SHEEP PRODUCTION SEMINAR

Proceedings
Seminar presented by ASAP (Southern NSW Branch), Sheep CRC & NSW DPI

Wednesday 29th May 2013
Pridham Centre
Cowra Agricultural Research and Advisory Station

WormBoss
Australia's sheep worm control resource

![Worm stats graph]

Highest YSS ASBV = 7.5
Average YSS ASBV = 0.2
Lowest YSS ASBV = -11.1

Australian Society of Animal Production
(Southern NSW Branch)
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Preface

In an increasingly competitive environment, farm businesses require an edge in order to improve productivity and remain profitable. For wool and sheep meat producers, productivity gains may be achieved through directing decision making toward flock health and production. Hence, the focus of this seminar, titled “2013 Sheep Production Seminar”, is to provide information applicable to issues currently facing sheep producers throughout the country.

An impressive line up of presenters, from the Sheep CRC, NSW DPI, White Suffolk Association and Sheep Meat Council, bring a wealth of knowledge and experience in their respective fields. The topics for each presentation are aimed to supply useful information on improving enterprise operation and overall productivity and profitability.

The Southern NSW Branch of the Australian Society of Animal Production (ASAP) continues to presents two seminars per year, one in autumn and the second in spring, with the aim of bringing together people from industry and research in order to facilitate awareness of advances in a range of areas associated with animal production.

This seminar would not happen without the support and dedication of organisations such as the NSW Department of Primary Industries, Sheep CRC and Sheep Connect NSW. I would especially like to thank all of the speakers for presenting and especially Gordon Refshauge and David Hopkins for organising this event and compiling these informative proceedings.

I trust you will enjoy reading these proceedings and encourage your attendance at the next ASAP Southern NSW activity.

Dr Russell Bush
President – ASAP Southern NSW
Outcomes and Future Directions for the Sheep CRC

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Introduction

Central the Sheep CRC’s research over the last six years has been the Information Nucleus program, set up to provide a resource for collecting genetic, biological and production data. Each year approximately 100 young rams were selected that were representative of the major breeds and joined, using AI, to around 5,000 ewes distributed across 8 sites in different climatic zones throughout southern Australia. The progeny were measured for a very wide range of traits including a number of novel and expensive parameters such as consumer tests for eating quality, intra-muscular fat and omega-3 fatty acids. Samples of DNA were analysed using the 50 k SNP-test and sub-samples of DNA stored for future analysis as DNA technologies develop further. With measurements for over 18,000 lambs and more than 10,000 genotype analyses the new data has provided a rich resource for researchers and formed the basis for developing new predictions of breeding values based on genomic data.

The addition of genomic information to the measurement of performance and use of pedigree data adds to the accuracy of predicting true genetic merit and is particularly useful in selecting younger animals for use in breeding programs and for incorporating difficult-to-measure traits in selection indexes. It is estimated that the use of genomic data can improve accuracies by around 40% when selecting month old Merino rams and around 12% when selecting rams at 18 months of age. For meat breeds, the main benefits of genomic information are seen in selection for eating quality traits and parasite resistance.

Meat science and eating quality

The breeding direction set by the lamb industry around 1990 was to produce larger leaner carcasses by increasing muscling, producing less fat and achieving faster growth rates. This approach has successfully changed the lamb product for export and domestic markets. The clear market signals and relatively straightforward set of traits to select for, made this transition relatively fast and effective.

The CRC’s Information Nucleus program showed that a number of rams, considered to be elite sires on the basis of growth rate, muscling and lean meat yield were amongst the poorest performers in terms of consumer scores for eating quality. The characteristics of sheep meat having the greatest influence on consumer perception of eating quality within a cut were deemed to be the content of intramuscular fat (IMF) and shear force of the muscle, where the latter is an objective measure of tenderness. While there is a strong negative relationship between increased lean meat yield and decreasing eating quality, there is sufficient variation around the relationship to provide good opportunities for selecting animals that can deliver both increased lean meat yield (LMY) and superior eating quality.

Measuring IMF and shear force in breeding programs is very expensive and would be impossible for most breeders. The development of genomic predictions of breeding values for these key traits is an important outcome from the CRC’s research. It means that selection for parallel improvements in lean meat yield and eating quality are now possible. The development of new genetic parameters for traits, such as omega-3 fatty acids and retail shelf life and meat colour, paves the way for further positive differentiation of lamb as a premium product.

It is, however, imperative that measurements continue to be made on reference flock animals in order to ensure that genomic selection accounts for the variation in eating quality and maintains the high industry standards for this critical factor underpinning the high value of lamb.
Wool – lightweight next-to-skin knitwear
The Sheep CRC has produced a quality management system for wool knitwear that will allow retailers and manufacturers to produce next-to-skin wool garments with predictable comfort and handle. At the heart of the system are two breakthrough technologies: The Wool ComfortMeter and The Wool HandleMeter.

After five years of comprehensive consumer wearer trials and parallel development of the new measuring system, we have an instrument that accurately predicts next to skin comfort. The Wool Comfort Meter allows retailers and manufacturers to specify a numerical value for comfort in their buying orders. This means that for the first time, retailers and manufacturers have a means of objectively specifying and promoting a garment on the basis of superior comfort and thereby overcome a concern of many consumers that wool garments can be itchy or prickly.

A parallel program focused on defining and calibrating handle measurements with expert assessors and consumers. As a result, we have developed an instrument that objectively measures the handle attributes of next-to-skin wool knitwear. The Wool HandleMeter measures the seven core attributes of handle: smoothness, softness, warm feel, dry feel, hairiness, tightness and perceived weight as well as an overall luxury handle index. The Wool HandleMeter allows retailers to specify a value for fabric handle in their buying orders, generating specifications for wool types and processing procedures to ensure buyer requirements are met by the supply chain.

A research pilot project is currently underway with AWTA providing a testing service with the Wool ComfortMeter and HandleMeter in Australia and in China. The new measurement systems offer retailers and knitters the ability to:

- Differentiate their next-to-skin wool products on the basis of elite comfort and hand feel;
- Develop a new range of second generation next-to-skin products that perform on comfort and superior handle;
- Transparently source and supply product against clear, objective specifications for comfort and handle, removing reliance on human estimation and the accompanying risk of customer dissatisfaction and product returns; and
- Consistently provide elite quality next-to-skin products, ensuring product comfort levels and handle standards are met not only between batches, but across seasons.

It is anticipated that the new measurement system will support and expand the demand for wool in the high-value market for lightweight base-layer garments worn next to skin. The high heritability of both fibre diameter and fleece weight will allow the sheep industry to rapidly respond to any change in market signals for finer wools suited to lightweight knitwear.

Sheep and their management
Reproduction efficiency - number of lambs weaned (NLW) is an increasingly important trait as the income from livestock sold and the importance of having surplus animals from which to select are both recognised profit drivers in a number of production systems. This is a relatively new development for many Merino breeders traditionally focusing on a self-replacing Merino flock where large numbers of wethers were kept for wool production.

With low heritability of the trait ‘number of lambs weaned’ and with relatively few rams having data available for this trait, the CRC focused on management options for improving reproductive efficiency. Two programs initiated by the CRC were the ‘Lifetime Ewe Management’ (LTEM) training program and the workshop series ‘Managing Scanned Ewes’.

The small group training program – LTEM has been very successful in achieving practice change and improvement in lambs weaned as well as increased stocking rates through better feed budgeting. It is now being supported by AWI and continues to be run and coordinated by RIST.
The Managing Scanned Ewes workshop was conducted with the pregnancy scanning contractors and their clients. It promoted similar principles of ewe management to those used in the LTEM program – i.e. ensuring that ewes are kept around condition score 3 during key periods of the reproduction cycle. It too has been a very successful program and has resulted in widespread practice change and improved lamb weaning percentages by those attending the workshops.

As more data becomes available from the Information Nucleus flocks there is growing evidence that number of lambs weaned (NLW) may soon become one of the traits that we can predict from genomic analysis with sufficient accuracy to be useful in commercial breeding operations.

Management of parasites (worms, flies and lice) and associated losses - remains one of the major costs for the sheep industry. One of the major contributions of the Sheep CRC in this area has been the development of a coordinated national approach to parasite management through development of WormBoss, FlyBoss and the re-writing of LiceBoss. With assistance from AWI, the CRC has produced an up-to-date web-based national resource that is increasingly used by parasitologists, veterinarians, producers and service providers as information of choice in making decisions on parasite management. The integrated ‘ParaBoss’ program will be launched by June 2013 and in this form will be managed and updated outside the CRC with support during the transition from AWI and MLA.

The CRC has also contributed to an improved understanding of factors contributing to sheep that are better adapted to the production systems and environments in which they are run. The workshop series ‘Bred-well Fed well’ was developed by the CRC for this purpose and its continued delivery is now supported by MLA and AWI. The publication ‘Sheep – the simple guide to making more money with less work’ has been prepared for WA producers and adapted for producers in the sheep-cereal zones. Further versions will be produced for the high rainfall zones.

There is also considerable research still underway to understand the impact of genetic parameters, management decisions and environmental factors on the well-being and productivity of sheep. Preliminary results indicate a positive effect of the trait PFAT on reproductive performance of progeny under harsh seasonal conditions. Still under study is how to balance this benefit against the impact of higher fat levels on lean meat yield and wool production.

Future opportunities

The CRC is preparing an application for a five year extension program that will build on three areas of research successfully completed and delivered during the current seven-year term. The focus for the next five year business plan will be to:

- build on the success of the genomic technologies;
- develop eating quality to a cuts-based grading system; and
- evaluate new approaches for pro-active management of animal wellbeing that will also improve productivity.

Successful outcomes in these three areas will also contribute to the development of the Australian sheep industry by making it more profitable and sustainable.

Genetic and genomics

The Sheep CRC was set up to develop the use of genomic technologies for the Australian sheep industry. When the program was designed in 2006 it was already clear that searching for genes of major effect as a basis for genetic selection was likely to be of little value. The potential of whole genome association analysis appeared to hold the greatest potential and the CRC’s Information Nucleus Program was a world-first design to take advantage of the features of whole genome association analysis. The program has been very successful and places the Australian sheep industry in a good position to take advantage of this new technology in commercial breeding programs. However, new genomic technologies are developing very quickly and there are now new opportunities that offer the sheep industry even greater potential improvements.
Full DNA sequencing for individual animals was not even considered at the start of the CRC, but is now becoming a mainstream technology in human genetic analysis and in predicting breeding values in production livestock species. The potential benefits of full sequencing key rams in the Australian sheep flock are the possibility of:

• more accurate predictions of breeding values;
• predictions of breeding values for minor breeds not currently possible; and
• accuracies of prediction which retain their value over time and reduce the cost of resource flocks.

The use of genomic information in breeding programs provides the basis for introducing new design concepts and it is important that these options are developed and evaluated with commercial ram breeders. The extension application will focus on applying the latest genomic technologies in the sheep industry through further research on DNA analysis and by working with ram breeders to maximise the potential benefits from the commercial application of the new technologies.

Further value for lamb and sheep meat

The new understanding of genetic and management inputs to manage improvement of LMY and eating quality will be extended to focus on cuts based grading and methods of obtaining best value from heavier lambs (over 25kg carcase weights) and for yearling Merino product in the export market. A major component of the work plan for the next five years is to work closely with participants in the supply chains to convert new information on genetics, management and processing into additional value.

Improved wellbeing and increase productivity

The Information Nucleus program has produced invaluable data that can now be used to review the implications of various combinations of genetic potential, patterns of production and challenges of different environments on survival and wellbeing. Varying survival of progeny and different levels of productivity, under a range of environmental conditions, provides a basis for understanding genetic selection for well-adapted animals and opportunities for making better culling decisions.

The work program will also include development and evaluation of auto-monitoring such as accurate roll-call, walk-over weighing and behavioural changes such as position in the flock when moving between paddocks or into water. Reducing the labour requirement while improving early detection of sheep needing attention is expected deliver better welfare outcomes and improve productivity.

Acknowledgements

I would like to thank Michael Thomson for his constructive suggestions on an earlier draft of this paper. This paper is an extract from a similar prepared for the Graham Centre Sheep Forum in Wagga Wagga (28 June 2013) and is printed in the proceedings of this conference with kind permission of the Graham Centre.
Introduction

The Australian sheep industry has undergone some significant changes in the past few decades. Many factors have brought about a dramatic fluctuation in sheep numbers from a peak of 170 million during the 1980’s to the current level of around 75 million (Barker 2013). Droughts, fluctuating prices, the influence of technology in competing enterprises and a generational shift in attitudes toward rural expectations have all impacted the current sheep industry. In addition to the huge variation in sheep numbers, the genetic composition of the population has changed from a predominately Merino maternal base with 2-3 main breeds used for cross breeding, to the current population which contains a significant mix of diverse genetics specifically suited to a much wider range of commercial preferences. The development of composite genetics for specific environments or markets has allowed commercial producers to tailor genetics for their specific requirements.

Perhaps the most significant development in the Australian sheep industry has been the development of a comprehensive performance recording system, Lambplan and MerinoSelect, under the management of Sheep Genetics Australia (SGA) that has replaced the time honoured system of visual classing and assessment. Historically, genetic gain has been slow and inconsistent with some momentous “breeding fads” actually stalling or reversing genetic gain for several generations. A performance recording system that independently evaluates measurable traits producing Australian Sheep Breeding Values (ASBV’s) has allowed for the consistent and rapid improvement across a range of commercially relevant traits that has been independently proven to increase profits across all breeds (Ramsay 2012).

The past 5-6 years has seen this advantage taken to the next level with the Sheep CRC using single nucleotide polymorphism (SNP) chip technology to identify DNA marker information and generating genomic breeding values that supplement ASBV’s for traits that have been historically been measured and has made possible selection for a range of traits that are hard to measure or cannot be measured on a live animal. The immediate advantages of DNA testing young animals is obvious but the identification of commercially advantageous traits alone will not improve genetic gain; it is the deliberate application of this technology into breeding programs that allows for accelerated and reliable genetic gain.

