td>1.3</td>
</tr>
<tr>
<td>Year 3</td>
<td></td>
</tr>
<tr>
<td>LTL</td>
<td>-7.4</td>
</tr>
<tr>
<td>SUP</td>
<td>-6.4</td>
</tr>
<tr>
<td>Difference</td>
<td>-1.0</td>
</tr>
<tr>
<td>NSUP</td>
<td>-1.9</td>
</tr>
<tr>
<td>SUP</td>
<td>-1.1</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.8</td>
</tr>
<tr>
<td>Year 2</td>
<td></td>
</tr>
<tr>
<td>Low rainfall</td>
<td>1.2</td>
</tr>
</tbody>
</table>
| Weight differences between LTL and TYP farms are summarised in Table 4. This table shows the advantage (if positive) or disadvantage (if negative) for LTL farms compared to TYP farms. Thus in Year 2 in the low rainfall comparison, the weight differences between the SUP and NSUP ewes on the LTL farm was 1.2 kg less than the weight differences between the SUP and NSUP ewes on the TYP farm.

Table 4. Weight differences between LTL and TYP farms.

<table>
<thead>
<tr>
<th>Weight changes over lambing (kg)</th>
<th>Weight changes from initial to last weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 2</td>
<td></td>
</tr>
<tr>
<td>Low rainfall</td>
<td>1.2</td>
</tr>
</tbody>
</table>
| Weight differences between LTL and TYP farms are summarised in Table 4. This table shows the advantage (if positive) or disadvantage (if negative) for LTL farms compared to TYP farms. Thus in Year 2 in the low rainfall comparison, the weight differences between the SUP and NSUP ewes on the LTL farm was 1.2 kg less than the weight differences between the SUP and NSUP ewes on the TYP farm.

Table 4. Weight differences between LTL and TYP farms.

<table>
<thead>
<tr>
<th>Weight changes over lambing (kg)</th>
<th>Weight changes from initial to last weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 2</td>
<td></td>
</tr>
<tr>
<td>Low rainfall</td>
<td>1.2</td>
</tr>
<tr>
<td>High rainfall</td>
<td>1.5</td>
</tr>
<tr>
<td>Year 3</td>
<td></td>
</tr>
<tr>
<td>Low rainfall</td>
<td>2.8</td>
</tr>
<tr>
<td>High rainfall</td>
<td>-2.9</td>
</tr>
</tbody>
</table>

The fact that differences are relatively small and not always consistent is probably not surprising, given:

1. The worm challenge did not appear particularly high during the trial period
2. Ewes were generally in good body condition
3. All farmers conducted similar treatments in their NSUP groups, irrespective of whether it was an LTL or TYP farm (i.e. a pre-lambing worm treatment to the ewes).
The most consistent differences were in the low rainfall comparison, showing ewes were about 1-3 kg lighter at lamb marking on TYP farms compared to LTL farms. Interestingly in Year 1, despite low WEC, the NIL group lost considerable weight over the lambing period (BWT2 to BWT3), as shown in Figure 2. Similarly in Year 3, the NIL group lost 3.8kg over the lambing period, and at the end of the trial remained 3.8kg lighter. These observations, particularly with the NIL groups, suggest that despite low egg counts, first cross ewes, particularly twin bearing ewes, will benefit from pre-lambing drenching.

Figure 2. Weight changes in ewes, Year 1, in Mob 1 SW2.

Lamb bodyweights

At lamb marking, there was no clear advantage for lambs that were reared from SUP ewes compared to those that had been reared from NSUP or NIL ewes. For the 13 comparisons available (two farms [four mobs of ewes] were excluded as the NSUP ewe mobs received either the same brand of controlled release anthelmintic capsule as the SUP ewes [Year 2 SW5] or a long-acting moxidectin product [Year 2 SW4]):

- for six mobs, lambs from SUP ewes were 0.5kg or more heavier than lambs from NSUP ewes.
- for two mobs, lambs from NSUP ewes were 0.5kg or more heavier than lambs from SUP ewes.
- for the remaining five mobs, differences in lamb weights were less than 0.5kg.

In terms of weight gain in lambs from marking to first sale, gains tended to be faster in lambs from NSUP ewes, with seven mobs having superior weight gains (>0.5kg heavier) in lambs from NSUP ewes, while only one mob had superior weight gains in lambs from SUP ewes. There was little or no difference in weight gains in the remaining six mobs. Table 5 provides a summary of lamb weights by ewe treatment for all mobs.

Table 5. Summary of lamb weights by ewe treatment, for all mobs for all years.

<table>
<thead>
<tr>
<th>Farm type</th>
<th>Weight 1 (kg)*</th>
<th>Weight 2 (kg)*</th>
<th>Weight gain (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTL farms</td>
<td>Lambs from SUP ewes</td>
<td>21.0</td>
<td>36.8</td>
</tr>
<tr>
<td></td>
<td>Lambs from NSUP ewes</td>
<td>20.5</td>
<td>36.5</td>
</tr>
<tr>
<td>TYP farms</td>
<td>Lambs from SUP ewes</td>
<td>21.4</td>
<td>39.2</td>
</tr>
<tr>
<td></td>
<td>Lambs from NSUP ewes</td>
<td>20.7</td>
<td>39.5</td>
</tr>
</tbody>
</table>

*Weight 1 – lamb marking or two to four weeks post marking.
^Weight 2 – immediately prior to first lambs being sold, approximately eight weeks post weight 1.

For the two mobs where NIL treatment ewes were monitored, the comparisons between lambs from SUP ewes, lambs from NSUP ewes (that were drenched with an effective short acting drench pre-lambing) and lambs from ewes that received no drench are summarised in Table 6.

Table 6. Summary of lamb weights from ewe mobs that included NIL treatment mobs.

<table>
<thead>
<tr>
<th></th>
<th>Weight 1 (kg)</th>
<th>Weight 2 (kg)</th>
<th>Weight gain (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>Lambs from SUP ewes</td>
<td>13.9</td>
<td>31.8</td>
</tr>
<tr>
<td></td>
<td>Lambs from NSUP ewes</td>
<td>13.4</td>
<td>31.3</td>
</tr>
<tr>
<td></td>
<td>Lambs from NIL ewes</td>
<td>10.7</td>
<td>31.3</td>
</tr>
<tr>
<td>Year 3</td>
<td>Lambs from SUP ewes</td>
<td>15.6</td>
<td>37.1</td>
</tr>
<tr>
<td></td>
<td>Lambs from NSUP ewes</td>
<td>15.9</td>
<td>38.1</td>
</tr>
<tr>
<td></td>
<td>Lambs from NIL ewes</td>
<td>15.6</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Overall, while there were sometimes advantages at or shortly after lamb marking from ewe treatment, any differences were largely negated by the time lambs were ready for sale. Similarly, suppressive worm treatments of lambs from lamb marking until first sale (monthly drenching) had a small and variable effect on lamb weight gains. For 10 of the 17 mobs, there was little or no difference in lamb weight gain (<0.5kg). In six mobs there was a small advantage in weight gain for worm suppressed lambs (0.7-2.2kg) and in one mob, untreated lambs gained more weight. Overall the average weight gain was 16.6kg for both monthly drenched lambs and un-drenched lambs.

Drench resistance status

Drench efficacy was determined on six of the eight farms either prior to the farm being involved in the trial, or as a result of the trial (Table 7). Drench resistance status for worm species is given in Table 8 (there were insufficient worm larvae recovered for SW2 and SW8 to provide this data).
Table 7. Drench efficacy for trial farms.

<table>
<thead>
<tr>
<th>Farm</th>
<th>% IVM</th>
<th>IVM</th>
<th>Mox</th>
<th>BZ+LEV</th>
<th>BZ+LEV +OP</th>
<th>BZ+LEV +IVM</th>
<th>LEV</th>
<th>Other</th>
<th>Description other</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1</td>
<td>84%</td>
<td></td>
<td>98%</td>
<td></td>
<td>98%</td>
<td></td>
<td></td>
<td></td>
<td>Derq/ABA</td>
</tr>
<tr>
<td>SW2</td>
<td>32%</td>
<td>88%</td>
<td>98%</td>
<td>71%</td>
<td>100%</td>
<td>79%</td>
<td>48%</td>
<td>BZ</td>
<td></td>
</tr>
<tr>
<td>SW4*</td>
<td>62%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td>⅓ Closantel</td>
<td></td>
</tr>
<tr>
<td>SW7</td>
<td>83%</td>
<td>100%</td>
<td>93%</td>
<td>97%</td>
<td></td>
<td>100%</td>
<td></td>
<td>Derg/ABA</td>
<td></td>
</tr>
<tr>
<td>SW8</td>
<td>60%</td>
<td>84%</td>
<td>73%</td>
<td></td>
<td>100%</td>
<td>98%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SW9</td>
<td>49%</td>
<td>88%</td>
<td>92%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td>Derg/ABA</td>
<td></td>
</tr>
</tbody>
</table>

* Haemonchus spp only  **BZ+OP and LEV+OP  ** *Lev x2

Table 8. Drench efficacy for worm species for farms with larval culture results.