Genomics for easy to measure traits

The use of ASBV’s allows for the prediction of the genetic merit of animals based on a range of phenotypic measurements adjusted for external influences and estimations based on pedigree and linkages between relatives and across different breeding enterprises. Seedstock producers use this information to tailor their genetics with an emphasis on the commercially relevant core traits relating to carcase (Growth, Fat, Muscle), wool (Fleece Wt, Micron) and fertility traits. This has resulted in excellent genetic gain in the Australian sheep industry and allowed for confident selection of superior genetics based on accurate, independent analysis of large amounts of data across all breeds and environments. The more data collected and analysed, the more accurate the ASBV’s on individual animals.

Inclusion of genomic breeding values, currently referred to as Research Breeding Values (RBV’s), into this analysis increases the accuracy of the performance values, therefore increasing the confidence in selection of high performance individuals. It is the early measurement of these core traits that provides the greatest advantage. DNA analysis at an early age also allows for the prediction of lifetime performance across a number of commercial traits that would otherwise have taken years to collect and analyse therefore allowing more confident earlier use of these genetics in breeding programs than would have been the case if relying on phenotypic measurements alone. Earlier use of genetics and
faster genetic turnover delivers faster genetic gain. While the advantage gained for the core traits is minimal in Terminal genetics due to the current widespread use of young genetics and accurate ASBV’s, it is the lifetime wool predictions in the Merino that will benefit most from DNA testing producing values for wool traits that may have taken 2-3 years to physically collect. The identification of the poll/horn gene marker is one test that is already being adopted in the Merino industry. One of the defining advantages of genomics is that, not only is it possible to gain early information on phenotypic traits that may take many years to physically measure, but we can also determine the impact of specific traits that contribute to lifetime profitability.

Genomics for hard to measure traits

Phenotypic traits that are easily measured have long been the focus of almost every structured breeding program. There are several traits that are hard to measure or almost impossible to physically measure on live animals and the use of DNA analysis has enabled breeders to confidently select for these traits. Predominately these traits relate to meat eating quality (Shear Force Tenderness, Intra Muscular Fat and Lean Meat yield), parasite resistance (Worm Egg Count), meat nutrition (Omega -3, iron, zinc), taste and shelf life properties, lifetime wool production traits (Adult Fleece Weight, Fibre Diameter, Staple Strength) and fertility (Number of Lambs Weaned). These traits, while some may not have obvious direct commercial impact to sheep producers, are vitally important to the processor, retailer and consumer. The consideration of these hard to measure traits into a breeding program is made possible through the generation of RBV’s, based on significant research and the identification of DNA markers as part of the Sheep CRC program. The integration of RBV’s into a sheep breeding program allows, not only consideration for phenotypic traits that are economically important to sheep producers, but consideration for those who handle and utilise the product after the raw product is sold off farm. This ultimately has significant impacts on the acceptability and market growth of the superior product and confidence to purchase the product in the commercial marketplace.

What Genomics means to the Industry

Clear advantages of utilising genomics for core traits alone are greater accuracy, earlier selection for superior animals and increased selection pressure which collectively results in faster genetic gain. Work in the dairy industry has shown genetic gain using genomics in a breeding program to be double that of traditional breeding systems (Schefers 2012, Hayes 2009) and can result in profits more than twice that from non genomic based programs (Taubert 2011). Gains of this magnitude may not be achievable in the sheep industry as Lambplan/Merino Select is already achieving reasonable genetic gain but genomics will enable additional gains across a much wider range of traits to be realised. Screening for traits using DNA analysis on very young animals and the subsequent generation of RBV’s will allow for all aspects of both phenotypic traits and hard to measure traits to be incorporated into a structured, multi-focused breeding program. While this provides benefit in traditional natural breeding programs, the use of artificial breeding techniques such as ET or JIVET/MOET will provide breeders with the confidence and means to quickly multiply superior genes resulting in significantly faster genetic gain and the accelerated spread of these superior genes throughout the sheep industry. Who ultimately benefits? Everyone within the Australian sheep industry from commercial sheep producers, right through to consumers.

The use of genomics adds to the accuracy and therefore confidence in any breeding program. What was historically a hit and miss approach to selection is now, with genomics, a measured calculation of all variables to achieve desired outcomes resulting in shorter intervals for adoption of superior traits and greater economic gain. Traditionally, relatively small selections of superior individuals were identified and tested to evaluate the probability of producing superior progeny. The genetic worth of sires was primarily assessed using progeny testing and the result, good or indifferent, may have taken several years to determine. With the use of genomics, a much larger population of individuals can be screened and assessed at a significantly earlier age for superior genes without the guesswork of either visual selection or decisions made with limited information. While DNA screening would predominately be limited to screening of potential young sires, the obvious potential to also screen selections from the ewe flock and use targeted ET or JIVET programs becomes evident. The impact within a breeding operation of ewe genetics is limited due the smaller numbers of progeny produced;
to be able to enhance the influence of the maternal component within a breeding program only adds to
the potential gains genomics offers.

One of the major constraints of any breeding program is the existence of correlations that can
impede the progression of specific objectives within a breeding program. These correlations exist in
all breeds but are especially important in the wool industry where many negative correlations exist
between carcase traits, fertility and wool characteristics. However, within any population there are
individuals that break the trend and the use of genomics allows seedstock producers to quickly and
confidently identify individuals that break targeted correlations and allows breeding toward a multi-
foocussed breeding objective without sacrificing one trait against the other. Traditionally, these “curve
benders” are the main reason why genetic gain has experienced phases of above average acceleration
and identifying them was more good luck than good management. Identifying them earlier using
genomic testing will only further accelerate the gains made through targeted selection for more than
one trait.

Identification and consideration of correlations in a breeding program is vital to achieving specific
breeding objectives. Without genomics this is predominately guesswork and to concentrate breeding
aims on more than just a few traits would often lead to limited or no progression in the breeding
program. The greatest benefit of genomics in this situation is the early identification of a range of
selected and varied traits on live animals allowing for the selection of individual animals that have the
right mix of traits all heading toward a targeted breeding objective. Genomics offers the unique
opportunity to concentrate selection pressure on a specific trait and at the same time regulate the
influence of negatively correlated traits to ensure genetic gain is not compromised. Genomic selection
should not result in a major change of breeding goals but it will add another level of selection on
which to make sire selections and consequently should improve the outcomes of selection decisions.

Genomics offers the opportunity to not only improve production traits but facilitates the
development of product differentiation based on RBV’s. The development of a niche market or
branded product requires some strict assurances to maintain quality and consistency. Genomics offers
a means to benchmark product excellence whether it is meat eating quality or wool quality that is
being marketed. The development of benchmarks based on genomic RBV’s are able to be
independently applied across the whole industry and provide confidence to producers and consumers
that whatever is claimed within the product description has been accurately verified through DNA
testing. Genomic benchmarks for meat eating quality in Australia are a real possibility within a very
short time frame and the same could be developed for a whole range of traits identifiable through the
use of genomics.

The development of genomics and the subsequent collection and storage of DNA will become a
significant asset for all livestock industries. As breeding lines become closer due to the extensive use
of superior animals to multiply favourable genes, so too does the risk of proliferation of harmful or
mutant genes. The existence of a data base of collected DNA will assist industry to identify and
control the expression of these faults in the sheep industry thus alleviating the need to develop a new
procedure for investigating the gene/s responsible. While research is currently looking at specific
genes in relation to current priorities within the Australian sheep industry, the future will more than
likely raise new issues and the existence of a substantial DNA collection will enable historical
investigation of any new trait that may become relevant.

Management Advantages using Genomics

Constant collection of data to obtain ASBV’s is time consuming and always has a human element
that can result in inaccuracies with data collection. While some degree of phenotypic measurement
needs to be maintained to retain the relevance and accuracy of RBV’s, there is the opportunity to
either reduce or temporarily cease phenotypic measurements and rely primarily on genomics to
evaluate potential high performance individuals. This could be appropriate in a drought season where
the genetic potential of a group of animals is not able to be achieved and rather than be cautious about
selections based on animals that have not reached their potential, the use of genomics will provide
confidence in the selection of superior animals, regardless of the effect of a tough season. Genomics would also assist where decisions have to be made to reduce flock numbers due to a range of circumstances enabling the higher performing individuals to be retained based purely on genomic predictions. The requirement to retain all animals to gain a full complement of phenotypic measurements is avoided allowing management to better deal with situations where flock structure and size may require some hard decisions to be made.

Identification of superior individuals or selection pressure has traditionally been achieved by an initial selection of a significant number of potential candidates and the preferential feeding and constant evaluation over an extended period of time of these individuals which has an associated higher cost of both inputs and management. Genomics offers the cost advantage of significantly reducing the number of potential young high performance sires that need to be set aside and evaluated, therefore reducing both feed and time inputs into the management of the next generation of sires. This results in the same high selection pressure but with a reduced impact on management. Young sires can be assessed using genomics, incorporated into joining programs and have progeny on the ground well before traditional means of evaluation would have provided enough information and confidence to use these sires.

Genomics allows for some significant changes in the manner by which we manage our stud flocks. Rather than attempting to fit genomics into current management practices, we now have the opportunity to structure flock management around genomics. The use of genomics goes beyond identification of production traits, but also provides animal identification and parentage which has vast implications for time management and efficiencies on property. The use of syndicate joining has always had the weakness relating to the absence of reliable pedigree information. While an ideal process in which to test a selection of ram lambs, the inability to accurately determine pedigree or the complete loss of the pedigree of progeny negated any advantages gained. Single sire joining while ensuring reliable pedigree information is a relatively inefficient use of resources and has the potential to result in lower conception rates or complete failure. Genomics not only allows early selection of potential young sires, but the subsequent accurate progeny matching to these sires. It allows the development of more appropriate breeding programs that are easier to manage, have superior economies of scale and provide elevated rates of genetic gain. The use of genomics results in more efficient use of inputs and higher gains through better use of all resources on property.

**Practical Application of Genomics: A Case study**

**TRADITIONAL SELECTION**

Potential sires are selected from a select group of sires that have been fully performance tested to provide accurate performance figures and are joined to groups of ewes selected from computer modelling with the objective of breeding to a mid parent value accounting for the performance figures of the ewe. Consideration of commercially relevant traits is restricted to what can actually be measured or obtained from correlations. For a January/February joining, all the information on young sires is not usually completed when the decisions on which sires to use have to be made so predominately hogget sires are preferred.

All mating groups are to a single sire to ensure accurate pedigree and backup rams in any AI program are preferably single sire. If ram lambs are to be used, they are also single sire joined but the problem of potentially very low conceptions is always a concern, especially involving ewe lambs which potentially provide the greatest genetic gain. The property is not set up with enough smaller joining paddocks and this can compound the problem of single sire mating. The process of joining in single sire mating groups requires numerous secure paddocks, preferably not too large, and intensive management of these groups to ensure that all ewes are joined successfully and the ram is actually working. Lambing involves tagging three times a day and recording of data associated with lambing to ensure accurate pedigree, but at best it is still not one hundred percent accurate as some ewes will walk off with another ewe’s lambs. The collection of all relevant data at lambing is crucial to ensuring the performance values attained are accurate and meaningful.
A typical data set required to gain ASBV’s on a specific sire is as follows:
Stud ewe 075718 gives birth to a set of twins on the 16th June 2011. We know that she was joined on the 17th January to sire 075630 as part of a synchronised joining program. The birth was unassisted and the other twin survived and was reared as a twin. The birth weight of the ram twin (Tagged 119194) was 5.7 kg and the ewe twin was 5.0 kg. A weaning weight of 54.2 kg was recorded on the 24th October and a subsequent weight and scan measurement on the 23rd March recorded a weight of 60.5 kg with 3.5 mm of fat and a muscle depth of 36 mm.

All this information is submitted to SGA, analysed through the Lambplan data base and information returned by the end of March 2012 as listed in Table 1, nine months after the birth of the sire. Previous to this final detailed information, all ASBV’s were based on weight measurements alone, the influence of pedigree and various correlations relating to phenotypic measurements collected.

Table 1. Typical reporting of ASBV results on an individual animal from Lambplan

<table>
<thead>
<tr>
<th>Pendarra 119194</th>
<th>Sex</th>
<th>Dob 16/06/2011</th>
</tr>
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<tr>
<td>2303242011119194</td>
<td>Bwt</td>
<td>0.07</td>
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<tr>
<td>7Mwrt</td>
<td>2.81</td>
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<tr>
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<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>Carcase</td>
<td>178.76</td>
<td></td>
</tr>
<tr>
<td>Lamb2020</td>
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</tr>
</tbody>
</table>

**GENOMIC SELECTION**

A group of potential young sires is selected from a large group using DNA testing in combination with breeding values for not only core traits but also hard to measure traits. Joining is not restricted to single sire mating due to the access of reliable parentage matching using genomics. This not only provides more accurate parentage but more efficient use of resources. Syndicate joining (more than one sire per ewe group) can be used to enable more efficient use of large paddocks, especially important to ensure good conception outcomes with ram lambs over ewe lambs and invaluable when the property is limiting in resources such as feed or water in a particular season.

Currently to gain a set of performance values on a sire using genomics, the same amount of phenotypic data is collected plus a blood sample is taken at weaning to provide all the information detailed in Figure 1 with better accuracies for the core traits and information on traits that are hard to measure. Information can also be gained on traits such as worm resistance which cannot be measured physically on the property due to low worm burden in a dry environment.

The advantage is that larger number of potential sires is able to be blood tested to ensure all potential candidates are fully evaluated for a range of traits exceeding what is traditionally available through phenotypic data collection. The blood cards are returned through SGA for analysis and the information is then available to be used by the end of November, five months after the birth of the lamb, therefore enabling genuine consideration for the use ram lambs for a January/February joining program.

The information required also allows for consideration of a whole new range of traits previously not possible with just phenotypic analysis and allows management decisions based on more accurate analysis of the complete genetic composition of the individual from genomic information combined with the actual measured performance of the animal. The influence of meat eating quality RBV’s is a significant consideration in our breeding objectives and genomics allows a balanced approach to achieving breeding objectives.
Collection of DNA has the potential to replace all phenotypic measurements with Genomics information alone. While this is a decision that will be up to individual breeders and we will continue recording all phenotypic measurements, it does provide an ideal opportunity during a tough season to make selections very early on which animals to retain rather than feeding the entire lamb drop through to obtain a complete set of meaningful phenotypic data resulting in huge savings on feed costs. In a situation where feed conditions have prevented the full genetic expression of traits, or lambs are being moved to a separate property, genomic testing provides additional confidence in selection of potential young sires that do not have the full complement of phenotypic measurements recorded. All these opportunities for better management and cost savings are possible through the well thought-out use of genomics in a breeding enterprise.