<table>
<thead>
<tr>
<th>Farm</th>
<th>Spp</th>
<th>IVM</th>
<th>Mox</th>
<th>BZ+LEV</th>
<th>BZ+LEV +OP</th>
<th>BZ+LEV +IVM</th>
<th>LEV</th>
<th>Other</th>
<th>Description other</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1</td>
<td>Trich.</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td>95%</td>
<td></td>
<td></td>
<td>100%</td>
<td>Derq/ABA</td>
</tr>
<tr>
<td></td>
<td>Tela</td>
<td>97%</td>
<td>97%</td>
<td></td>
<td>95%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Haem.c.</td>
<td>67%</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>SW4*</td>
<td>Trich.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tela</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Haem.c.</td>
<td>62%</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td>69%</td>
<td>⅓ Closantel</td>
</tr>
<tr>
<td>SW7</td>
<td>Trich.</td>
<td>59%</td>
<td>100%</td>
<td>94%</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
<td>Derq/ABA</td>
</tr>
<tr>
<td></td>
<td>Tela</td>
<td>86%</td>
<td>100%</td>
<td>96%</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Haem.c.</td>
<td>91%</td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>SW9</td>
<td>Trich.</td>
<td>100%</td>
<td>83%</td>
<td></td>
<td>0%</td>
<td></td>
<td></td>
<td>100%</td>
<td>Derq/ABA</td>
</tr>
<tr>
<td></td>
<td>Tela</td>
<td>60%</td>
<td>48%</td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Haem.c.</td>
<td>42%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

As can be seen from Tables 7 and 8, drench resistance is common on farms and the high prevalence of drench resistance has been well documented. It therefore reinforces the importance of individual farm tests to ascertain the range of effective drenches for that farm, to ensure that drenching when needed is effective.

It should be noted here that while there have been strong suggestions that summer drenching is likely to increase drench resistance due to the paucity of refugia at the time of drenching, this is unlikely to be the case with pre-lamb drenching.

Reproductive performance

There was insufficient data available to compare LTL and TYP farms on subsequent reproduction performance (number of foetuses per 100 ewes). However, it was noted that for the 12 mobs where comparisons could be made between sheep that had received no capsules or a single capsule prior to lambing, and those sheep that received multiple capsules for worm suppression during the year (SUP ewes), in six cases the difference was greater than 10 lambs per 100 ewes. In five of those cases, this was in favour of the NSUP ewes and in only one case was it in favour of the SUP ewes. In six of the 12 comparisons differences were less than 10 lambs per 100 ewes.
This is a somewhat surprising result, given that in 17 out of 24 comparisons SUP ewes were at least 0.5kg heavier than NSUP sheep and only in three cases did NSUP sheep have a weight advantage of over 0.5kg. Therefore, given the small but generally consistent weight gains associated with SUP treatment, and the strong association between bodyweight and subsequent fertility, it would have been expected that reproductive performance would have been at least the same or higher in SUP ewes.

While successive use of capsules is not recommended for worm control, and was only used in these trials to facilitate between farm comparisons, this preliminary data does suggest that further investigation on the reproductive effects of prolonged worm suppression using capsules is warranted if such strategies are considered in the future.

**Wool production**

Mobs were enrolled into the trial in April to June and the trials ended in the following April / May. All flocks enrolled shorn sheep in late spring meaning measurements at shearing only related to part of the trial period. Fleece measurements were collected from one mob in Year 1 and four mobs in Year 2. No comparisons could be made in terms of wool production between LTL and TYP flocks due to the lack of data. It was determined that it was not appropriate to assess wool production from the Riverina flocks due to the time of shearing in relation to the trial.

**Ewe ‘mortality’**

Ewe ‘mortality’ was calculated for each group based on the number of ewes absent at the final weighing (out of the 60 ewes enrolled in each group). It is possible that a small number of tags were lost, which would mean ewe ‘mortality’ was overestimated. It was also apparent on several farms that a number of trial ewes were either unexpectedly sold, or were inadvertently moved out of the trial mob. Therefore the final ewe numbers need to be treated with some caution.

For all mobs, the average number of ewes present at the trial completion was 46.4 and 47.0 for SUP and NSUP groups. For the 24 mobs analysed, nine mobs had more ewes present at the end in the SUP groups and 12 mobs had more ewes present in the NSUP groups. Three mobs had equal numbers of SUP and NSUP ewes present at the end of trial measurements.

Fifty-five ewes or more were present in only nine out of 42 groups of ewes, with eight of these nine managed by the same farmer. Thus, even allowing for one or two ewes losing their tags during the course of the trial, ewe ‘mortality’ appeared to be higher than five per cent in 80 per cent of trial mobs.

**Economic benefits**

The data collected from the Riverina flocks suggest there was little difference between the productivity of LTL and TYP flocks. Also, lamb selling weights and subsequent ewe reproduction did not appear to be greatly influenced by worm management, as evidenced by the within farm comparisons between SUP and NSUP groups.

However, it was noted that for TYP farms in Year 2, in the absence of knowledge of either their flock drench resistance status or the expected worm challenge, producers either opted to potentially over-treat their sheep (higher rainfall TYP farm) or ignore worms (lower rainfall TYP farm). Thus, for the high rainfall producer, the use of a combination capsule, combined with a combination oral drench pre-lambing almost certainly resulted in no additional benefits other than simply the combination oral drench. Equally, for the low rainfall producer, the decision not to treat ewes pre-lambing was made without reference to the season or expectations, and loss of ewe bodyweight during lambing was the result.

Favourable seasonal conditions meant these losses in ewe bodyweight did not translate to lower sale weights of lambs; lambs were lighter after lamb marking compared to worm suppressed ewes.

This suggests that producers in high rainfall areas may be over-treating sheep, and producers in lower rainfall areas may be under-treating sheep. Under-treatment may be more costly in poorer seasons than those encountered during this trial.

It should be noted that considerable effort was taken in Year 2 to match LTL farms with TYP farms. Unfortunately, both TYP farms withdrew from the trial, and the failure to collect reproductive data or re-enrol either farm in Year 3 meant that proper comparisons between LTL and TYP farms were limited. In addition, drench resistance testing could not be carried out on either farm. The TYP farms selected in Year 3 had previous drench resistance testing on their properties, and had experience with monitoring worms via worm egg counting, and so worm control on these farms was likely better than the average farm in the region. The failure to collect any lamb data on the TYP low rainfall farm in Year 3 also severely restricts our confidence in any economic analysis.

However, from our experiences in the trial, it would seem reasonable to estimate the cost: benefit from LTL worm management in the Riverina region as shown in Table 9.
Table 9. Cost:Benefit by rainfall region.

**Lower rainfall regions**

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Costs/ewe</th>
<th>Benefits/ewe</th>
<th>Cost: Benefit per 1,000 ewes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-lamb drench</td>
<td>$0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drench resistance testing (every 3-5 years)</td>
<td>$600/farm (ie $150/yr)</td>
<td></td>
<td>-$150</td>
</tr>
<tr>
<td>Monitoring</td>
<td>No need</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extra lamb weight</td>
<td>0.5kg @$5 for 140% lambing</td>
<td>$3.50</td>
<td>$3500</td>
</tr>
<tr>
<td>Extra lambs born</td>
<td>No evidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nett profit / loss</td>
<td></td>
<td></td>
<td>$2750</td>
</tr>
</tbody>
</table>

**Higher rainfall regions**

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Costs/ewe</th>
<th>Benefits/ewe</th>
<th>Cost: Benefit per 1000 ewes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-lamb drench</td>
<td>Use a short-acting effective drench</td>
<td>$0.60</td>
<td>$3.00</td>
</tr>
<tr>
<td>Drench resistance testing (every 3-5 years)</td>
<td>$600/farm (ie $150/yr)</td>
<td></td>
<td>-$150</td>
</tr>
<tr>
<td>Monitoring</td>
<td>6 mobs @$35/mob</td>
<td></td>
<td>-$210</td>
</tr>
<tr>
<td>Extra lamb weight</td>
<td>No extra gain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extra lambs born</td>
<td>No evidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nett profit / loss</td>
<td></td>
<td></td>
<td>$2030</td>
</tr>
</tbody>
</table>

Four key messages were identified and agreed on by the local project advisory group, which included producers, veterinarians, agricultural resellers and consultants:

1. Engagement by producers in worm management is essential across all parts of the region. In the absence of this engagement, producers in the lower rainfall area were likely to waste money on unnecessary measures, while producers in the higher rainfall areas may lose productivity.
2. Nutrition is the most important single factor in worm control. First cross ewes in good condition are reasonably resilient to worms. Worms will most likely impact flocks in years when ewes are in poor condition.
3. A single pre-lamb drench is a prudent strategy, especially in higher rainfall areas.
4. Monitoring drench resistance status is important.

In addition, the regular recovery of *Haemonchus* species from a number of farms during the three year trial raises the question as to whether the strains of *Haemonchus* species have adapted themselves to the temperate Riverina climate and given the pathogenicity of *Haemonchus* species this hypothesis warrants further investigation.

**Conclusions**

Two main constraints have limited the value of the trial results. Firstly, the high turnover of farms resulted in incomplete data sets and difficulty in interpreting the results. Secondly, and probably more importantly, the occurrence of three above-average autumn / winter periods are almost certainly not representative of the likely conditions under which prime lamb production will usually occur. The above average seasons almost certainly will have reduced the impacts of worms in the mobs monitored, thereby leading to an underestimate of the value of sound worm management.

Despite the limitations, some significant recommendations have come out of this work. It is clear that prime lamb flocks in good condition, and experiencing good nutrition, are reasonably resilient to worms. While ewe bodyweights may decline over lambing, and lamb weights may be lighter at lamb marking as a result, lamb finishing weights may not be affected in good seasons. Suppressive drenching of lambs has little effect on weight gains under such conditions.

While worm egg counts were generally low to moderate, the consistent presence of *Haemonchus* on several farms that are winter dominant rainfall farms may indicate adaption of *Haemonchus* to cooler climates and warrants further investigation.

In prime lamb flocks where lambs are sold either off their mothers or within the first five to six months of age, a single pre-lambing drench to the ewes is probably both prudent and sufficient. Provided the drench resistance status of the farm is known and ewes are in good condition, the use of a short acting pre-lambing drench is likely to provide the most economic means of worm control in both lower rainfall and high rainfall regions of southern NSW. In addition, monitoring worm egg counts may provide further confidence to producers in higher rainfall areas.

**Information transfer – communication, advisory group, extension**

A key aim of the Lifting the Limits Project was to produce useful key worm control messages for local prime lamb producers. The Riverina research suggests there should and would be different messages for the lower rainfall cropping region and the higher rainfall eastern / southern region.
It is suggested that producers in higher rainfall areas may be over-treating their ewes by using more expensive longer acting products that may be unnecessary for prime lamb ewes in good body condition. Conversely, producers in lower rainfall areas may be under-treating ewes by not giving a pre-lambing drench. While such an approach may be sufficient in good seasons, it is likely that production losses will occur in average or poorer seasons. Given these effects, it is estimated the adoption of LTL worm management could result in returns of $2.75 per ewe in lower rainfall areas and $2 per ewe in higher rainfall areas.

References
Using second-generation annual, hard-seeded pasture legumes to ‘meat’ lamb production targets in southern Australian mixed farming zone

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Take home messages:
- Lambs gained 249 g/head/d on bladder clover hay and 204 g/head/d on arrowleaf clover hay, which was greater than lambs fed subterranean clover hay. These results were consistent with the metabolisable energy, crude protein content and dry matter intake levels of the hays.
- Lambs grazing arrowleaf clover in the spring grazing period had greater growth rates compared to bladder clover, biserrula, lucerne or lucerne-phalaris pastures.
- Biserrula and bladder clover produced higher lamb growth rates compared to lucerne and lucerne-phalaris pastures in the spring period.

Background
Subterranean clover (Tesota subterraneum L.) and various annual medics (Medicago spp.) have been the foundation of pasture-based production systems in the mixed farming zone of southern Australia. However, in recent decades, their suitability for this role has decreased principally due to changes in climatic, biological and edaphic factors. The perennial legume, lucerne (M. sativa L.), has also been used increasingly in mixed farming systems, however, its adaptation is limited due to intolerance of the plant and associated rhizobium to acid soils that are prevalent through the mixed farming zone of NSW.

Arrowleaf clover, biserrula, bladder clover, French serradella and gland clover varieties were developed as a result of a number of legume breeding programs from the mid-1980s through to mid-2000s in response to issues encountered with traditional legumes. These species are generally more resilient in terms of persistence under adverse climatic conditions. Additionally, they possess one or more of the following key traits; deeper root systems resulting in greater drought resistance of both seedling and mature plants, capacity for significantly higher seasonal herbage production, improved pasture persistence from higher hardseed levels and hardseed breakdown patterns compatible with seasonal rainfall incidence, greater acid tolerance, tolerance to common pests and pasture diseases, and ease of harvesting with conventional cereal harvesters (Loi et al., 2005; Revell et al., 2012).

This has resulted in the increased adoption of these species predominantly in cropping-pasture rotation systems. While agronomic suitability of these new species to the mixed farming zone has been demonstrated (Hackney et al., 2015), little research has been undertaken on their role (as grazed or conserved fodder) in livestock production systems, either as monocultures or in pasture mixtures. Furthermore, no studies have quantified the effect of these annual legumes on the rumen environment and their contribution to microbial nutrients and fermentation by-products required for animal production, including muscle and wool growth.

The ability of these pasture legumes to extract moisture for longer periods (Loi et al., 2005) and consequently extend the growing period of the plant also makes for a more sustainable source of grazing for livestock. The wider growing window, earlier regeneration and later senescence of these legumes also enables them to provide substantial quantities of senesced herbage for utilisation over the summer period. These are important features when determining the contribution of such pasture legumes to the feedbase and the subsequent impact on meat, fibre and milk production.

Although there is information on the agronomic characteristics of these pasture legumes in a number of environments, little is known about animal production from them when grazed or fed as conserved forage. This paper will report results from two experiments.

Utilising second generation annual legumes as conserved forages
Utilisation of pasture growth in spring rarely exceeds 30 per cent in this region (Kaiser et al., 2006), and feed gaps are common in summer, autumn and often winter. Thus, conservation of excess spring growth of these second-generation legumes would provide an alternative to purchasing supplementary feed sources or untimely sale of livestock.

Photograph: Toni Nugent
An animal house experiment was undertaken in 2015 at the NSW DPI Animal Nutrition Unit to quantify liveweight gain (LWG) and dry matter intake (DMI) in lambs fed arrowleaf clover (cv. Cefalu), bladder clover (cv. Bartolo) and subterranean clover (cv. Mt Barker) hay. Twenty-four Merino wether lambs (aged nine to 10 months) were fed ad libitum in individual pens for 51 days, with eight lambs allocated to each hay diet. Liveweight change and BCS was measured weekly and feed intake was measured daily. Subterranean clover was used as a control diet.

The hays were sourced from various locations in the Riverina region. At time of cutting, the bladder clover was approximately 40cm tall and at 40 per cent flowering, and the arrowleaf clover was approximately 80cm tall and in late vegetative stages of plant growth. Both hays were dried for 10 days between cutting and baling. The stage of growth of the subterranean clover hay was not assessed at cutting. The average nutritive value of the hay diets throughout the experimental period, as determined by wet chemistry analyses, is presented in Table 1 along with the DMI and LWG of lambs. Liveweight gain of lambs consuming the three diets over the 51-day period is also shown in Figure 1.

Table 1. Average crude protein (CP), metabolisable energy (ME), in vivo organic matter digestibility (OMD) and lamb DMI and LWG of the arrowleaf clover (AC), bladder clover (BC) and subterranean clover (SC) hays in the animal house experiment in 2015.