**Conclusion**

Genomics is the “Satellite Navigation System” for the Australian Sheep industry that will allow breeders to more accurately develop a genetic blueprint for achieving targeted outcomes and at the same time increase rates of genetic gain. It will allow breeders to navigate around issues that have previously been virtually impossible to resolve and provide new opportunities for future breeding programs and the development of new products.

Genomics also offers the opportunity to adjust flock management to increase efficiencies of both inputs and time. The overall contribution of genomics to industry is more consistent and accelerated genetic gain resulting in higher returns to producers and more consumer confidence in the products that the Australian sheep industry through its producers is marketing.

**References**


Managing Scanned Ewes – Sheep CRC Workshop Series

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Summary

Estimates suggest about 30\% of the national ewe flock is scanned to determine pregnancy status. Most of the scanning is said to identify wet and dry ewes; scanning ewes for twins is increasing and, more recently, so too is foetal ageing. Evidence is building that supports the value of pregnancy scanning using ultrasound, with benefits for the ewe, the lamb and their production. The Co-operative Research Centre for Sheep Industry Innovation (Sheep CRC) supported the ‘Managing Scanned Ewes’ (MSE) workshop series, which was delivered between 2009 and 2012. The workshops were attended by 1571 producers, who were responsible for over 3.14 million sheep. These workshops aimed to: extend the practice of pregnancy scanning and ewe management to producers across the nation; increase adoption of scanning; and increase the productivity of the national ewe flock. This paper reviews available literature on the benefits of pregnancy scanning and presents a summary of the workshop presentations and the outcomes of the MSE workshops.

Introduction

There are currently 110 pregnancy scanners operating in Australia. These operators are estimated to be scanning approximately 30\% of the national ewe flock. Thus, the number of scanned ewes is around 12 million, of which about 60\% (7.2 million) are scanned for wet and dry (pregnant or not pregnant), while the remainder are scanned to identify twin lambs (4.8 million). It is expected that the number of ewes scanned will continue to increase with concomitant increases in the number of ewes scanned for twins.

At the November 2012 national conference for pregnancy scanners, the 40 operators in attendance indicated that the number of producers requesting scanning for twin lambs was increasing, was higher among crossbreed producers and was higher in high rainfall environments. Among Merino producers and in lower rainfall environments, scanning requests were more commonly for wet and dry status. Requests to estimate foetal age are also increasing, again with more crossbred producers in particular asking for the late mated ewes to be additionally drafted or identified.

Review of literature

Real-time ultrasound scanning of ewes at gestational ages between D50 and D100, is a safe and practicable means of diagnosing pregnancy status (White \textit{et al.} 1984), with accuracies of 97\% for the number of lambs born compared to the number of foeti identified (Fowler and Wilkins 1984). Real-time ultrasound can be used to identify pregnancy status from as early as D25 to the point of lambing and can also be used to identify reproductive tract disease in the male and female (Buckrell 1988). Current recommendations are to diagnose pregnancy at 45 days post-breeding, at which stage accuracy is sufficiently high (Goel and Agrawal 1992).

Identifying pregnancy status provides the opportunity to reduce nutritional supply to dry ewes and enhance nutrition for twin bearing ewes. The first implication of pregnancy status diagnosis is that flock segmentation is required to realise the potential benefits. For the benefits of scanning to be maximised, the opportunities it provides to increase selection pressure for improved fecundity, reduced reproductive wastage and increased wool production must be utilized (Bowman \textit{et al.} 1989).
The first Australian publication examining the potential of real time ultrasound in pregnancy diagnosis was that of Fowler and Wilkins (1984). That study was undertaken with a slow operator scanning speed of one minute per sheep. The study was able to demonstrate accuracy of pregnancy diagnosis to be 99.4%, with an accuracy for the number of foeti present being 97%. Factors affecting accuracy included litter size and foetal age. Diagnosing pregnancy in ewes at 40-47 days post-mating was 93% accurate, which returning to 98% for ewes at 56 to 96 days. Scanning for wet and dry was 100% accurate, identification of single lambs was 98% accurate and for twins was 68-80%. Improving techniques and increasing the time taken to examine ewes increased twin accuracy to 93.8%. Differences between operators were small, but training was recommended to lift accuracy. The most common error was twins being present in ewes scanned as singles. Triplets and quadruplets were generally inaccurately identified, but were at least always identified as twins.

Curnow et al. (2011) discusses the complexity of on-farm adoption, highlighting variation between farmers in their attitude to risk, their knowledge and skill levels and their confidence under peer review by neighbours as common barriers. Vanclay (2004) discussed up to 27 principles affecting adoption of technology and practices by farmers, 16 of which relate to sheep-focussed farm systems, the most important being that technology is not automatically legitimised because it is scientific and the perception of low profitability in particular farmers’ environments associated with various technologies. What is clearly needed is an examination of the motivations for scanning practice across regions, supported by economic analysis to highlight the conditions when pregnancy scanning is profitable, and under what circumstances it is not.

The value of pregnancy scanning

There continues to be disagreement about the value pregnancy scanning offers producers. Studies of producer focus groups in Western Australia found a dichotomous view towards pregnancy scanning. Some producers felt it was an essential tool to manage scarce nutrition; others felt it was not worth the cost. Those producers who did not favour pregnancy scanning tended to be happier with their flock fertility and lamb survival rates (Elliott 2011). The strong view was that in flocks with very high fertility rates (the number of ewes pregnant per ewe mated), there was no value in scanning, no saving of feed costs in removing “half a dozen dry ewes in a hundred”. This demonstrates an economic approach is taken by producers to the importance of pregnancy scanning, but which does not consider the biological (genetic) ramifications. The genetic value is long term improvement of flock reproduction. The sheep industry requires is a set of conditions that need to be met before a positive return on investment can be achieved, for a wide range of environments and business structures (i.e. location, dam breed, proportion of wethers and proportion of crossbreeding).

Economic modelling of the value of pregnancy scanning in South West Victoria suggested benefits of pregnancy scanning of about $1.55 per ewe (Young 2008). Identification of dry ewes and their sale after shearing was the most significant contributor to the return on investment (60% of profit), while management of twins as a separate mob accounted for 40%. If dry ewes are 5% or less there was no value in scanning and only when twin rates were 15% or more, did it become profitable to scan for litter size. The cost of scanning itself, per ewe, had a relatively minor influence on the return on investment in scanning and, hence, should have an equally minor influence on the decision to scan for pregnancy status (Young 2008). This economic study revealed the circumstantial conditions that need to be considered by the producer to capture the full value of scanning.

Holmes and Sackett (2006) examined scanning ewes for twins and identifying foetal age. Recommendations were made to maintain the condition of single bearing ewes that will lamb in the first cycle and to supplement twin bearing Merino ewes to avoid dramatic loss of condition (i.e. so the ewe does not lamb in less than condition score two). At feed costs of $170 per tonne, the breakeven price was $25 per Merino lamb. It was important that improvements in twin lamb survival occur. The advice for the management of crossbred ewes, when lambs were valued at a $60, was not as clear.
In a later edition, Holmes and Sackett (2008) stated that for crossbred producers to justify the cost of scanning and feeding twin bearing ewes, there needs to be at least 10% dry ewes in the flock. That modelling assumed improvements in lamb survival were uneconomic for crossbred ewes and deliberately aimed to offer ewes 75% of their maintenance requirement. For Merino producers, modelling showed similar returns to crossbred ewes, when the proportion of dry ewes was around 10%. The return on investment in scanning increases when the proportion of twin ewes increases. The take-home message from Holmes and Sackett (2008) was that it was more profitable not to scan but ensure adequate nutrition for ewes in late pregnancy, managing them as if the whole flock were bearing a single lamb and were to lamb in the first cycle of lambing, rather than scanning and managing according to pregnancy status.

It is not clear if any of the economic studies accounted for genetic gain, achieved via the additional selection pressure attained from the increased surplus of young sheep. Furthermore, the assumptions made in the models were based on reductions in lamb survival of average birthweight lambs and did not consider the much larger reduction in survival for already light weight lambs. As is discussed later in this paper, there are also benefits for the dam’s fleece weight and ewe survival, as well as for the fleece and liveweight of the offspring. Improving aspects of reproduction is not simply about the economics, however, implications for animal welfare (ewes and lambs) must be considered. For example, some authors have posited that lamb mortality rates of greater than 5% are unacceptable (Fragkou et al. 2010). Lamb mortality rates in Australian are commonly between 15 and 20% (Hinch 2008).

**Scanning for litter size**

There is some debate about the benefits of scanning for litter size (twinning). The study undertaken by Hocking Edwards et al. (2011) is one of the best demonstrations of what pregnancy scanning can contribute to long and short term profitability. Some ewes were managed to lamb in body condition score 3 (Jefferies 1961; Russel et al. 1969), having been scanned for litter size. The study compared the performance of ewes managed for body condition score three (CS3) to ewes managed according to local practice. It was revealed that the normal practice resulted in ewes being fed 70-90% of their average requirements during early to late pregnancy, only meeting 100% of the requirement of single bearing ewes during lactation; 15% of the flock were bearing twins. Compared to the ewes managed according to local practice, those managed for CS3 had heavier fleeces and improved ewe survival. Of the progeny born to CS3 ewes, newborn lamb survival was significantly higher in single (+11%) and twin (+29%) lambs. Liveweight was higher at weaning and to 6 months of age, by which time the single lambs of ewes managed according to local practice caught up to the twin lambs of ewes managed to achieve CS3. Compared to the fibre production of all single-born lambs, the fleece weight over three shearings was no different for CS3 twins, with little or no difference for aspects such as fibre diameter or staple strength.

No formal examination of scanning practice across regions appears to have been undertaken. Anecdotally, adoption of twinning appears to have some regional distribution. Pregnancy scanners whose clients operate in rangelands and semi-arid environments are most commonly directed to wet and dry. Towards the Slopes and Tablelands, in the higher rainfall environments of NSW, pregnancy scanners are more commonly directed to ‘twin’ the ewes and “spray-mark the lates”.

**Scanning for foetal age**

Adoption of scanning for foetal age appears to attract a growing interest, but there has been no formal study of the value of ageing to producers.

Early Australian work was able to develop models for age prediction based on the length of the metacarpal (cannon) bone and the biparietal (skull) diameter (Greenwood et al. 2002). In that study, estimates of foetal age were made to 5 days of age. In examining a single operator, Robertson et al. (2012) found that estimating age to 5 days was too imprecise. Ageing to 5 days was satisfactory for lambs 10.5 and 12 weeks of age, but was not satisfactory for lambs 10 weeks and younger. Those authors, however, continued to support grouping scanned ewes into early and late mobs. It is
recommended that producers wanting to separate groups of ewes into foetal age mobs need to make some assessment of the accuracy of their operator before establishing the practice as a routine activity. It could be reasonably assumed that operators improve their accuracy with experience and sufficient feedback. In which case, continued advanced training for operators is likely to yield improvements on the return on investment for foetal aging and twinning.

Future uses for pregnancy scanning might also include scanning pelvic dimensions to identify ewes with elevated probabilities of dystocia, and to do so early in life, before mating maiden ewes (Warren et al. 2012). It might be possible to select rams on this basis also, to mate to large or smaller pelvis ewes.

Managing scanned ewes - workshop program

Since 2009, 78 managing scanned ewes (MSE) workshops have been undertaken. These workshops have been attended by more than 1500 producers (Table 1), under whose management were more than 3.14 million sheep. The MSE workshops were held in each sheep producing state, with NSW, Victoria and South Australian producers hosting the most (Table 2).

Table 1. Total number of workshops, their participants and the number of sheep managed by participants for each year of the program

<table>
<thead>
<tr>
<th>Year of workshop</th>
<th>No. of workshops</th>
<th>No. of participants</th>
<th>No. of sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>28</td>
<td>501</td>
<td>901,360</td>
</tr>
<tr>
<td>2010</td>
<td>16</td>
<td>363</td>
<td>777,610</td>
</tr>
<tr>
<td>2011</td>
<td>14</td>
<td>317</td>
<td>695,490</td>
</tr>
<tr>
<td>2012</td>
<td>16</td>
<td>321</td>
<td>595,180</td>
</tr>
<tr>
<td>2013</td>
<td>4</td>
<td>89</td>
<td>175,100</td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>1519</td>
<td>3,144,740</td>
</tr>
</tbody>
</table>

Table 2. Total number of workshops, their participants and the number of sheep managed by participants by state

<table>
<thead>
<tr>
<th>State</th>
<th>No. of Workshops</th>
<th>No. of Participants</th>
<th>No. of Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>27</td>
<td>678</td>
<td>1,099,040</td>
</tr>
<tr>
<td>Vic</td>
<td>22</td>
<td>436</td>
<td>709,260</td>
</tr>
<tr>
<td>SA</td>
<td>15</td>
<td>251</td>
<td>538,660</td>
</tr>
<tr>
<td>Qld</td>
<td>8</td>
<td>142</td>
<td>385,770</td>
</tr>
<tr>
<td>Tas</td>
<td>2</td>
<td>44</td>
<td>215,230</td>
</tr>
<tr>
<td>WA</td>
<td>2</td>
<td>25</td>
<td>na*</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td>1571</td>
<td>3,145,370</td>
</tr>
</tbody>
</table>

*na, no data was available

Surveys in 2011 of MSE workshop participants attending during 2010 and up to June 2011 revealed that 51% of participants felt the workshop had a major or moderate impact on their flock reproduction, with 75% reporting increases of 10 to 15% in lambing percentage. This improvement was attributed to higher conception rates, better lamb survival or both. The majority of producers (75%) aimed to get their flock in condition score 3 for lambing.