<table>
<thead>
<tr>
<th></th>
<th>CP (%)</th>
<th>ME (MJ/kg DM)</th>
<th>In vivo OMD (%)</th>
<th>DMI (kg/d)</th>
<th>LWG (g/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>15.8</td>
<td>9.8</td>
<td>67.6</td>
<td>1.34</td>
<td>204a</td>
</tr>
<tr>
<td>BC</td>
<td>20.4</td>
<td>10.3</td>
<td>72.9</td>
<td>1.50</td>
<td>249a</td>
</tr>
<tr>
<td>SC</td>
<td>15.6</td>
<td>9.0</td>
<td>65.3</td>
<td>1.31</td>
<td>182a</td>
</tr>
</tbody>
</table>

a Values with different superscript are significantly different (p<0.05)

There was a significant statistical difference in liveweight gain between the bladder clover hay and subterranean clover hay whilst there was no statistical difference between arrowleaf clover and the subterranean clover hays (Figure 1 and Table 1). The level of lamb production in each of the diets was consistent with the level of ME, CP and DMI between the diets.

Further research is warranted on these second generation legumes to determine the optimal time for cutting and baling in order to capture forage quality and quantity, for maximum animal production.

Figure 1. Liveweight gain (kg) of lambs consuming a diet of either arrowleaf clover, bladder clover, or subterranean clover hay over a 51-day period.

Exploring alternative options for grazable pastures – which legume performs best?

Lucerne is a common pasture legume used in the mixed farming zone, however, its adaptation in central and southern NSW is limited by soil acidity, which affects both the plant and plant-rhizobia. Further, lucerne does not perform well in soils with limited water holding capacity. Managing long-term balance of legume to grass species in a lucerne-grass mixed pasture can also be difficult, with reduced legume content affecting animal production. Furthermore, some grass pastures species, such as phalaris, struggle to persist in lower rainfall zones. Both lucerne and lucerne-grass pastures are also inflexible in a cropping-pasture system, unlike annual legumes.

In spring of 2015 an experiment was carried out for six weeks (September – November) on the CSU farm to investigate Merino and cross-bred lamb growth rates on arrowleaf clover (cv. Arrotas), biserrula (cv. Casbah) and bladder clover (cv. Bartolo) compared to lucerne (cv. Sardi) and lucerne-phalaris (cv. Advanced AT) pastures. During this period, pastures were stocked according to the carrying capacity of each pasture type, whilst also being managed for seed set for subsequent year regeneration. The carrying capacity of the pastures is shown in Table 2.

Table 2. Average carrying capacity of the legume and legume-grass pastures throughout the 2015 grazing trial.

<table>
<thead>
<tr>
<th>Carrying capacity (sheep/ha)</th>
<th>Arrowleaf</th>
<th>Biserrula</th>
<th>Bladder</th>
<th>Lucerne</th>
<th>Lucerne-phalaris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrowleaf</td>
<td>21.5</td>
<td>16.2</td>
<td>15.1</td>
<td>27.1</td>
<td>31.8</td>
</tr>
<tr>
<td>Biserrula</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bladder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lucerne</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lucerne-phalaris</td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

NB. The carrying capacity set was based on feed availability and stage of growth in the annual pasture legumes to manage for seed set and subsequent year regeneration.

Lambs grazing arrowleaf clover, bladder clover and biserrula gained significantly more weight on average compared to the lambs on lucerne and lucerne-phalaris over the six-week period (Figure 2). Lambs on lucerne-phalaris pastures gained the least amount of weight over the six-week period (Figure 2), which was most likely attributable to the declining legume content over the grazing period, a result of sheep selectively removing the legume content in the first two weeks of grazing.
The results from this study show that in the spring grazing period, arrowleaf clover resulted in higher value of production on a per hectare basis ($/ha) than all other pastures, whilst biserrula resulted in the least production (Table 3). Lucerne and lucerne-phalaris pastures resulted in greater total value of lamb liveweight gain compared to either biserrula or bladder clover pastures (Table 3). It should be noted that both the lucerne and lucerne-phalaris pastures were able to be stocked heavier as they did not need to be managed for seed set, unlike the annual legume pastures.

Table 3. Value of total lamb liveweight gain ($/ha) for the spring grazing period of 2015.

<table>
<thead>
<tr>
<th>Pasture Type</th>
<th>$/ha *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrowleaf clover</td>
<td>475.34</td>
</tr>
<tr>
<td>Biserrula</td>
<td>295.29</td>
</tr>
<tr>
<td>Bladder clover</td>
<td>307.21</td>
</tr>
<tr>
<td>Lucerne</td>
<td>414.30</td>
</tr>
<tr>
<td>Lucerne-phalaris</td>
<td>366.49</td>
</tr>
</tbody>
</table>

*2.80/kg used to calculate value of liveweight gain

A small proportion of sheep were removed from the biserrula pastures throughout the experimental period due to the occurrence of primary photosensitisation (photo below). Anecdotal evidence suggests that animals are more susceptible to photosensitisation when the plant is flowering, however, limited controlled experiments have quantified the incidence of primary photosensitisation at different stages of plant growth and the causal toxin is still unknown.

Moderate primary photosensitisation on a lamb grazing biserrula pastures during the winter period and the resulting, swelling, hair loss and scabbing/hardened skin.

Figure 2. Liveweight change of Merino and cross-bred lambs grazing a range of pastures during the six-week spring grazing period.

The carrying capacity set was based on feed availability and stage of growth in the spring grazing period of 2015.

Figure 1. Liveweight change of Merino and cross-bred lambs grazing a range of pastures during the six-week spring grazing period.

Another grazing trial is due to commence in mid-July 2016 on the same grazing site, which will investigate lamb growth rates, grazing preference and feed intakes on arrowleaf clover (cv. Arrotas), bladder clover (cv. Bartolo), biserrula (cv. Casbah), French serradella (cv. Margurita), gland clover (cv. Prima) and Lucerne (cv. Sardi) pastures grown as monocultures and also over sown with grazing oats.

Conclusions

Some of the second-generation annual pasture legumes have equivalent (as conserved and grazed forages), or greater potential than traditional pasture species to produce high amounts of highly nutritious spring herbage (particularly under less-than-average rainfall years) and result in greater liveweight gains in lambs of both Merino and cross-bred sheep breeds.

Acknowledgements

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References


Revell CK, Ewing MA and Nutt BJ (2012). Breeding and farming system opportunities for pasture legumes facing increasing climate variability in the south-west of Western Australia. *Crop and Pasture Science, 63*(9), 840. doi: 10.1071/cp12160
Why pregnancy scan?

Pregnancy scanning of ewes in mid-pregnancy can be used to investigate reproductive problems in flocks (Celi and Bush, 2010). It is also a useful management tool. Scanning for pregnancy allows separation of pregnant and non-pregnant ewes, while identification of single from multiple-bearing ewes can allow differential management based on foetal number (Celi and Bush, 2010). Industry guidelines suggest that pregnancy scanning for multiples every year is ‘not negotiable’ (Trompf et al., 2015). The reason given for this is that it allows tailored feeding of ewes, in particular twin-bearing ewes, either by using supplements and/or allocation of paddocks (Trompf et al., 2015). But is this recommendation really not negotiable, or will the benefits of scanning in any particular year depend on seasonal conditions?

A recent paper suggested that pregnancy scanning for multiples had only a small benefit of $0.80 per ewe, based on a static (average year) optimised model (MIDAS) for a representative farm at Hamilton, Victoria (Young et al., 2016).

The cost of hitting lifetime ewe targets in scanned and unscanned Merino flocks - a simulation using a dynamic model, AusFarm

Modelling study

The ‘farm’ simulated was 1,000 hectares, located at Holbrook in southern NSW. It was subdivided into nine paddocks and a feedlot; eight of the paddocks (each 120ha) contained phalaris and sub clover pasture at high soil fertility. A ninth paddock (40ha) was added to simulate a low value area that empty ewes could be assigned to. The feedlot was utilised when groundcover levels fell below predetermined levels, to minimise damage to the paddocks from overgrazing.

The simulation was run using weather data for Holbrook from 1963-2013. AusFarm (essentially Grassgro but able to apply an infinitely flexible set of management rules – see: www.grazplan.csiro.au/?q=node/3) is a dynamic model driven by historical daily weather data over the simulation period. So the results reflect outcomes from implementing several management strategies if they were applied consistently over the 51 years of the simulation.

The system was a self-replacing flock of medium-Merino ewes (50kg SRW). Ewes were joined in April to commence lambing in September. After weaning the lambs were grown out until the next year’s joining, at which time wether lambs and surplus ewes were sold. Wether lambs were sold at weaning if there was insufficient feed (average of < 3,000 kg/ha) in the paddocks. Shearing occurred 25 days before joining and old ewes (i.e. above five years) were cast for age following shearing.

When pregnancy scanning was included in the operation, ewes were scanned 90 days after joining then separated on the basis of being empty, carrying a single lamb or carrying two or more lambs. From scanning, grazing management was applied to prioritise the twin-bearing ewes over the single-bearing ewes, who in turn were prioritised over the empty ewes. In short, at scanning, depending on the proportion of twin-bearing ewes, pasture area was over-allocated to the twin bearing ewes who received approximately 25 % more area per head than the single-bearing ewes. Both mobs of ewes were rotated to the paddock in their allocated section of the farm that contained the greatest amount of feed every seven days. The empty ewes were placed in a ‘poor’ paddock containing native pasture species. If not scanned, the entire ewe flock grazed together and were allocated the best paddock for intake every seven days from joining to weaning. Whether scanned or not, from weaning up until joining weaners were allocated the best paddock with dry ewes the second-best paddock every seven days.

The MIDAS model used in the above modelling study was based around an ‘average’ year – a situation that will rarely occur in the real world. The purpose of the current study was to use a dynamic model to determine the cost of meeting these optimal liveweight / body condition score (BCS) profiles when variability in production driven by historical weather data was applied.

Photographs: TA Field Estate Pty Ltd
Two condition score profiles were tested in the simulation:

a) Condition Score Profile 1 broadly reflected the Lifetime Ewe Management (LTEM) recommendations for the high rainfall sheep zone (NSW winter dominant rainfall zone; rainfall >550 mm) and the optimal weight profile identified by Young et al. (2016) for Hamilton (Vic). Between weaning and joining, ewes were allowed to lose weight to a minimum BCS 2, but (when necessary) were fed from six weeks prior to joining so they were at BCS 3 at joining. Ewes were allowed to lose weight to a minimum BCS of 2.6 at scanning. Thereafter ewes were supplementary fed (when necessary) to reach BCS 3 at lambing. Ewes were then allowed to lose weight to weaning, but ensuring that BCS of ewes was at least 2.5 at weaning.

b) Condition Score Profile 2 was a more conservative feeding regimen, with ewes fed to maintain a minimum BCS 2 throughout the year.

Outcomes

BCS profiles

Figure 1 shows the median (i.e. ‘middle’ over the long-term) BCS of ewes at joining, 90 days pregnancy (scanning), lambing and weaning. As expected, the median exceeds the target condition score, because in better seasons when lower supplementary feeding was not required to meet the minimum BCS, the condition score will exceed the target.

The condition score profiles in Figure 1 show there is minimal effect on the median condition score of single-bearing ewes across scanning and supplementary feeding treatments. When ewes were scanned and differentially managed, the median condition score of twin-bearing ewes was higher at lambing and weaning compared to scanning. When ewes were not scanned and differentially managed, the median BCS of twin-bearing ewes was lower at lambing and weaning in comparison to scanning (i.e. 90-days pregnancy). For twin-bearing ewes, the median BCS at lambing was just below BCS 3 when ewes were not scanned, and exceeded BCS 3 when ewes were scanned and differentially managed. Median BCS of twin-bearing ewes at lambing was also slightly higher when ewes were fed to LTEM guidelines compared to maintaining above BCS 2.

Figure 1. Body Condition Score (BCS) of dry (red), single-bearing (green) or twin-bearing (blue) ewes at joining, scanning, lambing and weaning under one of four management regimens: a) differentially managing ewes from scanning and feeding under LTEM guidelines; b) not scanning ewes and managing under LTEM condition score guidelines; c) differentially managing ewes from scanning and managing to minimum BCS 2; and d) not scanning and managing to minimum BCS 2. Stocking rate 7 ewes/ha. Data is median BCS across years 1963-2013 inclusive.
Feed utilisation, supplementary feeding and lamb production

Pasture utilisation and the amount of supplementary feed both increased with stocking rate (Table 1). Pasture utilisation changed little with management treatment. The amount of supplementary feed per ewe was slightly higher for ewes differentially managed from scanning and fed to LTEM condition score guidelines at stocking rates of 5-6 compared to other treatments. Feeding to LTEM guidelines increased the median annual amount of supplement fed by 4-10kg/ewe. The median amount of supplement fed was slightly higher for ewes differentially managed from scanning when following LTEM guidelines, however this effect was reversed when only feeding to a minimum BCS target. Median weight of lamb sold per hectare differed little between treatments at the same stocking rate and increased with stocking rate.

Table 1. Effect of treatment on median pasture utilisation, supplementary feeding and lamb production. Treatments are scanning for pregnancy status and differentially managing ewes based on number of foetuses (+Scan); not scanning ewes (-Scan); feeding to Lifetime Ewe Management BCS targets (LTEM); and feeding to maintain ewes above BCS 2 throughout the year (BCS>2.0).

<table>
<thead>
<tr>
<th>Stocking rate ewes/ha</th>
<th>Scanning</th>
<th>Feeding</th>
<th>Utilisation</th>
<th>Supp. feeding kg/ewe</th>
<th>Lamb sold kg lamb LW/ha</th>
</tr>
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<tbody>
<tr>
<td>5</td>
<td>+Scan</td>
<td>LTEM</td>
<td>32</td>
<td>24</td>
<td>116</td>
</tr>
<tr>
<td>6</td>
<td>+Scan</td>
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<td>37</td>
<td>32</td>
<td>131</td>
</tr>
<tr>
<td>7</td>
<td>+Scan</td>
<td>LTEM</td>
<td>42</td>
<td>48</td>
<td>147</td>
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Gross margins

Median income increased as stocking rate increased in all treatments, and at stocking rates in the range 5-7 ewes/ha the income was similar across treatments (Table 2). Median expenses were higher when ewes were fed to LTEM principles compared to a minimum BCS 2, and were also higher when ewes were scanned and differentially managed. Both of these were due to the higher supplementary feeding rates per ewe and/or additional costs associated with scanning. The median gross margin was highest at a stocking rate of 7 ewes/ha and feed cost $250/t when ewes were fed to maintain BCS above 2 and were not pregnancy scanned. Sensitivity analysis using grain prices of $200/t or $300/t identified that this treatment also produced the highest gross margins across this range of grain prices, although the stocking rate at which the highest gross margin return was achieved was reduced to 6 ewes/ha at the higher grain price. The mean gross margins were much lower than the median gross margin, suggesting the ‘average’ was influenced by high losses in some years, however the stocking rate and management regimen that achieved the highest return were unchanged when looking at average instead of median. The measure of variation in gross margin, the coefficient of variation, was reduced when ewes were fed to maintain above a BCS 2 rather than fed to the LTEM guidelines (Table 2). The lower variation indicates lower risk, although this difference is not large.
Table 2. Effect on stocking rate and median gross margin (GM) returns. Treatments are scanning for pregnancy status and differentially managing ewes based on number of foetuses (+Scan); not scanning ewes (-Scan); feeding to Lifetime Ewe Management BCS targets (LTEM); and feeding to maintain ewes above BCS 2 throughout the year (BCS>2.0). The base gross margin calculation uses a grain cost of $250/t for supplementary feeding and the sensitivity analysis uses grain price of either $200/t or $300/t. Shaded values are highest median gross margin within treatment.

Discussion
The case for strategically pregnancy scanning and differentially managing ewes between scanning and lambing to increase lamb survival relies on a number of assumptions, the key ones being that ewes in higher condition score will produce lambs with higher birthweight, and having lambs with higher birthweight will increase survival. The MIDAS model used by Young et al. (2016) was explicitly adjusted for this assumption. In contrast, AusFarm models mortality of newborn lambs as a function of ewe condition, rainfall, temperature and wind speed (Andrew Moore, per comms). Therefore the model used in the current study does incorporate BCS, but may not be based on the same datasets. Research in Western Australia and Victoria identified that ewe condition score at about day 100 of pregnancy and ewe nutrition from day 100 to lambing can have a small but significant impact on lamb birthweight, but this does not always affect lamb survival, and the importance of birthweight for lamb survival may also relate to weather conditions at a particular location (Oldham et al., 2011). It is therefore possible that a strategic decision to pregnancy scan every year together with an absolute focus on condition score targets may lead to inefficient allocation of resources and no improvement in profitability due to an over-estimation of the benefits of management interventions that increase ewe condition score.
In the above scenario lambing time aligns with feed availability. The effect of this may therefore be to minimise the need to supplementary feed ewes, and that in a high proportion of years ewes will be in good condition regardless for feeding regimen. When the model was run for a scenario where ewes were joined six weeks earlier to see if this changed the ‘optimal’ management approach, the median gross margin for not pregnancy scanning and only feeding ewes to maintain BCS above 2 remained higher than other treatments, with the advantage being $8-11/ha. Further work is required to determine if scanning will have additional benefits in a system that does not align with feed availability, such as an autumn lambing.