Since attending the workshop, 79% of producers scan for twins, compared to 49% prior to attending. After scanning, 63% tried to manage their mobs according to nutritional and management needs, yet only 55% examined udders for wet and dry ewes after lambing (Hatcher et al., 2013). Other practice changes included 74% of respondents selecting better lambing paddocks, providing more
shelter, creating smaller lambing-mob sizes and providing some supplementation for twin bearing ewes.

**National scanners training workshops**

Training workshops have been provided to improve the consistency and quality of sheep scanning. At these workshops pregnancy scanners are provided with updates on technology and are retrained in the methods of identifying litter size and estimating foetal age. Table 3 lists the number and location of workshops which have been undertaken since 2011. The process of gathering the scanners has helped to identify reproduction issues and make observations of adoption within the industry. In the absence of the Sheep CRC providing support for training workshops, there remains a strong enthusiasm among existing operators to continue group training events, which may be self-funded events.

**Table 3. Location, date and number of scanners attending scanner-training workshops**

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Number scanners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burra SA</td>
<td>February 2011</td>
<td>10</td>
</tr>
<tr>
<td>Uralla NSW</td>
<td>March 2011</td>
<td>5</td>
</tr>
<tr>
<td>Canowindra NSW</td>
<td>November 2012</td>
<td>25</td>
</tr>
<tr>
<td>Bendigo Vic</td>
<td>July 2010</td>
<td>50†</td>
</tr>
<tr>
<td>Canowindra NSW</td>
<td>November 2012</td>
<td>40†</td>
</tr>
</tbody>
</table>

† Workshop held as part of the National Scanners Conference

**Managing scanned ewes - workshop content**

By 2007 the national flock had fallen in size to around 71 million sheep (ABARE 2007). Adding to the pressure on the flock size was a record high lamb slaughtering. These facts motivated the Sheep CRC commitment to the MSE program.

The MSE workshops centred on re-educating producers on topics of reproduction management and discussed how to include pregnancy scanning into existing management programs. The discussions focussed on management interventions relevant to issues such as: matching feed supply to feed demand; identifying critical times of the reproduction cycle; managing sheep health; ewe condition; causes of lamb mortality; how to plan a successful scanning; how to manage dry, single and twin bearing ewes; how to undertake selection for reproduction and what level of gross margin was associated with different levels of reproduction for a range of enterprises.

Key messages of the MSE workshops included selection of ewes for fertility, where identifying twice dry ewes and culling them achieved the greatest rate of gain in flock fertility while removing the smallest fraction of ewes. Pasture quantity targets were identified for single- and twin-bearing ewes and producers were shown how to assess ewe fatness. Benchmark fatness values were identified for the stages of reproduction. Producers were also shown how to assess reproduction levels in their flock and were encouraged to develop annual management programs to achieve improved reproduction and to consistently refer back to them.

**Conclusions**

The number of ewes being pregnancy scanned across Australia is increasing. This suggests that producers view pregnancy scanning as a means to cost-effectively increase weaning rates. The science examining the value of pregnancy scanning demonstrates that it is accurate and offers improvement to ewe and lamb survival and subsequent productivity, but that the degree of complexity pregnancy scanning offers in terms of flock segmentation and supplementation needs to be considered against both economic and genetic circumstances. The MSE workshops have delivered high quality ewe management information to a large group of producers, to support the growth of the practice. Decisions on how to incorporate pregnancy scanning into their flock need to consider a range of important factors including economic, genetic and welfare outcomes. The MSE workshops have been
able to do this for the participants, whose changes in sheep management have resulted in increases in weaning rates.

References


Staple strength – What have we learnt from the Sheep CRC’s Information Nucleus?

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Summary

The measurement of staple strength does not have a single, simple biological basis as it was developed as a physical measure primarily to predict the efficiency of early stage processing. This fact is a likely contributor to the large differences in phenotypic expression of SS both within and between flocks, which in turn makes on-farm management of SS complicated. Genetic improvement of SS can produce long term improvements as the yearling and adult expressions of the trait are both highly heritable and highly genetically correlated. The considerable variation in ASBVs for yearling and adult SS provides an opportunity for commercial sheep producers to identify sires with superior genetics for SS when deciding which rams to purchase for use in their flocks. While a genotype x environment interaction was identified between the IN sites, it is likely to be of little commercial relevance as the correlation between sire EBVs was high. Fibre diameter was the only key wool production and quality trait to have an unfavourable genetic relationship with SS such that selection for increased SS will lead to broader fibre diameter. However, the genetic variation between sires means that there are sires out in industry that combine high ASBVs for SS with low ASBVs for fibre diameter. The coefficient of variation in fibre diameter (CVFD) is an effective alternate selection criteria for SS on a within flock basis when selecting replacement animals to remain in the flock however, more research is required to quantify the value of CVFD for between flock selection.

Introduction

Staple strength (SS) is a physical measurement of a material property. It is the peak force (measured in Newtons, where 1 kg = 9.81N) required to break a staple of a given linear density (measured in kilotex, which is the weight in grams of 1 kilometre of staple):

\[
\text{Staple strength (N/ktex)} = \frac{\text{Force (Newtons)}}{\text{Clean weight (g) / Staple length (mm)}}
\]

The Automatic Tester of Length and Strength (ATLAS) machine was developed in the early 1980s to provide an objective measure of both the length and strength of sale lots replacing visual appraisal of staple length and the ‘flick-test’ for SS. Only staples longer than 50mm are measured for SS as 25mm of each staple is held in the tip and base jaws of the ATLAS and cannot be tested and therefore not broken (Australian Wool Testing Authority Ltd 2000). In 1988, the TEAM Project (Trials Evaluating Additional Measurements) established that key early stage processing performance parameters: i. Hauteur or the average fibre length of top; ii. CVH a measure of the variation in hauteur; and iii. Romaine a measure of the efficiency of the topmaking process – which is the proportion of noil, short fibre, generated during topmaking (relative to the total weight of top and noil produced) can be predicted using the staple measurements provided by the ATLAS together with the standard core test results (Anonymous 1988). The use of the TEAM formulæ as a benchmark has enabled individual mills to significantly improve their processing performance (TEAM-3 Steering Committee 2004).

Staple length and strength measurements first appeared in wool sale catalogues in the 1985-86 wool selling season (Adams and Kelly 2000) and in 1991 IWTO-30 “Determination of Staple Length and Strength” was adopted by the International Wool Textile Organisation (IWTO) as a full test method. This facilitated the calculation of premiums and discounts for staple length and strength based on the auction prices paid for individual sale lots. Given the significant impact of SS on hauteur, CVH and romaine it is not surprising that SS is consistently second only to fibre diameter as a key determinant of the value of raw wool (Australian Wool Innovation and Meat & Livestock Australia 2008). Wool measuring 35N/ktex is considered ‘sound’ and is used as the benchmark for reporting
premiums and discounts for wools of varying SS. The premiums paid for high SS sale lots and the discounts applied to sale lots with low SS are both considerably greater for fine wools compared to medium wools (Figure 1). The range in price paid for wool varying in SS from 14N/ktext to 40N/ktext in fine wool is commonly 250c/kg clean, while the same range in medium wools is 100c/kg clean. Given these clear price signals, it is not surprising that increasing the SS of their wool clip continues to be a major goal for many Australian Merino producers, particularly those producing fine wool.

Figure 1. Premiums and discounts (c/kg clean) applied to various staple strength (relative to 35N/ktext) at auction for (a) fine (17.5 – 19.5 \( \mu \)m) and (b) medium (19.5 – 21.5 \( \mu \)m) wool from Apr 1995 to Oct 2009 (Source: http://www.wool.com/Fibre-Selection_Woolcheque_Wool-characteristics_Price-schedules.htm 30Apr13)

SS – a material property not a biological phenomenon

As detailed above, SS measurement was developed to measure a material property and does not directly relate to a single biological phenomenon (Adams et al. 2000). For uniform single wool fibres, N/ktext is a measure of the intrinsic strength or tenacity of the fibre because the linear density (weight/length) is an estimate of the fibre’s cross-sectional area (Hynd and Schlink 1993). However staples consist of many hundreds of single wool fibres and the measured strength in N/ktext does not solely relate to the intrinsic strength of the proteins that make up the fibre. Other key staple components including variation in fibre diameter (FD) along fibres; variation between fibres and follicle shutdown together with intrinsic fibre strength reduce SS from a theoretical maximum of 150 – 160 N/ktext (Schlink et al. 2000; Thompson and Hynd 2009). While these four biological components interact to influence both the tex component of SS and the force required to break the fibres, it is the impact of these components on the tex of the staple that is the most important factor influencing SS. Intrinsic fibre strength has been shown to play only a minor role in determining the SS of wool staples (Thompson and Hynd 2009), while fibre shedding and follicle shutdown are not usually important contributors to variation between animals or flocks in SS (Adams and Kelly 2000). The tex of a staple and its SS is therefore predominantly influenced by those factors that alter the FD along a wool fibre and variation in FD between fibres comprising the staple. As a result, it is not surprising that the SS of an individual sheep is a complex interaction between the environment in which it lives (including seasonal conditions, the nutritional environment as well as rumen microbial effects), the animal’s physiological state, disease status and its genotype (Hynd and Schlink 1993), as each of these factors can have a significant impact on FD both along and between fibres.

Environmental differences in SS

The genetic diversity and geographical location of the 8 flocks that comprise the Cooperative Research Centre for Sheep Industry Innovation’s (Sheep CRC) Information Nucleus (IN) provides a current snapshot of variation in SS across Australia. The average SS of the yearling (shorn at approximately 11 months of age) Merino progeny born between 2007 and 2010 was 32.6N/ktext while that of the adult animals (shorn at approximately 23 months of age) was 35.0N/ktext. However, there was considerable variation between sites for both yearling and adult SS (Figure 2 a&b).
In addition to differences in the environment between the eight IN sites, including rainfall; seasonality of pasture growth; time of shearing relative to the weakest part of the staple; and time of lambing relative to shearing (for the adult ewes), variation in the base ewe population between sites contributed to the significant differences between the sites in SS. For yearling SS each of the sites was different from the others (P<0.001, Figure 2a), IN01 (Kirby), IN02 (Trangie), IN03 (Cowra) and IN04 (Rutherglen) each had above average SS (37.1, 35.4, 37.7 and 35.1 N/ktex respectively) with IN05 (Hamilton), IN06 (Struan), IN07 (Turretfield) IN08 (Katanning) having lower than average SS (27.4, 30.3, 24.9 and 23.0 N/ktex respectively). In general those sites with a Mediterranean climate (i.e. IN06, IN07 & IN08) had the weakest wool (i.e. lowest SS). Interestingly, while the average SS of the adult Merinos was higher than that of the yearlings, the difference was not consistent between flocks (Figure 2b). The variable sensitivity in SS of individual ewes to reproduction (Robertson et al. 2000; Thornberry et al. 1988), is the most likely explanation for the inconsistency. Variation between IN sites is not likely to be the cause as the time of shearing relative to the time of lambing as shearing at most IN sites occurred within 2 months of lambing, meaning the weakest point was likely to be at either the tip or base of the staple not the midpoint.

There were significant differences between drops in both yearling & adult SS (P<0.001). Note that for the analyses of the IN wool data, drop (i.e. the year an animal was born) is fitted as a fixed effect to separate the different cohorts of IN progeny. Therefore, differences between drops may represent both the environment experienced by the animal’s dam during pregnancy and lactation as well as the differences in the wool growing season experiences by the animal itself. For these analyses yearling SS was highest for the cohort of progeny born in 2007 and decreased with each subsequent drop with all drops significantly different from each other (32.1, 30.6, 29.9 and 29.3 N/ktex for 2007, 2008, 2009 and 2010 drop animals respectively). Adult SS was highest for progeny born in 2009 (35.6 N/ktex), followed by 2007 (35.4 N/ktex) and then 2008 (34.6 N/ktex) with all drops again significantly different from each other. There was a highly significant interaction between drop and IN site (P<0.001) for both yearling and SS, which highlights the large influence of the environment on SS. Ewes had lower SS than wethers as yearlings (P = 0.005), but higher SS as adults (P = 0.005). However, the small differences were significant (<0.5N/ktex as yearlings and 1.5 N/ktex as adults). There was no significant difference in either yearling or adult SS due to the MERINOSELECT Wool Type (i.e. ultrafine/superfine, fine/fine-medium or medium/strong), birth rearing rank or age of dam.

The impact of pregnancy status on staple strength

Pregnancy and lactation can have a significant impact on SS with reductions of up to 45% reported for ewes raising twins compared to dry sheep (Thornberry et al. 1988). Among all the IN ewes, dry ewes had the highest SS, followed by single bearing ewes, while twin bearing and lambed and lost ewes were not different to each other (P<0.05 Table 1). Lee et al. (2003) and Masters and Mata (1998) both reported a similar trend, albeit with larger differences in SS between the various pregnancy status groups. However, when the three MERINOSELECT Wool Types in the IN were analysed separately, the negative impact of reproductive performance on SS was greatest for ultrafine/superfine ewes that conceived and raised twins (Table 1).
Managing the environmental differences in SS

On farm management of staple strength was the focus of much work in the late 1990s with the CRC for Premium Quality Wool developing strategies to manage the FD profile (Figure 3) to produce wool fibres that were more uniform in diameter along their length and higher SS (Peterson et al. 2000).

One of the main findings from that body of work was that liveweight can be used as a proxy for changes in the FD profile, therefore minimising liveweight variation over a full year should reduce variability in wool growth, FD variability and hence SS (Peterson et al. 2000). The key windows for managing SS were to increase the initial liveweight (Figure 3, circle 1) or minimise the decline in liveweight over summer-autumn (Figure 3, circle 2) using targeted supplementary feeding or grazing management specifically to control intake on green feed to limit FD increases after the break of the season (Figure 3, circle 3) (Peterson et al. 2000). However, these strategies are not always effective with results varying between autumn and spring shorn wools, the age of the animal, sex and pregnancy status (Peterson et al. 2000). Furthermore, some of these strategies may compromise fleece value through higher FD from increasing the minimum FD, decreasing clean fleece weight per head through increasing stocking rate to limit intake of green feed or negatively impact on the performance of breeding ewes by restricting liveweight gain during pregnancy. Therefore, any management strategy to increase SS must be both carefully considered and executed. Moving lambing or shearing times can lead to significant increases in SS but can also have negative consequences. Moving lambing later in the year can lower weaning weights as weaning will occur when pasture quality and quantity are in decline which can compromise weaner survival, while changing the time of shearing has the potential to increase vegetable matter content (Peterson et al. 2000).

The genetics of staple strength

Given the large impact of the environment and the variable responses to on-farm strategies to manage SS, genetic improvement of the trait becomes an important approach to produce long term...
improvements in SS. The rate of genetic improvement possible for a particular trait is a combination of:

i. the heritability;
ii. the variability; and
iii. the ability to reliably quantify the genetic differences between sheep.

**Heritability, variability and reliably selecting superior sires for high SS**

The heritability of yearling SS was 0.33 while that of adult SS was 0.36 (Table 2), both would be classified as highly heritable traits (i.e. >0.3). The CV of yearling and adult SS were 28.4 and 26.5% respectively. Both the heritability and CV of SS estimated from the IN are similar to the average heritability of 0.34 with a CV of 29.2% reported by Safari et al. (2005). This indicates that SS will respond to selection and the variation between animals will increase the rate of genetic improvement.

<table>
<thead>
<tr>
<th>Average (N/ktex)</th>
<th>CV (%)</th>
<th>Heritability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearling SS</td>
<td>32.6</td>
<td>28.4</td>
</tr>
<tr>
<td>Adult SS</td>
<td>35.0</td>
<td>26.5</td>
</tr>
</tbody>
</table>

Table 2 The average, CV and heritability of yearling and adult SS from the Sheep CRC IN

With respect to reliably quantifying the genetic differences between sheep, there is considerable variation in ASBVs for SS among the sires used in the IN (Figure 4). The average ASBV for yearling SS was -0.2, however there was a range of 18.6N/ktex between the highest and lowest ASBV (-11.1 to 7.5 N/ktex). The range in ASBVs for adult SS was slightly greater, being 20.09 (-9.53 to 10.56 N/ktex). The current range of SS ASBVs in MERINOSSELECT is 25.3 N/ktex. ASBVs therefore, provide a reliable means of ranking sires based on SS and can be used to identify sires with superior genes for SS when making ram purchasing decisions.

Figure 4. There was an 18.6N/ktex range between sires used in the IN for yearling SS

**What about genotype x environment interactions?**

The presence of a genotype x environment interaction (GxE) can change the ranking of a sire from one environment to another. Therefore, selection of a sire based on his progeny’s performance in one environment may not translate into superior performance in a different environment. Within the IN there was evidence of a GxE for both yearling and adult SS. A sire x flock effect included in the modelling of these two traits accounted for 2.8% and 3.7% respectively of the phenotypic variation. Dominik et al. (1999) identified a GxE for SS between 2 management groups (that mimicked typical ‘stud’ and ‘commercial’ nutritional management levels) but concluded that it was not likely to be of

---

1 Sheep Genetics ASBV and Index Percentile Band Table Run date 21-Jan-13
practical significance as the genetic correlation between the two environments was greater than 0.8 (correlations below 0.8 indicate the presence of a GxE of agricultural importance (Robertson 1959). To examine this we compared the performance of sires at Armidale (IN01) and Katanning (IN08) as these sites had the most diverse environments and all IN sires were used at each. For both yearling and adult SS, the correlation between sire EBVs in both environments was greater than 0.8 (Figure 5a&b) indicating that, while present, the GxE for SS is likely to be of little commercial relevance.

\[ y = 0.9553x + 0.0286 \]
\[ R^2 = 0.9589 \]

\[ y = 1.0762x - 0.06 \]
\[ R^2 = 0.96 \]

Figure 5. The correlation between IN sire EBVs at Armidale (IN01) and Katanning (IN08) were greater than 0.8 for both yearling (a) and adult (b) SS indicating a GxE of little commercial relevance

When is the time to select sires?
Within the IN, the genetic correlation between yearling and adult SS was high (0.85) indicating that the SS of wool grown at the yearling and adult stages are affected by the same genes. This means that selection for SS at the yearling age is highly genetically correlated with stronger staples as adults and yearling rams will retain that superiority as they get older.

What about genetic relationships with other wool production and quality traits?
SS is only one of a range of wool quality traits that impact on the price paid for wool, so selection decisions must be made on the range of traits that impact on enterprise profitability. It is therefore, important to take into account the genetic relationships with other traits including liveweight, wool production and both visual and measured wool quality. The genetic correlation between YSS and YFD was low (0.27), that between YSS and AFD negligible (0.16) but those between YFD and YSS (0.46) and AFD and ASS (0.43) were both moderate. These estimates are similar to those reported by (Safari et al. 2005) and are indicative of a unfavourable genetic relationship between SS and FD such that genetic selection for increased staple strength will lead to broader fibre diameter. The plot of the IN sires ASBVs for YSS and YFD provides a graphical representation of this genetic relationship, with the trend line clearly showing that on average sires with higher ASBVs for YSS will also have broader than average ASBVs for fibre diameter (Figure 6). However, the genetic variation occurring between sheep can be used to identify and select sires that ‘buck’ this trend, there are sires in the top left hand corner of the chart that combine high ASBVs for SS with low ASBVs for FD, that is their progeny grow fine fleeces with high SS.
With the exception of FD and resistance to compression (RTOC), all of the significant genetic correlations between SS and other wool production and quality traits are favourable (Table 3). Selection for increased SS will generate:

i. little to no correlated improvements in greasy wool colour (i.e. whiter wool) and staple structure (i.e. finer staple bundles), off-shears liveweight, GFW, SL or Y-Z (i.e. clean colour);

ii. small improvements in fleece rot (i.e. decreased incidence of bacterial staining), character (i.e. better defined and more regular crimp frequency), dust (i.e. less penetration of dust into the staple), yield. CFW, FDSD and Y (i.e. brightness);

iii. moderate improvements in weathering (i.e. less visible weathering at the tip of the staple and deterioration of fibre structure) and the incidence of midbreaks; and

iv. large correlated improvements in CVFD.

As discussed above, selection for increased SS will generate correlated increases in both FD and RTOC. This indicates that fleeces will become broader with increased compressional harshness which while good for upholstery and carpet end-uses is not suitable for next-to-skin apparel.

Table 3  Genetic correlations* between SS, visual wool quality traits, off-shears liveweight & wool production and measured wool quality traits

<table>
<thead>
<tr>
<th>Visual Wool Quality Scores</th>
<th>YSS</th>
<th>ASS</th>
<th>Liveweight &amp; wool production</th>
<th>YSS</th>
<th>ASS</th>
<th>Measured wool quality</th>
<th>YSS</th>
<th>ASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>-0.12</td>
<td>-0.11</td>
<td>OSLWT</td>
<td>-0.01</td>
<td>0.06</td>
<td>FD</td>
<td>0.27</td>
<td>0.46</td>
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<tr>
<td>Character</td>
<td>-0.32</td>
<td>-0.10</td>
<td>GFW</td>
<td>0.07</td>
<td>0.00</td>
<td>FDSD</td>
<td>-0.34</td>
<td>-0.26</td>
</tr>
<tr>
<td>Dust</td>
<td>-0.39</td>
<td>-0.15</td>
<td>Yield</td>
<td>0.40</td>
<td>0.32</td>
<td>CVFD</td>
<td>-0.62</td>
<td>-0.64</td>
</tr>
<tr>
<td>Weathering</td>
<td>-0.54</td>
<td>-0.43</td>
<td>CFW</td>
<td>0.23</td>
<td>0.11</td>
<td>Curve</td>
<td>0.11</td>
<td>0.22</td>
</tr>
<tr>
<td>Fleece rot</td>
<td>-0.28</td>
<td>-0.24</td>
<td>SL</td>
<td>0.10</td>
<td>0.05</td>
<td>RTOC</td>
<td>0.13</td>
<td>0.27</td>
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<tr>
<td>Staple structure</td>
<td>-0.09</td>
<td>0.12</td>
<td>MID</td>
<td>-0.23</td>
<td>-0.44</td>
<td>SL</td>
<td>0.10</td>
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<td>0.18</td>
<td>Y</td>
<td>0.03</td>
<td>0.10</td>
</tr>
</tbody>
</table>

* Negligible correlations (i.e. <0.2) are in italics text, low correlations (i.e. 0.2 – 0.4) are in normal text, medium correlations (i.e. 0.4 – 0.6) are in bold text and high correlations (i.e. >0.6) are shaded. ✓ indicates a favourable genetic relationship.

It is important to note that breeding objectives that aim to improve the various visual wool quality traits, liveweight, wool production, fibre curvature, midbreaks and brightness will produce correlated
increases in SS although of a relatively low magnitude. However, the high unfavourable genetic correlation between FD and SS means that breeding objectives that aim to reduce FD will lead to lower staple strength unless some selection pressure is placed on SS. For this reason it is recommended that commercial producers aiming to reduce the fibre diameter of their wool clip make ram purchase decisions based on an index that includes SS, such as the MERINOSELECT Fibre Production+ (FP+) index for predominantly wool production enterprises or Merino Production+ (MP+) index for enterprises with significant surplus sheep sales. After 10 years the use of these indexes can generate +2.8% fleece weight (FW), +1.1 kg liveweight (LWT), -1.3 μm in FD and +4.6N/ktex in SS and +4.3% FW, +5.0 kg (LWT), -0.7 μm in FD and +3.0N/ktex in SS for the FP+ and MP+ indexes respectively.

Selecting replacement ewes and wethers to retain in the flock

For commercial producers, genetic information is not readily available to assist with selecting replacement ewes and wethers to retain in the breeding flock or wool growing enterprise. ASBVs are not available for commercial ewes and the relatively high cost of SS measurement, currently $11.66 when done in conjunction with a yield test\(^3\), means that it is necessary to identify replacement animals on the basis of a cheaper effective alternative selection criterion. When selecting replacement sheep from within the cohort of young animals born into the flock (i.e. within flock selection), it is necessary to consider the phenotypic correlations between SS and other wool production and quality traits as they are an indication of the relationships between traits in the current generation of animals.

Within the IN, all of the phenotypic correlations with SS, with the exception of FD, FDSD and CVFD, were negligible (i.e. >0.20) (Table 4). CVFD had the strongest favourable phenotypic correlation (-0.40 and -0.34 for yearling and adult SS respectively), which indicates that within the current generation of a flock, those animals with lower CVFD will have higher SS. This means that CVFD, which received as part of the standard FD measurement, is the best trait to use as an alternative selection criteria for SS. The phenotypic correlations estimated in the IN agree with previous work (Swan et al. 2008; Greeff 1999). However, it must be noted that there is currently some conjecture within the industry about the value of using CVFD as an alternative selection criteria for SS across flocks as the relationship between CVFD and SS varies between bloodlines (Adams and Briegel 1998). Further analyses are currently underway to increase our understanding of within and between flock variation in CVFD and it relationship with SS.

Table 4 Phenotypic correlations* between SS, visual wool quality traits, off-shears liveweight & wool production and measured wool quality traits

<table>
<thead>
<tr>
<th>Visual Wool Quality Scores</th>
<th>YSS ASS</th>
<th>Liveweight &amp; wool production</th>
<th>YSS ASS</th>
<th>Measured wool quality</th>
<th>YSS ASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
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<td>-0.05</td>
<td>OSLWT</td>
<td>0.06</td>
<td>0.05</td>
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<tr>
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<td>Dust</td>
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<td>0.00</td>
<td>Yield</td>
<td>0.18</td>
<td>0.15</td>
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<tr>
<td>Weathering</td>
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<td>-0.05</td>
<td>CFW</td>
<td>0.17</td>
<td>0.07</td>
</tr>
<tr>
<td>Fleece rot</td>
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<td>-0.07</td>
<td>RTOC</td>
<td>0.07</td>
<td>0.09</td>
</tr>
<tr>
<td>Staple structure</td>
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<td>-0.11</td>
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<td>Y-Z</td>
<td>0.02</td>
<td>0.03</td>
</tr>
</tbody>
</table>

* Negligible correlations (i.e. <0.2) are in italics text, low correlations (i.e. 0.2 – 0.4) are in normal text, medium correlations (i.e. 0.4 – 0.6) are in bold text and high correlations (i.e. >0.6) are shaded. ✓ indicates a favourable phenotypic relationship.

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3 AWTA Raw Wool Testing Fees 2012/13
Is staple strength an indicator of ‘robustness’ or ‘resilience’?

Thompson et al. (2006) reported that selection for SS resulted in a 30% difference in lamb mortality among flocks. Their study compared various biochemical profiles of neonatal lambs born in a flock selected for high SS (SS+) with those born lambs in a flock selected for low SS (SS-). SS+ lambs appeared to mature more rapidly, had a shorter gestation and were better able to adapt from foetal to postnatal metabolism (Thompson et al. 2006). An initial analysis of the genetic relationships between wool production and quality and lamb survival in the IN identified low positive genetic correlations between both yearling and adult SS and lamb survival. This indicates that selection for higher SS will lead to correlated increases in lamb survival – however, further work is required to quantify the magnitude of the response. There were also moderate to high negative genetic correlations between CVFD and lamb survival, particularly survival at birth, indicating the selection for low CVFD will lead to correlated increases in lamb survival. These findings make it reasonable to hypothesise that ewes with less variation in CVFD may be more robust or resilient and are better able to cope with variable feed availability during the reproductive cycle and may prove to have superior lifetime productivity. Further research is required in this area.

Conclusions

SS is a measurement of a material property and unlike other wool production and quality traits has no single, simple biological basis. This contributes to the large differences in phenotypic expression of the trait which makes on-farm management to improve SS problematic. Therefore genetic improvement of SS is an important means to produce long-term improvements in SS. For commercial producers, selection of sires using an index that includes SS can generate simultaneous decreases in FD and improvements in SS and overcome the high unfavourable genetic correlation between these two traits. CVFD can be reliably used as an alternative selection criterion for SS when selecting replacement animals to enter either the breeding flock or wool growing mob in a self-replacing Merino enterprise, however more research is required to quantify the value of CVFD for between flock selection.

Acknowledgements

We acknowledge the dedicated team of scientists and technical staff at each of the 8 INF sites who are responsible for management of each of the flocks and implementation of the comprehensive sampling, assessment and measurement protocols.