Pregnancy scanning may be more beneficial in flocks with a higher reproductive rate (AWI and MLA, 2008). To test this the reproductive rate was increased from 68 singles / 28 twins scanned per 100 ewes (the base scenario) to 48 singles / 48 twins per 100 ewes. The median gross margin return from pregnancy scanning was at least as high as not scanning with the higher reproductive flock at a grain price of $250/t. Scanning and feeding ewes to maintain BCS above 2 had a median gross margin return $10-12/ha higher than other management regimens under the high reproduction scenario.

Conclusion

There is no doubt that pregnancy scanning can be a useful tool, for example to identify reproductive problems or manage sheep in a tough season. The above study suggests however that pregnancy scanning and differentially managing ewes between scanning and lambing will not necessarily increase returns. Tactical use of this tool may therefore be appropriate in flocks with moderate reproductive rates and with lambing times that align with feed availability. Following LTEM guidelines may have other benefits not considered in the modelling, such as improved ewe wool production and tensile strength, and increased progeny fleece weight and decreased fibre diameter.

References


Management to improve lamb survival

Take home messages:
• On average, 20 per cent of lambs born die.
• Starvation / mismothering / exposure and lambing difficulty are usually the major causes.
• Target the key causes of death to gain the largest improvement in survival.

Background
In Australia, on average 20 per cent of lambs born will die, with 90 per cent of deaths occurring during or within seven days of birth. This represents a large loss of income for producers, and may be perceived as a welfare issue. Variation between properties and seasons is large, with ranges in mortality of 4 - 50 per cent for singles and 15 – 85 per cent for twins being measured (Kleemann and Walker, 2005). Reducing mortality below around 10 per cent for singles and 30 per cent for twins in commercial situations is difficult (Hinch and Brien, 2014), but levels much above these indicate potential for improvement.

Why do lambs die?
The major cause of death for lambs will vary between farms and seasons, but starvation / mismothering / exposure and difficult births are generally the largest causes (see Table 1), as found in numerous post-mortem surveys of dead lambs. Foxes are generally blamed for more deaths than they cause, as they mostly scavenge dead or dying lambs, rather than killing lambs that would have lived. However, foxes, wild dogs and pigs can cause large losses in some locations. Infection / disease can also cause large losses where an outbreak occurs, but in normal grazing conditions, lamb loss from infection is low when ewes are vaccinated annually pre-lambing. Likewise, the number of deaths due to deformities is generally low. Mineral deficiencies (e.g. iodine, selenium) that reduce lamb survival are known to occur in some regions (particularly sandy or coastal type soils), but are preventable and generally are not a major cause in most sheep-breeding regions.

Proportion of lambs born as twins (or multiples)
Since the survival of twins is lower than singles, a lower proportion of ewes producing twins rather than single lambs could improve lamb survival. However, unless the survival of twins is very low (below 60 per cent), producing more twins generally increases the number of lambs marked per ewe, which can be more profitable.

Adequate nutrition
Nutrition of ewes is the most important factor influencing lamb survival. Optimum nutrition minimises difficulties during birth, improves maternal behaviour, allows ewes to provide sufficient colostrum and milk, and allows ewes to stay on the birth site longer to bond with the lamb, reducing mismothering. Lambs born to well-fed ewes are better able to cope with poor weather (i.e. maintain body temperature), and follow the ewe.

Ewes gain weight and maintain condition during late pregnancy with adequate nutrition. Avoid having fat (condition score 4) ewes at lambing as this increases the risk of pregnancy toxaeamia and lambing difficulty. Ewes in condition score 2 or less also have an increased risk of their lambs dying, particularly if twin-bearing.

Which lambs are most at risk?
• Lambs born as multiples (twins 30 per cent mortality), rather than singles (10 per cent mortality)
• Merino, rather than crossbred lambs
• Lambs born to maiden ewes – maidens have 10 per cent lower survival than mature ewes.

Management to improve survival
The key causes of low lamb survival need to be targeted to achieve an increase in survival. Which management is most effective on particular properties will vary depending on what are the major causes of death.

Table 1. Percentage of lamb deaths due to various causes.

<table>
<thead>
<tr>
<th>Causes</th>
<th>% of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starvation / mismothering / exposure / lambing difficulty</td>
<td>80</td>
</tr>
<tr>
<td>Primary predation / infection / deformed / mineral deficiencies / other</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>
Lambing at a time when there is sufficient green pasture so ewes don’t need to move far to graze or water is ideal. However, choice of month of lambing is a compromise with likely weather conditions at lambing, allowing sufficient time of green pasture until lambs are weaned, time for weaners to be heavy enough prior to summer to minimise the risk of weaner deaths, sale dates for lambs, and fitting around other farm activities. Lambing in autumn around Wagga Wagga usually means ewes will need higher rates of supplementary feeding during lambing compared with later lambing, unless stocking rates are reduced, both of which reduce income after costs. Very low lamb survival can result where ewes do not have adequate feed during lambing, due to ewes having delayed / insufficient colostrum, ewes moving to graze / water / feed truck when the lamb is too young or weak to keep up (both desertion and mismothering), and an increase in lambing difficulty due to ewes being weak.

Long-term supplementary feeding may be needed during poor pasture conditions. However, short-term supplementary feeding to increase colostrum production may improve survival even where pasture conditions are not clearly inadequate. Feeding 0.5 kg/ewe/day barley or lupins for seven days prior to and the first week of the peak lambing period (i.e. differs for spring and autumn joined flocks) can increase overall lamb survival by 7 per cent or more (Nottle et al., 1998). Results have been variable, with no benefit where ample green pasture is grazed (Kopp et al., in press), and larger increases in survival where pasture is poor quality or limited. The survival of twin lambs has been increased by 27 per cent by feeding lupins for 17 days prior to a synchronised lambing, when ewes were losing condition (Hall et al., 1992). The cost of grain should be considered against the likelihood of an increase in survival and the value of extra surviving lambs.

Month of lambing - choice of lambing time affects both the likelihood of adequate pasture being available for the ewe, and the risk of poor weather causing either heat or cold stress to newborn lambs. The risk of high chill weather varies between locations and in different months. Choosing to lamb at times of milder weather (e.g. autumn) may have a higher risk of pasture quality being inadequate and ewes needing supplementary feed, increasing costs. Month of lambing also influences the number of ewes able to be carried by the association between feed supply and demand, so potential number of lambs born.

Shelter - Are ewes lambing in a location and month when poor weather is likely? Shelter that reduces wind speed may increase survival in cold, windy weather, but will be ineffective in mild weather. Up to 90 per cent of lambs born during a cold, wet, windy weather event can die, but secondary hypothermia under less extreme cold weather contributes to an increase in deaths from starvation (cold lambs are less likely to suckle, which makes them less able to maintain body temperature, which can make them incapable of suckling).

In cold, windy environments such as Hamilton, Victoria, rows of tall grass have improved lamb survival by 50 per cent. Winter-born lambs at Tarcutta showed only a 7 per cent increase in survival (77 per cent vs 70 per cent) for twin lambs born in shrub shelter compared with hessian shelter, but not in all years, and no increase for singles. Ewes may not seek shelter from wind, so shelter that covers the whole paddock will be more effective than shelter only in one part of the paddock. Shearing of ewes pre-lambing can cause the ewe to feel cold so seek shelter, potentially increasing the number of lambs born in sheltered locations. However, shearing to cause ewes to seek shelter is only effective if within four weeks of lambing (Lynch and Alexander, 1980). Shearing close to lambing may also reduce lamb survival through the ewe leaving newborn lambs to seek shelter themselves, or by reducing the bulk (windbreak potential) of the ewe. Shearing during late pregnancy also increases the risk of metabolic issues and ewe deaths.

Shearing of ewes in mid-pregnancy may in some situations increase lamb survival by increasing birthweight. For this strategy to be effective, the birthweight of the lambs must otherwise be low, and the ewe has sufficient fat reserves or access to improved nutrition so that increased nutrition can increase lamb birthweight (Kenyon et al., 2003).

Consider the cost of creating shelter against the value of potential increased production. Fenced rows of shrubs can be effective, but expensive, and can create homes for foxes, rabbits and weeds. Tall grass or pasture can also be effective, but consider any cost in lost grazing time. Use natural, existing shelter where possible to reduce costs.