References


Live export, marketing and OJD

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Introduction

I run a mixed farming operation in the Cowra district, growing wheat and triticale, and producing prime lambs for export. I became a Director of the Sheepmeat Council of Australia (SCA) in 2008 and President in 2011.

My presentation addresses three major issues facing the Australian sheepmeat industry: the challenge of Ovine Johne’s Disease (OJD); improving market access and trading opportunities; and developments in the live export sector.

Ovine Johne’s Disease

SCA, alongside other industry groups such as WoolProducers Australia, have been developing a new national Plan for the management of Johne’s disease. The National OJD Management Plan 2013-2018 will be implemented from July 1 2013. This plan will lead to a greater focus on biosecurity at a farm and regional level. This includes new tools such as the national Sheep Health Statement (SHS) to assist producers to make informed decisions about OJD and other diseases when trading sheep.

Marketing

There is growing global demand for Australian lamb and mutton, particularly in the emerging Asian economies. SCA is committed to enhancing international relations to increase the consumption of sheepmeat in key export markets. Council has encouraged an increased focus on opening markets in Asia. China is becoming a major destination for Australian sheepmeat products and the demand for quantity and quality continues to grow. For example, the export volume of mutton reached 3,401 tonnes swt in March, a massive increase of 554% on March last year (MLA 2013a). SCA has also been exploring the potential of the Indian market, a natural sheepmeat market, where opportunities exist in the high end retail and foodservice sectors. The Indian market for Australian sheepmeat is only in its infancy. However, with a rapidly expanding middle class, currently around 170 million people, the demand for quality product is increasing. Over the last six months 14 tonnes of sheepmeat has been sold as trial shipments, exploring new supply chain arrangements and testing import regulations.

Live export

The livestock export industry continues to be fundamental to the success of the Australian sheep industry, and it underpins markets across the country. Live Australian sheep are in high demand in export markets due to their high quality and consistency of supply. In 2012, Australia exported over 2.2 million sheep worth approximately $280 million (MLA 2013b). The Middle East is our largest mutton and live sheep market and is also a burgeoning lamb destination, built on our enviable reputation as a reliable supplier of high quality, safe halal sheepmeat.

The livestock export industry is especially important to the Western Australian sheep industry. In 2012, Western Australia exported 78% of Australia’s total sheep exports (MLA 2013b). As a 2011 report into the livestock export sector from the Centre for International Economics highlighted, livestock export, on average, significantly increases livestock prices across the Australian sheep industry (CIE 2011). The report suggested that without the trade, prices in the west would fall 42 per cent for older sheep; or a reduction in farm gate price of 46 cents per kilogram.

Council has devoted significant effort in strengthening both the boxed trade and the live trade. The implementation of the Exporter Supply Chain Assurance System (ESCAS) has been a priority for the Council. SCA has worked as part of the Industry Government Working Group (IGWG) to implement this new regulatory framework (see IGWG 2011). ESCAS
ensures that animals are treated to World Organisation for Animal Health (OIE) standards for animal welfare. This process allows animals to be effectively traced or accounted for by exporters within a supply chain through to slaughter.

Australia is the only country in the world that invests in improving animal welfare in the countries to which we export livestock. SCA believes our ongoing involvement in the livestock export trade provides an opportunity to influence animal welfare conditions in importing countries.

References


Challenges Facing the Australian Sheep Industry in Terms of Traceability and the Potential Impacts on Producers

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Introduction

Improved efficiencies to lower the cost of processing per kilogram of product, organised supply and product quality are important for long term profitability of the lamb industry. An improved flow of information throughout the supply chain is a critical component to achieve this outcome. The Lamb Supply Chain & Animal Information RD&E Plan has identified this as a high priority for the Australian sheep/lamb industry (Williams et al. 2012) and integral to this plan is traceability.

Traceability has been defined in many ways (Olsen and Borit 2013), but in terms of the meat industry it can be simply defined as the ability to maintain the identity of an animal from the farm, through slaughter and distribution, to the consumer (Jensen and Hayes 2006). In recent years there has been an increased focus on the traceability in food supply chains. Costly food scandals which have received world wide media attention including the Bovine Spongiform Encephalopathy (BSE, or mad cow disease) outbreak in the mid-nineties (Olsen and Borit 2013) and more recently horse meat incorrectly labelled as beef, have played a major role in this increased focus on traceability. Domestically and internationally, it is becoming important that producers, processors, wholesalers, exporters, and retailers are able to ensure the identity and traceability of both livestock and meat. This means that record keeping must guarantee traceability across all sectors of the supply chain and that the information collected is accurate, viable and can be verified (Smith et al. 2008).

At the processing level in Australia, the requirement for tracking of animals via the National Livestock Identification System (NLIS) has introduced a level of complexity in data recording, but also has the potential to significantly improve the communication flow between producers and processors on such things as carcase performance and prevalence of disease. In order for traceability systems to operate efficiently and effectively a streamlined approach is needed. Troy and Kerry (2010) highlighted that the adoption of larger data handling systems like those offered through radio frequency identification (RFID) and wireless sensor networks (WSN) are essential to achieve this efficient, streamlined approach and, importantly, meet regulatory and consumer requirements (Troy and Kerry 2010). This type of technology has been, to some degree, successfully adopted in other industries such as the beef and pork and this has occurred predominately overseas (Troy and Kerry 2010; Andersen et al. 2012).

Earlier work in the Australian sheep industry by O’Halloran et al. (2008) proved the concept that individual animal/carcase identification could be successfully maintained from farm through to the boning room with the development of prototype electronic tracking systems using both electronic ear tags and gambrels. However, the cost of implementing EID tags in individual sheep is significant (CIE 2010). Given the increased requirements from certain markets, such as the European Union (EU), to maintain the identity of the carcase from the point of head removal until carcase disposition, a greater focus has been placed on tracking systems within the abattoir. More recently, there has been development of a working system that allows individual carcase identification using a mob-based traceability system to be recorded via the visual ear tag, which is then linked automatically to a gambrel carrying a unique identification on the slaughter chain (Wright et al. 2010). Further work is needed to refine these systems and use the collected information more effectively to improve processing efficiency.

There has been extensive work developing supply chains within NSW. A strategic approach is required to successfully progress into the future, which identifies how R&D can aid processors to measure carcases and provide better information to producers. Considerable work has occurred on-
farm to change the genetics of lamb production, coupled with production systems, but often these benefits are not translated clearly back to producers, nor is there financial incentive. Similarly, at the other end of the supply chain, technology to improve eating quality, nutritional value of lamb and new products is required, but there are no on-line measurement systems to collect this information and provide it to the sector that influences these issues.

The objective of this paper is to: 1) outline the importance of traceability to Australian sheep industry; 2) outline the current traceability system used within Australia; 3) detail the types of traceability systems used by other major sheep producing other countries; 4) discuss where to for the Australian sheep industry in terms of our traceability system; and 5) outline an advanced in abattoir traceability and monitoring system.

**Importance of traceability to Australian sheep industry**

It is critical that the Australian sheep industry have an effective and reliable traceability system in place to ensure the profitability and sustainability of the industry, especially in the international market. Smith *et al.* (2005) identified that traceability was important in many ways including: to ascertain the origin and ownership of animals and meat and hence, deter theft and misrepresentation; for biosecurity protection including surveillance, control and eradication of foreign animal diseases; for compliance with international customer requirements; for compliance with country of origin labelling requirements; for improvement of supply management; distribution/delivery systems and inventory controls; to facilitate value based marketing; to isolate food safety problems; minimise product recalls and improve crisis management. There have been estimates that even a small, three month foot and mouth outbreak would cost the Australian red meat industry billions of dollars (Condon 2013; CIE 2010) hence, the industry cannot afford to compromise the integrity of its traceability system. Improved traceability is an insurance policy for a valuable and expanding industry. Traceability requirements are increasingly seen as a means of maintaining and requiring key export markets, especially in the event of a disease outbreak (CIE 2010).

Consumers, especially from Europe, Japan and the US are becoming increasingly concerned about the source of their food supply, ethical production and processing, and product safety and quality (Plessis and Rand 2012; Smith *et al*. 2005; Troy and Kerry 2010). As outlined by Smith *et al*. (2005), increasing pressure from consumers and to some extent the media, retailers and markets, highlight that it is essential that any company/supplier connected to the food supply chain needs to embrace traceability to stay competitive. This poses the question of how do we ensure traceability of Australian sheep?

**Current traceability system used within the Australian sheep industry**

The National Livestock Identification System (NLIS) is Australia’s system to identify and trace livestock including cattle, sheep, goats and pigs for:

- Biosecurity of disease control;
- Food safety and product integrity; and
- Satisfying market access requirements.

NLIS Sheep & Goats was introduced on 1 January 2006. It is a mob-based traceability system where all movement of mobs of sheep or goats are recorded on the NLIS database. A movement document known as National Vendor Declaration (NVD) is required as is a visually readable ear tag printed with the Property Identification Code (PIC) on all sheep and goats leaving a property. Hence, traceability is provided by the combination of ear tags, NVD’s and timely uploads of all mob movements to saleyards, abattoirs and other properties to the NLIS database.

The requirement is that all sheep must be ear tagged before they are moved from any property to a saleyard, abattoir or another property. The tag must be printed with the PIC of the property the sheep are moving from (unless the sheep are bought in sheep and have already been tagged). An NVD must be fully completed and accompany the sheep when they move. If the mob is non-vendor bred or mixed
and contains tags with different PICs, all ‘Other PICs’ must be written on the movement document or a pink post breeder ear tag must be attached alongside the breeder tag with the current property’s PIC printed on it for those sheep which have been bought in. The effectiveness of this system is heavily reliant on vendors providing accurate information on the NVD, and all necessary uploads completed on any livestock movement to the NLIS database.

Types of traceability systems used by other major sheep producing countries

Smith et al. (2008) outlined the type of traceability programs of some of the major sheep producing countries. An updated summary of this information is shown in Table 1. Both Australia and Canada have similar systems in place (Carlberg 2010). Namibia had adopted EU standards for animal traceability to retain EU market access (Bass et al. 2008). China has the largest sheep population but there is no mandatory identification system in place, or for New Zealand. In 2005, after industry analysis, it was determined that there was no need at that point for New Zealand; it was decided to wait to determine the effectiveness of the EU traceability systems (Bass et al. 2008).

Table 1. Status of traceability program implemented and type of ear tag used in major sheep producing nations

<table>
<thead>
<tr>
<th>Location</th>
<th>Status of traceability program and year implemented</th>
<th>Ear tag Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Mandatory, birth to slaughter (2006)</td>
<td>Visual</td>
</tr>
<tr>
<td>China</td>
<td>Voluntary</td>
<td>n/a</td>
</tr>
<tr>
<td>Ireland</td>
<td>Mandatory, birth to retail – same as EU (2010)</td>
<td>Electronic/Visual</td>
</tr>
<tr>
<td>Namibia</td>
<td>Mandatory, birth to slaughter for EU export (2002)</td>
<td>Visual</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Voluntary</td>
<td>n/a</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Mandatory, birth to retail – same as EU (2010)</td>
<td>Electronic/Visual</td>
</tr>
<tr>
<td>United States</td>
<td>Voluntary- system for disease control</td>
<td>Visual</td>
</tr>
</tbody>
</table>

Source: adapted from Smith et al. (2008)

In 2010, the use of mandatory EID tags was implemented in the EU (Barge et al. 2013). The United Kingdom and Ireland have subsequently made changes. In general the identification requirements for sheep born after 1 January 2010 are a follows: All sheep must be tagged with at least one tag by 9 months of age or on leaving the holding of birth, which ever comes first. Animals to be kept for breeding must be double tagged by 9 months of age with a conventional saleyard tag in the left ear, bearing a 12 digit number, and either a ruminal bolus or an electronic tag in the right ear, bearing the identical 12 digit tag number on the conventional mart tag. In general both tags on a sheep fitted with an electronic tag will be yellow. The tag on a sheep fitted with a ruminal bolus will be light blue. In the case of sheep intended for slaughter before 12 months of age they may be tagged in just the left ear with a conventional slaughter tag. In the case of sheep going for sale via a mart before 12 months old they may be tagged in just the left ear with a conventional tag which must be approved as a mart tag. Upgrading to EID - Animals less than 12 months of age bought at marts and tagged with one conventional mart tag can be upgraded to double tagging with a specific EID tag if they are to be retained for breeding. This must be done by the time the animal is 12 months of age (DAFM 2012).
As various countries establish and enhance their animal identification programs it places increased pressure around the world for countries to improve their systems in order to stay competitive (Murphy et al. 2008). The CIE report in 2010 stated that countries are entitled to impose traceability criteria on imports, if these do not exceed requirements applied domestically. This means that if the EU were to impose their requirements, the current Australian system would have to be able to prove a similar level of traceability.

Where to for the Australian sheep industry in terms of our traceability system?

There has been much debate over many years not only within Australia, but also overseas (Barge et al. 2013; Calberg 2010; Feng et al. 2013; Smith et al. 2008) on the value of implementing EID tags in sheep to improve traceability. The NLIS was implemented in the cattle industry in 2004. A very real scenario for the Australian sheep industry is that we follow the beef industry and more recently the EU sheep industry and introduce the mandatory use of EID tags in sheep. One state within Australia has shown little support for the current mob-based NLIS system and is keen to implement EID tags. This raises questions including; what are the perceived benefits and costs for industry and what other options are there?

Benefits of implementing EID

There are some potential benefits from the implementation of EID tags in sheep including: maintaining market accessibility; increased productivity through individual performance management on farm; potentially decreasing labour requirements via walk over weighing and auto drafting; access to real time data on wool and reproduction performance (Sheep CRC 2002) and efficient reading of large numbers of individual devices for upload to the NLIS database when sheep are moved between PICs. This would still be heavily reliant on producers and require more effort than transferring of mobs between PICs on the database. To realise many of these benefits however, a significant amount of capital and knowledge to operate scanners is required on-farm.

Additional benefits could also be shown in terms of processing with improved inventory management and feedback provided to producers on conformance to carcase specifications, animal health and bruising. In order to realise these benefits, a large capital outlay is required for “hook tracking” infrastructure by the processor.