Where there is limited shelter, give priority use to twin-bearing ewes. Alternatively, early and late lambing groups could use the shelter at different times. Avoid severely restricting nutrition in order to provide shelter.

Lambs can die from heat stress. Where possible, provide shade and minimise the distance ewes have to walk to feed and water if lambing during hot weather.

Stocking rate (density of ewes at lambing) - there is conflicting evidence as to optimum mob size or stocking rate. Stocking rates above 18 ewes/ha can lead to increased interference by other ewes, but lamb survival has not always been reduced. Studies using between 2.9 to 23.9 ewes/ha (Kleemann et al., 2006) or 14.3 to 143 ewes/ha (Winfield 1970) have shown no effect of stocking rate, yet small mobs of ewes lambing at 30 ewes/ha compared with 16 ewes/ha had
24 per cent lower twin survival (Robertson et al., 2012). Little work has been conducted on mob size, and while the optimum mob size for both single and twin lamb survival from mature ewes appears to be around 400 ewes (Kleemann et al., 2006), other factors may be more important. AWI is currently funding research on the effect of mob size.

**Separation of single and twin-bearing ewes** - lambing twin-bearing ewes in separate paddocks to singles does not appear to increase survival of lambs (Gambley and Hinch, 1998). However, separation may improve survival if this allows preferential management – twins can be placed in more sheltered paddocks or where better feed is available. Separation may also reduce feeding costs if only one group requires feeding.

**Age of ewes** - avoid lambing mature and maiden ewes in the same paddock. Research suggests this may reduce the survival of lambs from maiden ewes by 10 per cent. A difference in ewe behaviour is likely to have been the cause, although this is not known. Current research is evaluating whether pre-lambing exposure of maiden to adult lambing ewes can improve the survival of lambs from maidens.

Lamb survival improves with age of ewe to around six to seven years, depending on environment. Health issues (tooth loss, poor condition, udder issues such as mastitis and shearing cuts) are more common in older ewes, but some ewes remain productive to 10 years of age.

**Genetics** - avoid buying rams with high birthweight Australian Sheep Breeding Values (www.sheepgenetics.org.au) or blocky shoulders as this can result in increased lambing difficulties. High birthweight rams (0.4 to 0.6 kg ASBV) led to 21 per cent of single-bearing Merino ewes being assisted to lamb, compared with 10 per cent for lower birthweight rams, in one unpublished study.

While some breeds have higher lamb survival than others, and the Merino has lower survival than most, lamb survival has a very low heritability and genetic improvement will be slow.

Maternal behaviour score (ewe staying close to lamb while the lamb is tagged soon after birth) is not a reliable indicator of lamb survival. Alternatively, some ewes repeatedly fail to rear their lambs, and some genetic improvement could be made by culling ewes that fail to rear lambs. However, this may not be economically worthwhile since repeated failure cannot be determined early in a ewe’s breeding life, factors other than the ewe often determine lamb survival (e.g. born on a cold, rainy day) making it difficult to identify ewes with poor rearing ability, and if a large number of ewes are sold this loss of stocking rate may cost more than the small improvement in overall lamb survival.

**Conclusions**

Target the key causes of mortality in order to achieve the largest increases in lamb survival. Ensuring ewes have adequate nutrition, and avoid lambing in high-risk weather are the most important factors to reduce deaths from starvation, mismothering, exposure and lambing difficulty. Which management methods will both increase survival and be cost-effective will vary between individual farms and sheep management systems.

**References and further reading**


Increasing lamb survival on-farm

Tim Westblade
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Take home messages:
• Pastora Poll Merinos comprises 4,500 breeding ewes that lamb in July-August
• The ewe base is managed as a commercial operation
• Lambing in paddocks with shelter increase overall lambing percentages.

In the early stages of pregnancy, Tim avoids handling the ewes as much as possible. Maintaining bodyweight is optimal to prevent stress to the developing embryo. Embryos easily perish if conditions are unfavourable especially in the early stages.

Scanning
Ewes are scanned for multiple pregnancies and given preferential treatment. They are put on the best feed to optimise live birth rates. The Westblades aim for a condition score 3.5 for multiple foetuses ewes and condition score 3 for single foetus ewes at lambing. After scanning, any grain that is fed is supplemented with lime to meet calcium requirements.

Lambing
Tim believes pasture length is key at lambing, and aims for his pastures to be 7-10cm for their twin ewes and 3-5cm for single foetuses ewes.

At the start of lambing they put the feed-cart away. Feedlots or stubble paddocks are used in the lead up to lambing to allow maximum pasture growth on the lambing paddocks.

Lambing in late winter increases the exposure to harsh weather conditions, the biggest contributor to lamb mortalities in most years. This can be a major management issue, but the Westblades have found their lambing percentages at marking are better in their twin ewes, if they lamb them down in paddocks with shelter (e.g. taller dead grass, partially standing stubbles, heavily timbered areas, longer Lucerne plants or any shelter that breaks the wind).

As an example, in 2015 a mob of 600 single ewes was split into three paddocks. Two of these mobs were lambed in open paddocks and the other was lambed in a tree creek line. The two mobs in the bare paddocks marked 93 per cent and 94 per cent, and the creek lined mob marked 107 per cent. Feed availability in all three paddocks was similar.

Minimal interruption to the lambing ewes is essential, with ewes observed from a distance.

As a general rule, the Westblades’ lamb their singles in mobs of 400 and twins in 200-250 mobs. The smaller the twin mobs, the better for the six-week lambing period. All available paddocks are used on the farm at this time. If more paddocks were available, Tim says he would lamb the twins in mobs of 150-200.

Tim does not use winter cereal paddocks for lambing, saying he has seen too many pregnancy toxæmia issues with clients using them to lamb. Instead he prefers to run his weaners on these paddocks.

They class their ewes after weaning and identify all that have failed to rear a lamb, with ‘repeat offenders’ culled. Tim also culls all first-time offenders with obvious reasons for the failure (i.e. low bodyweights, age and bad udder conformation).
A similar system applies to the dries after scanning, with all repeat offenders culled and first-time dries classed extremely hard.

**Weaning**

Lambs are weaned at an early age, weaning as early as 10 weeks in a tight spring. The ewes and lambs have different feed requirements and are best managed in separate mobs.

When the ewes are lambing, immediate thoughts turn to where the ewes will be placed once the lambs are weaned. The fatter we can get our ewes after weaning the easier they are to manage throughout the summer when feed becomes tighter.

Building reserves throughout the spring flush equates to better economics and efficiency, rather than having to feed grain to add the bodyweight. At Pastora if they miss building their weight due to low feed availability, from a bobtail spring, they get a second chance after the header goes through and leaves the stubbles.
The Trouble with Sub project update

Ms Janelle Jenkins  
Riverina Local Land Services, Tumut  
T: 02 6941 2253, E: Janelle.jenkins@lls.nsw.gov.au

Take home messages:

- The survey found subterranean clovers are poorly nodulated in the pastures of the medium to high rainfall zones of the Riverina region.
- Many of the soils sampled were affected by acidity, particularly in the sub soil.
- Few landholders appear to be applying the important (for nitrogen fixation by legume) micro nutrient molybdenum.
- The rhizobia present in the soil are by large of an effective strain and are also generally fixing atmospheric nitrogen.

Project background

Subterranean clover and its associated rhizobium, \textit{Rhizobium leguminosarum} bv. \textit{trifolii}, have added greatly to soil fertility and animal production systems in southern Australia. Australian soils are relatively low in fertility and the use of annual legumes in grazing systems increases the production of the system via the extra nitrogen entering the soil that subsequently is available for non-fixing plants. Annual legumes, particularly subterranean clover, improve the quality of the feedbase in terms of digestibility, palatability and protein content, which in turn increases both overall carrying capacity and individual livestock growth rates.

It has been estimated that legume fixed nitrogen contributes approximately $AUS4 billion to the Australian economy. The cost of nitrogen fertiliser is predicted to increase over time, thus resulting in the increasing importance of legume fixed nitrogen to our agricultural system.

From the 1970s there have been increasing reports of general pasture legume decline. Many mechanisms have been suggested for this apparent overall decline. Some of the main factors implicated include increasing soil acidity, use of pesticides toxic to rhizobia, dilution of effective rhizobia types in the soil with ineffective types and the declining use of molybdenum fertilisers.

The relationship between the legume species and rhizobium strain is generally very specific. In the case of subterranean clover, the various strains of the \textit{Rhizobium leguminosarum} bv. \textit{trifolii} are the bacteria to form this symbiosis. It has been noted that low soil pH and high aluminium levels can interfere with the persistence of rhizobia and its ability to infect the host plants.

The Trouble with Sub is a survey project that was undertaken in 2015 to determine whether subterranean clover was in decline across the Riverina region. The project was managed by Harden Murrumburrah Landcare Group in partnership with Riverina Local Land Services, other local Landcare and farmer groups, and the CRS at Murdoch University. This project worked closely with other relevant Meat and Livestock Australia (MLA) and Grain Research and Development Corporation (GRDC) funded projects. This project was funded by the Australian Government under the National Landcare Program.

Project aims

The project aims were:

- to determine if there were measurable growth and nodulation issues with pasture legumes in medium / high rainfall areas of the Riverina.
- to undertake a preliminary determination of the factors that may be contributing to this decline (i.e. soil restrictions, inadequate nodulation and/or the lack of effective rhizobia in the soil).

Survey process

More than 80 paddocks containing subterranean clover were surveyed from Bland, Coolamon, Cootamundra, Gundagai, Harden, Junee, Lockhart, Temora, Tumut, Wagga Wagga and Young shires (Figure 1). The paddocks ranged from long to short-term pastures in rotation with crops. The date the paddocks had been originally sown ranged from paddocks sown in the 1950s (with clover regenerating each year), to new paddocks last sown down in 2014. Over 50 per cent of the paddocks sampled had been sown since 2000, Table 1.
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Table 1. Samples and nodule scores.

<table>
<thead>
<tr>
<th>Year Sown</th>
<th>Sample (n)</th>
<th>Av. Nodule Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950s</td>
<td>4</td>
<td>2.31</td>
</tr>
<tr>
<td>Unsure*</td>
<td>9</td>
<td>1.8</td>
</tr>
<tr>
<td>1990-99</td>
<td>10</td>
<td>1.64</td>
</tr>
<tr>
<td>2000-2009</td>
<td>13</td>
<td>2.04</td>
</tr>
<tr>
<td>2010 – 2015</td>
<td>30</td>
<td>2.73</td>
</tr>
</tbody>
</table>

*Some paddock histories to be collected

The first paddock sampling occurred about eight to 10 weeks after the autumn break, starting in the last week of July 2015. Information collected at this sampling included scoring the root nodules for presence, number, colour and size (Figure 2). Nodules were also collected for strain identification. The collected nodules were placed in desiccating vials and sent to Murdoch University for analysis using the novel MALDI-ID approach. The MALDI technique was compared to DNA-based methods and was effective in identifying the rhizobia strains taken from the nodules. The MALDI method provides quick identification and a high laboratory throughput, making the technique relatively accurate and cost effective compared to more tradition identification methods.
Figure 2. Score card for scoring root nodules.

<table>
<thead>
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<th>Year Sown</th>
<th>Sample (n)</th>
<th>Av. Nodule Score</th>
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</thead>
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<td>4</td>
<td>2.31</td>
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<td></td>
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Table 2. Pasture composition for sample sites.

<table>
<thead>
<tr>
<th>Pasture composition</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ann Grasses</td>
<td>24</td>
</tr>
<tr>
<td>Peren Grass</td>
<td>11</td>
</tr>
<tr>
<td>Native Grass</td>
<td>3</td>
</tr>
<tr>
<td>Legumes</td>
<td>48</td>
</tr>
<tr>
<td>Peren Broadleaf</td>
<td>3</td>
</tr>
<tr>
<td>Broadleaf Sps</td>
<td>9</td>
</tr>
<tr>
<td>Bare ground</td>
<td>0</td>
</tr>
</tbody>
</table>

A soil sample was also collected for comprehensive soil testing at the 0-10cm depth. A second less comprehensive soil test was used on soil samples collected from the 10-20cm depth. The landholders supplied paddock histories, including information such as fertiliser, chemical usage and cropping history. Pasture composition from the sample sites was also recorded (Table 2).

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<table>
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<tbody>
<tr>
<td>Ann Grasses 24</td>
</tr>
<tr>
<td>Peren Grass 11</td>
</tr>
<tr>
<td>Native Grass 3</td>
</tr>
<tr>
<td>Legumes 48</td>
</tr>
<tr>
<td>Peren Broadleaf 3</td>
</tr>
<tr>
<td>Broadleaf Sps 9</td>
</tr>
<tr>
<td>Bare ground 0</td>
</tr>
</tbody>
</table>

The second paddock sampling occurred in mid-October and was timed to occur at approximately the time of peak spring pasture production. The purpose of this visit was to collect above ground leaf tissue samples for nitrogen fixation effectiveness determination, using the N15 technique. This required the collection of legume plants, and also an annual non-legume (therefore non-nitrogen fixing) reference plant with a similar root depth as the legume, such as barley grass or annual ryegrass.

Project results

The results from the 81 paddocks sampled indicated that 97 per cent of the paddocks surveyed (from those sown in the 1950s to 2014) had poor nodule formation on their roots systems, scoring less than a rating of 4 (Figure 2). The average rating of nodulation across all samples was 2.24. Table 3 shows the percentage of paddocks in each nodule score category.

Table 3. Percentage of paddocks in each nodule score category.

<table>
<thead>
<tr>
<th>Nodule score</th>
<th>Percentage of paddocks sampled (n=81)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>5</td>
</tr>
<tr>
<td>1-2</td>
<td>40</td>
</tr>
<tr>
<td>2-3</td>
<td>32</td>
</tr>
<tr>
<td>3-4</td>
<td>22.5</td>
</tr>
<tr>
<td>&gt;4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The results of the MALDI identification indicated that much of the rhizobia found within the nodules were of the more current inoculant strain WSM1325, either as the sole type found in the sampled paddocks or in combination with older and less effective strains including TA1, WU95 and CC275e and other naturalised strains. Figure 3 shows the dominance of the WSM1325 strain.
The results of nitrogen fixation from the second paddock visit indicated that 97 per cent of the samples collected were fixing atmospheric nitrogen at the collection date. This data concurs with the nodule scoring information, which showed that almost all of the 2,025 legume plants scored had some (if few) nodules present.

Researchers in the past have explored the link between poor rhizobia nodulation rates and low soil pH. Commercial rhizobia in laboratory cultures have been shown to have suppressed activity at pH (CaCl) <5.5 and be completely inhibited at pH (CaCl) <4.5. High levels of aluminium in the soil affect the ability of rhizobia to form symbiosis with legumes. Aluminium (if naturally high in soils) becomes more plant available in the soil as pH decreases.

Many of the sampled paddocks were affected by soil acidity. Table 4 shows many of the sampled paddocks had acid topsoils (less than pH 5.2 CaCl₂ in the 0 - 10cm depth), however many more had acid subsoil (less than pH 5.2 CaCl₂ in the 10 - 20cm depth) in a range that is considered to have an impact on rhizobia nodulation and function.

<table>
<thead>
<tr>
<th>pH CaCl₂</th>
<th>% paddocks sampled (n=81)</th>
<th>0-10cm</th>
<th>10-20cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5.2</td>
<td></td>
<td>42</td>
<td>79</td>
</tr>
<tr>
<td>≥5.2</td>
<td></td>
<td>58</td>
<td>21</td>
</tr>
</tbody>
</table>

The soil micronutrient molybdenum has an important function in the process of rhizobia extracting nitrogen from the atmosphere. Therefore rhizobia infected legumes have a higher molybdenum requirement than non-fixing plants. Another compounding factor is that as soils become more acid the availability of molybdenum in the soil solution becomes restricted. It is a possibility that low soil levels of molybdenum could be restricting the ability of the nodules to extract atmospheric nitrogen in acid soils. The paddock histories collected indicated that only four of the 55 landholders who returned the paddock history had been using molybdenum fortified fertiliser or pesticides in the past 10 years.

The project survey yielded a large quantity and variety of soil and cultural practice data. There are still relationships between legumes rhizobia levels and these factors currently being analysed. A further project is also being designed to test some of these factors implicated in rhizobia decline due to start in autumn 2017.

Conclusions

Subterranean clover and its accompanying rhizobia, *R. leguminosarum* bv. *trifolii*, have added greatly to Australian agricultural systems, both in terms of increased soil fertility and also in overall production from pasture and livestock systems. The symbiotic relationship between legume and rhizobia form the basis of these advantages. However, this project adds some weight to the idea that subterranean clover is somewhat in decline in southern Australia. Many factors have been attributed to this decline, but the main factors investigated in this project including soil acidity and aluminium levels appeared to be associated with soil rhizobia population decline.
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