Costs of implementing EID

The logistics of scanning thousands of sheep at major saleyards is an issue that requires consideration. Saleyards need be able to read ear tags on delivery to ensure that the animal is tagged and that the tag reads electronically. Sheep with non-read or missing tags will need to be drafted automatically, tagged and then be returned for re-reading and allocation into the same consignment so that their property of origin PIC is retained. The time taken to conduct large sales and the infrastructure cost at saleyards is a major impediment to the adoption of individual sheep EID systems.

The overall cost to industry for the level of traceability improvement with a EID system is a major industry concern. A cost-benefit analysis has been conduct by CIE (2010). This analysis reported on 3 options, where: option 1 was the enhanced mob-based system including verification and enforcement of business rules along the chain; option 2 was based on EID with exemptions – exempting all lambs, sheep and goats sold from property of birth to the abattoir or live export; and option 3 was based on EID without exemptions. Within options 2 and 3, a further 2 scenarios provided based on 2 prices for the EID tags; one is the 2010 pricing of $3.40 and one is a national pricing of $1.40 per tag. Table 2 shows the benefit cost summary of each scenario.
Table 2. Benefit cost summary

<table>
<thead>
<tr>
<th>Options</th>
<th>Benefit ($m) *</th>
<th>Cost ($m)</th>
<th>Benefit cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1</td>
<td>511</td>
<td>98</td>
<td>5.2</td>
</tr>
<tr>
<td>Option 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td>782</td>
<td>383</td>
<td>2.0</td>
</tr>
<tr>
<td>National</td>
<td>782</td>
<td>207</td>
<td>3.8</td>
</tr>
<tr>
<td>Option 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td>951</td>
<td>587</td>
<td>1.6</td>
</tr>
<tr>
<td>National</td>
<td>951</td>
<td>289</td>
<td>3.3</td>
</tr>
</tbody>
</table>

*Present value of benefits (across beef, sheep, goats and pigs) and costs, compared to baseline. Costs and benefits are expressed in net present values for the period 2011-2020 using a 7% discount rate. Source: CIE (2010)

Option 1 has the highest economic payoff with a cost benefit ratio of 5.2, despite having the lowest potential benefits its ongoing costs are significantly lower compared to options 2 and 3. Option 3 would deliver the greatest benefits mainly due to its assumed greater international credibility in tracing. The benefits are 86% higher when compared to option 1 but its costs are 294% more, even when considering the lower tag prices under the national purchasing strategy (CIE 2010). The implementation of EID tags would certainly seem to be advantageous to top sheep producers within Australia, but could potentially push a large proportion of producers out of the industry due to extreme costs. So what other options do we have?

Advanced in-abattoir traceability and monitoring system

It is critical for the Australian sheep industry to be able to ensure our customers we have a robust traceability system. As previously highlighted, the main issue with our current system is that it relies heavily on the provision of accurate information on the NVD by vendors. Two operations have been conducted by regulatory staff to observe the level of traceability. In 2007, exercise “sheepcatcher” showed average traceability to be 58% and this result did not meet the National Livestock Traceability Performance Standards (NLTPS) (CIE 2010). In 2012 exercise “tuckerbox”, where nearly 240,000 sheep and small number of goats were traced to 232 properties, 11 saleyards and most sheep abattoirs in NSW during a simulated foot and mouth outbreak, demonstrated that 90% of sheep and cattle could be traced in the first 24 hours. Such compliance is in accordance with the NLTPS (Bell et al. 2013). This dramatic improvement is due to the availability of the NLIS database, introduced from 2010 for sheep, allowing rapid tracing of sheep and cattle movements in the first 24 hours and the greater awareness of the NLIS requirements from all involved. These results indicate that with further audits, awareness and education campaigns, compliance could be further increased.

An additional concept proposed to strengthen the current traceability system is the development and introduction of an in-abattoir traceability system. This system is made up of many components and the level of adoption by abattoirs is optional, but ultimately a full system has the ability to achieve the following: streamline the traceability of the mob-based system and increase compliance rates (providing quick and easy trace back information); provide feedback on animal health issues and carcase characteristics to producers; better target consumer/market demands with the ability to make more informed decisions using real time data; automatic carcase draft; improved chiller management to reduce labour costs; improve stock inventory and streamlined information flow of electronic data from saleyard to abattoir database and abattoir to NLIS database. The development of this new system will have many economic benefits to the whole sheep industry. The integrated system will be an essential platform and aid in the roll out of other technologies currently being developed by MLA such as Livestock Data Link (LDL) by capturing accurate information (ear PIC numbers) relating to individual animals within a mob.

The majority of the technology required for the purpose of in-abattoir monitoring systems are not new and are currently widely used in other industries. There is, however, a need to develop additional hardware and software. A key component of the system is the use of digital camera technology to capture ear tags and hence PIC numbers. The digital camera technology uses optical character
recognition (OCR) to automatically record individual animal PIC numbers to a database. The aim of this system is to remove human error and decrease current labour requirements while maintaining the level of traceability. Via digital recording the individual PIC for each carcase within a mob, compliance is automatically being monitored (i.e. any additional PIC numbers within a mob will be identified). The OCR has the ability to identify tag manufacturer and colour, store the image in a database against animal body number and the ear-tag image, PIC and body number can be displayed at the AQIS inspection station and all retain and condemn reasons can be electronically recorded.

For an increased level of sophistication the OCR technology can then be linked in with the use of RFID gambrels. This allows individual carcase information to be electronically stored for each carcase in a database. Figure 1 illustrates an example of a kill floor and the potential data capture and sorting positions including; ear tag, skins, dentition, AQIS, fat measure, scales, chiller management.

![Figure 1. Example of kill floor plan and potential data capture positions](image)

This system allows real time decisions to be made on the suitability of carcases for specific market destinations by using all information collected in the database including: method of sale (over the hook verses saleyard); breed; Mob (pre entered); animal class (lamb, hogget, mutton, rams); carcase weight; fat depth; body type; with the potential to use pH and temperature data (for the prediction of eating quality) to grade carcases more efficiently and improve consumer satisfaction. The additional benefits for processors of this system include: improve stock inventory; real time information on what stock (bodies and hot weight) is currently in chillers and thus, a greater understanding of what stock may still need to be purchased to fill orders.

Suppliers will also be able to access greater feedback on information such as compliance to specifications (weight, fat, yield estimate from boning room) and NLIS compliance from the vision system station, skins information from the skin grading touch screen, animal health feedback and information packs based on data collected from AQIS touch screen (for example if there is a high incidence of grass seed a information pack could be sent out on best management strategies) and price information.

**Conclusions**

It is critical for the Australian sheep industry to be able to quickly and reliably trace sheep to minimise the financial damage from an exotic disease outbreak and protect the reputation for quality in international markets. Although the current NLIS database system with mob-based uploads could be improved, exercise “tuckerbox” has shown it to be an effective tool to trace sheep in the event of a disease outbreak. Based on industry benefit-cost analysis it does not appear to be economically viable to make EID tags mandatory and such a development would have a significant negative impact on industry profitability. Therefore, it would appear that greater investment into ensuring compliance of the current mob-based system with improved in abattoir tracking and information integration would provide a high standard of traceability in a more cost effective way.
References


Update on Worm Control in Sheep

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stephen.love@dpi.nsw.gov.au

Introduction

Gastrointestinal parasitism is the number one disease of sheep in Australia from an economic point of view (Sackett et al. 2006).

Drenches (anthelmintics) remain an important part of worm control, but resistance of worms to these chemicals is a major concern. Resistance has worsened over the last 10 years with macrocyclic lactones (MLs) in particular being affected (Bailey and Nielsen 2005).

In view of this, there has been a general shift away from prescriptive, calendar-based strategic worm control programs for sheep, especially in ‘Haemonchus-areas’, towards an increased emphasis on integrated parasite management (IPM) and treatments based on worm egg count monitoring rather than visual assessment or the calendar. However, IPM, although vigorously promoted, is only variably adopted.

In this paper we discuss current issues and developments in the management of sheep worms.

Cost of worms

In a Meat and Livestock Australia (MLA)-funded review of the cost of endemic diseases in Australia, internal parasites (worms) were the number one disease agent of sheep in Australia, closely followed by external parasites (lice and flies) (Sackett et al. 2006). (For cattle in the southern temperate zones of Australia (‘cattle-southern’), gastrointestinal parasites, excluding liver fluke, are ranked second after bloat in economic importance.)

This 2006 study estimated the annual cost of sheep worms in Australia to be almost $400 million. Around 80% of the cost was attributed to production losses rather than costs of control. These latter costs normally include drenches, labour and diagnostic testing, including faecal worm egg count (WEC) monitoring, commonly known as ‘WormTesting’.

As most of the cost comes from production losses, losses due to worms can go largely unnoticed. It also means the focus tends to be on the relatively smaller but more obvious costs (cost of testing and treating) rather than on less obvious but larger costs (production losses).

Furthermore, the worms themselves are largely invisible, i.e. one cannot easily discern if a sheep has a significant worm burden merely by looking at the animal, unless clinical disease has set in, by which time production losses are already substantial.

Finally, the problem of ineffective drenches as a result of resistance is also largely invisible. By the time clinically obvious control failures occur on-farm, resistance to the drench(es) used is already quite advanced. Meanwhile, production losses escalate.

Everything considered, this means a major problem with worm control is ‘invisibility’: worms and their effects, and drench resistance, although significant, go unnoticed all too easily. ‘If you don’t measure it, you can’t manage’ very much applies to worm control.

Central to sensible worm control is objective and regular assessment of worm burdens, productivity, and drench efficacy. The tool to use for the first and last of these is WECs.
Drench resistance

Resistance Australia-wide

Love (2011) gave an overview of the prevalence and management of drench resistance in Australia, but recent work (Bailey et al. 2013), summarised in figure 1 below, has shown that the situation has deteriorated further since then.

Figure 1. Percent of farms with efficacy (WECRT %) less than 95% in any of *Haemonchus*, *Trichostrongylus* or *Teladorsagia* spp. (Australia wide, 2009-2012) (Bailey et al. 2013)

BZ=benzimidazole group. LEV=levamisole group. ML=macrocyclic lactone group. IVM=ivermectin, which, like MOX and ABM, is an ML. AAD=aminoacetoniitrile derivatives group. MPL=monepantel, which is an AAD. MOX=moxidectin. ABM=abamectin. WECRT%=efficacy=% reduction in worm egg count after treatment. *Haemonchus*=barber’s pole worm. *Trichostrongylus*=black scour worm (and stomach hair worm). *Teladorsagia* (*Ostertagia*) *circumcincta*=small brown stomach worm.

Bailey et al. (2013) also reported the range of efficacies found for each drench active, giving an indication of the severity of resistance, not just the prevalence of resistance (which is generally defined as efficacy <95%). This is summarised in figure 2 below.

Figure 2. Average efficacy for different drenches and worms on farms, Australia, 2009-2102 (Bailey et al. 2013)

For every drench tested, efficacies against the various worm species range from zero % (severe resistance) to 100% (fully effective). Numbers of farms for each test result ranged from 40 - 27. BZ=benzimidazole group. LEV=levamisole group. IVM=ivermectin. ABA=abamectin. MOX=moxidectin NAP=naphthalophos. Haem=*Haemonchus* Tel=*Teladorsagia* (*Ostertagia*) Trich=*Trichostrongylus*. 
Resistance in the Central West, Lachlan and Hume LHPAs – recent surveys

Resistance is no longer just common in the ‘higher prevalence’ areas, such as the New England region of New South Wales and the south west of Western Australia.

Recent surveys by Livestock Health and Pest Authority (LHPA) District Veterinarians in the Central West (Walker et al. 2013), Lachlan (Braddon 2013) and Hume LHPA (Shergold and Morton 2013) districts of NSW have shown that resistance to drenches, including the macrocyclic lactones (MLs, ‘mectins’), is now quite common in those areas too.

Figure 3. Percent of farms (n=58) with efficacy (WECRT %) less than 95% in Haemonchus, Teladorsagia and Trichostrongylus spp. in the Lachlan LHPA (Braddon 2013)

NAP=naphthalophos. ABA=abamectin. BZ=benzimidazole group. LEV=levamisole group. WECRT%=efficacy=% reduction in worm egg count after treatment. Haem(onchus)=barber's pole worm. Trich(ostrongylus)=black scour worm (and stomach hair worm). Tel(adorsagia (Ostertagia))=small brown stomach worm.

Figure 4. Percent of farms (n=10) with efficacy (WECRT %) less than 95% in Haemonchus, Teladorsagia or Teladorsagia spp. in the Central West LHPA (Walker et al. 2013)

BZ=benzimidazole group. LEV=levamisole group. ABA=abamectin. CLOS=closantel (*no claim for efficacy against Trich or Tel). NAP=naphthalophos (**no claim for high efficacy against Trich or Tel). DERQ=derquantel. All drenches used at recommended dose rates. WECRT %=efficacy=% reduction in worm egg count after treatment. Haem(onchus)=barber's pole worm. Trich(ostrongylus)=black scour worm (and stomach hair worm). Tel(adorsagia (Ostertagia))=small brown stomach worm.
Shergold and Morton (2013) reported that a number of drench resistance trials were conducted across the Hume region in 2012. Poor drench efficacy was common, with less than 95% efficacy for ivermectin, for example, being found on each of eight properties tested. Efficacy for a levamisole-benzimidazole combination drench was also commonly below 95%.

Integrated parasite management (IPM) – having more strings to your bow

In view of the importance of worms – and the challenge of drug resistance – IPM has been promoted for many years, especially in the last 10-20 years, with a view to sustainably improving worm control (more particularly, health, productivity and welfare) and reducing reliance on drenches, or at least using them better.

IPM involves using an array of worm control options, ‘chemical’ and ‘non-chemical’. These options include:

- The right drench at the right time
  
  The right drench generally will be a broad-spectrum product but more importantly has been tested (DrenchTest or DrenchCheckDay10) and shown to be effective on the producer’s property. The most expensive drench is the one that does not work. Timing is determined by regular WormTesting and the recommend program for the area. See the Drench Decision Guides here: [http://www.wormboss.com.au/tests-tools/management-tools/drench-decision-guide.php](http://www.wormboss.com.au/tests-tools/management-tools/drench-decision-guide.php)

- Grazing management
- Breeding for resistance of sheep to worms, and nutrition for resistance and resilience
- Regular monitoring and testing
- Managing drenches and drench resistance


Diagnostic tools

Faecal worm egg counting (WEC) remains the standard tool for monitoring worm burdens and assessing drench efficacy, although work on other approaches continues.

Faecal worm egg counting (WEC), with or without larval culture and differentiation (‘worm-typing’) is still the standard diagnostic tool, with useful adjuncts such as the lectin binding assay and the Haemonchus Dipstick Test being tested and deployed in recent years. There has also been work on ‘higher tech’ methods such as immunodiagnostic and molecular biological approaches.

The lectin binding assay is designed to assist laboratories to provide faster ‘worm typing’ results. The assay quickly differentiates *Haemonchus* eggs from other ‘strongyle’ eggs. The traditional method (larval culture), still most commonly used, is to culture faeces after the eggs have been counted and to ‘worm type’ on the basis of larval morphology. This takes 1-2 weeks. See [http://www.sheepcrc.org.au/management/worms-flies-lice/rapid-laboratory-test-for-haemonchus-in-worm-egg-counts.php](http://www.sheepcrc.org.au/management/worms-flies-lice/rapid-laboratory-test-for-haemonchus-in-worm-egg-counts.php)


Some new control options

Two new drench groups have appeared on the horizon in recent years. The AAD (aminoacetonitrile derivatives) group, represented by monepantel (Zolvix® (Novartis)) is available in Australia. The spiroindoles, represented by derquantel, marketed in combination with abamectin as Startect® (Pfizer), are not yet available in Australia.
An *Haemonchus* vaccine (‘Barbervax’) has been undergoing trials in Australia with a view to registration. This could be a boon to producers in haemonchosis-endemic areas (e.g. north-eastern NSW), especially given the worsening problem of drench resistance (Smith *et al.* 2013).

CSIRO (Knox and Faedo 2002) has done work on a nematophagous (‘worm-eating’) fungus (*Duddingtonia flagrans*) for sheep worm control. A commercial company has been conducting trials in sheep, cattle, horses and goats with a view to registration (M Knox, *pers. comm.*). Knox (2002) also reported on the use of copper oxide wire particles (COWPs) to control *Haemonchus* in sheep, however the potential for copper poisoning if COWPS are used in areas that have pyrrolizidine alkaloid-containing plants, such as *Echium* (Paterson’s Curse), *Heliotropium* (Heliotrope) and *Senecio* (Fireweed etc) spp, is one issue to be considered.

**WormBoss re-born**

WormBoss, first launched in 2005, has undergone a major revision and, along with a brand new website, was launched on 21.11.12. This Sheep CRC-supported project has brought together various experts and other stakeholders from around Australia to produce a world-class national repository of information and decision support system. WormBoss helps Australian sheep producers to better manage worms, which are a major impediment to health and productivity.

**Essential take-home messages – the two Ws**

- **W**ormBoss: for information on all aspects of integrated worm control including regional programs. [www.wormboss.com.au](http://www.wormboss.com.au)
- **W**ormTesting
  - to see if you need to drench
  - to check drench efficacy

**Further information – some recommended sources**

- WormMail in the Cloud: [www.wormmailinthecloud.wordpress.com](http://www.wormmailinthecloud.wordpress.com)

**References**


Also cited in Ecos Magazine (CSIRO): “Worm eater shows green promise”.


NATIONAL SHEEP HEALTH STATEMENT (SHS)

Completing this Sheep Health Statement (SHS) will assist prospective buyers to determine the suitability of these sheep for their enterprise. Although the SHS is voluntary in some states, it is mandatory in NSW and SA. (Version3, July 2013)

A: BIOSECURITY INFORMATION

<table>
<thead>
<tr>
<th>A1. All consigned sheep were born on the consignment property.</th>
<th>Yes □ No □</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2. The number of different sources of sheep that have been <strong>INTRODUCED</strong> onto the consignment property in the last 5 years is:</td>
<td></td>
</tr>
<tr>
<td>0 (closed flock) □ 1-5 □ 6+ □ Rams Only □</td>
<td></td>
</tr>
<tr>
<td>A3. All consigned sheep are from a property with a livestock biosecurity plan. <strong>(see note 1)</strong></td>
<td>Yes □ No □</td>
</tr>
<tr>
<td>If Yes, Property Plan □ Regional Biosecurity Plan □ ...........................................(name)</td>
<td></td>
</tr>
</tbody>
</table>

B: FOOTROT / LICE / OVINE BRUCELLOSIS

<table>
<thead>
<tr>
<th>B1. To the best of my knowledge, all consigned sheep are from a <strong>flock free</strong> of <strong>VIRULENT FOOTROT.</strong></th>
<th>Yes □ No □</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2. To the best of my knowledge, all consigned sheep are from a <strong>flock free</strong> of <strong>LICE.</strong></td>
<td>Yes □ No □</td>
</tr>
<tr>
<td>B3. All consigned sheep are from a flock in an <strong>OVINE BRUCELLOSIS Scheme.</strong></td>
<td>Yes □ No □</td>
</tr>
<tr>
<td>If Yes, Flock Accreditation No. (except Qld) ......................... Expiry Date...../...... / 20......</td>
<td></td>
</tr>
</tbody>
</table>

C: OVINE JOHNE’S DISEASE (OJD)

<table>
<thead>
<tr>
<th>C1. All consigned sheep are from a SheepMAP flock. <strong>(see note 2)</strong></th>
<th>Yes □ No □</th>
</tr>
</thead>
<tbody>
<tr>
<td>If yes, Status: .................................. Year commenced in SheepMAP: ..................</td>
<td></td>
</tr>
<tr>
<td>C2. All consigned sheep are from a flock with a negative test for OJD. <strong>(see note 3)</strong></td>
<td>Yes □ No □</td>
</tr>
<tr>
<td>If Yes, which test?</td>
<td></td>
</tr>
<tr>
<td>Faecal 350 within the past 24 months □ Abattoir 500 within the past 24 months □</td>
<td></td>
</tr>
<tr>
<td>Abattoir 150 within the past 12 months □ Other <strong>(see note 4)</strong>...................................</td>
<td></td>
</tr>
<tr>
<td>C3. To the best of my knowledge, all consigned sheep are from a <strong>flock not</strong> infected or suspected of being infected with OJD. <strong>(see note 5)</strong></td>
<td>Yes □ No □</td>
</tr>
<tr>
<td>C4. All consigned lambs are ‘T’ tag lambs. <strong>(see note 6)</strong></td>
<td>Yes □ No □</td>
</tr>
<tr>
<td>C5. (a) All consigned sheep are Approved Vaccinates. <strong>(see note 7)</strong></td>
<td>Yes □ No □</td>
</tr>
<tr>
<td>(b) If Yes, I have been continuously vaccinating all retained lambs in the consignment flock for OJD for ............ years.</td>
<td></td>
</tr>
<tr>
<td>C6. Sheep <strong>INTRODUCED</strong> onto the consignment property in the last 5 years were from a flock with: <strong>(see notes 2,3 and 7 - multiple answers may be applicable)</strong></td>
<td></td>
</tr>
<tr>
<td>SheepMAP accreditation □ Negative Faecal 350 □ Negative Abattoir 500 □</td>
<td></td>
</tr>
<tr>
<td>Negative Abattoir 150 □ All Approved Vaccinates □ Unknown status □</td>
<td></td>
</tr>
<tr>
<td>Other □ <strong>(see note 8)</strong>........................................................................................................</td>
<td></td>
</tr>
</tbody>
</table>

D: TREATMENT INFORMATION OF CONSIGNED SHEEP

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Product</th>
<th>Last Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Parasite Treatment</td>
<td></td>
<td>Month ....... Year ........</td>
</tr>
<tr>
<td>Internal Parasite Treatment</td>
<td></td>
<td>Month ....... Year ........</td>
</tr>
<tr>
<td>Vaccination (other than OJD)</td>
<td></td>
<td>Month ....... Year ........</td>
</tr>
</tbody>
</table>

E: ADDITIONAL INFORMATION **(optional - see note 9)**

| |
| |

F: DECLARATION **(see note 10)**

| I (full name): .......................................................... |
| Address: .............................................................................................................. |
| declare that, I am the owner and/or person responsible for the husbandry of the sheep in this consignment and all the information on this Sheep Health Statement is true and correct: |
| Signed: ........................................... Date: ........ /....... / 20...... |
| Phone Number: .................................. Fax number/email: ........................................... |

Producers are advised to retain appropriate records to support this declaration. Persons making false statements may be liable under fair trading and other relevant state legislation.
NOTE 1: **Biosecurity Plan**: Agreed actions and activities of farms and/or producers to prevent the incursion of animal disease(s) into a flock or onto a property. It may outline measures including (but not limited to) conditions on sheep movements into the area, vaccine policy and response to disease detection. These plans can be at a property or regional level and can cover a range of diseases. The National Farm Biosecurity Reference Manual for Grazing Livestock Production and regional biosecurity plan guidelines can be used to develop plans.

NOTE 2: **SheepMAP**: An audited quality assurance program incorporating a property biosecurity plan, animal health risk assessment, testing, and movement controls that provide a source of low risk animals. (Note: level of testing varies depending on status.)

NOTE 3: **Faecal 350**: A test of 350 representative sheep over 2 years of age (or all sheep over 2 years of age in smaller flocks) by Pooled Faecal Culture (PFC) or equivalent test in pools of up to 50 sheep. The sheep must have been on the property for at least 2 years.
- **Abattoir 500**: At least 500 sheep, over 2 years of age, have been submitted to an abattoir in the past 24 months, in 1 or more lots, have been examined and all found negative for OJD. The sheep must have been on the property for at least 2 years.
- **Abattoir 150**: At least 150 sheep, over 2 years of age, have been submitted to an abattoir in the past 12 months, in 1 or more lots, have been examined and all found negative for OJD. The sheep must have been on the property for at least 2 years.

NOTE 4: **Other**: Post mortem examination by a SheepMAP vet with no indication of OJD, or other negative test.

NOTE 5: **Infected Flocks**: A flock which is infected with OJD, and there is evidence of, or likely potential for, transmission of infection within the flock and the flock has not met the requirements for resolution of infection in accordance with the current National OJD Standard Definitions, Rules and Guidelines (SDR&Gs).

**Suspected of being infected**: A flock is suspected of being infected with OJD if the owner has reasonable grounds to believe that the flock has been exposed to OJD infection or that OJD may exist in the flock, based on:
- trace back or trace forward contact with an infected flock
- contact with OJD contaminated land or facilities
- a positive Johne's disease screening test, e.g. abattoir monitoring or blood (ELISA) test
- is a neighbour of an infected flock unless there is an effective biosecurity barrier
- clinical signs of OJD, or
- advice from the relevant state agricultural department.

NOTE 7: **'T' tag (terminal) lamb**: A lamb which is to be slaughtered before it cuts its first permanent teeth and is identified by an NLIS (sheep) 'T' tag. The 'T' tag may be a requirement for trading into some areas.

NOTE 8: **Other**: This could include sheep sourced from historical Low Prevalence Areas (LPA), or sheep that previously had an ABC score higher than 4, or were from an area with a regional biosecurity plan.

NOTE 9: **Additional information**: A producer may wish to add additional information pertaining to the consignment and/or consignment flock that is not covered by answering the listed questions. Examples may include historical tests or prevalence areas for OJD, history of OJD vaccination if not continuous, worm resistance test results, where introduced sheep were sourced from, blood lines, micron, breed society, etc.

NOTE 10: **Declaration**: Signing this declaration has legal significance. Regulatory authorities may take legal action, and purchasers may seek damages for any information that is incorrect. Before signing you must be satisfied you understand all elements of the document, and these explanatory notes.

For more information on biosecurity or diseases go to www.animalhealthaustralia.com.au
Please register me for the Sheep Connect network:

- Name: 
- Address Line 1: 
- Address Line 2: 
- Town: 
- Postcode: 
- Phone No: 

- Please tick your preferred delivery method for your Sheep Connect event list and provide details: (select only one)
  - Fax (number) 
  - Email (address) 

- Please tell us which event types you would like to be notified of (only events that cover the topics you select will be included in your event list):
  - Enterprise and business planning
  - Natural resources, pastures and grazing
  - Breeding and selection
  - Sheep reproduction
  - Health and welfare
  - Feeding and nutrition
  - Shows and ram sales
  - Webinars
  - Only events within _______ kms of my postcode

- Please tell us which topics you would most like to see covered at events in your district:
  - Enterprise and business planning
  - Natural resources, pastures and grazing
  - Breeding and selection
  - Sheep reproduction
  - Health and welfare
  - Feeding and nutrition
  - Other (please specify) 

- I have read the Sheep Connect NSW privacy statement (over page) and understand how my personal details may be used.

Your details will be registered and you will start receiving your event lists soon. You will also receive a username and password so you can update your details at any time on the Sheep Connect NSW website.

Thank you for registering for the Sheep Connect NSW network!
Sheep Connect NSW privacy statement

NSW DPI will collect your personal information including your contact and email details for the purposes of establishing a database of sheep producers ("the Sheep Connect Database"). Your details will be stored in the Sheep Connect Database, which will be held electronically by NSW DPI.

NSW DPI will use your contact details held in the Sheep Connect Database to notify you about sheep industry events and other information directly related to Sheep Connect NSW. We may also provide the information to Australian Wool Innovation for the purposes of providing you with information relating to your sheep producing business. The supply of your personal information is voluntary. You may access or correct this information by contacting NSW DPI on 02 6391 3954 or by writing to Sheep Connect Project Coordinator, NSW Department of Primary Industries, Orange Agricultural Institute, Forest Rd, Orange NSW 2800.

Please return your completed registration form to the Sheep Connect NSW team:

Postal Address
Sheep Connect NSW
C/O NSW Department of Primary Industries
Locked Bag 6006
Orange NSW 2800

Phone / Fax / Email
Phone: 02 6391 3954
Fax: 02 6391 3922
Email: sheep.connect@dpi.nsw.gov.au