final report

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Balmoral Sire Evaluation: Walkover weighing and commercial pedigree options

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Abstract

Although big differences in performance of individual sheep within a mob are known, without full pedigree and individual performance analysis it is difficult to differentiate between environmental and genetic influences. This project compared three methods of dam pedigree identification of lambs (Tag at birth, DNA parentage test and ‘Pedigree Matchmaker’ analysis) in a large commercial merino flock using electronic tags. The pedigree identification methods were analysed for the ability to produce a result, sire and dam accuracy, labour input and annual costs. The DNA method was the most expensive at $20.00 per lamb weaned but also the most accurate for dam identification at 97.88%. The tag at birth method cost $12.50 per lamb at 85% dam accuracy and Pedigree Matchmaker cost $4.65 per lamb at 85.1% dam identification accuracy. The project also assessed the effectiveness of an in paddock ‘walk over weighing’ (WOW) monitoring system. This trial demonstrated that remote monitoring of individual sheep body weights using electronic tags in a commercial situation is possible. WOW provided real time information on individual and mob weights as well as performance analysis and the ability to access this information at will via an app on a smartphone. The trial also encountered some deficiencies in existing technology and progressively developed solutions to these problems.
Executive summary

Commercial Pedigree Identification

Traditionally in large sheep flocks establishing full pedigree has been considered too time consuming and expensive without a justifiable business model that demonstrates the economic and genetic gain benefits. Full pedigree identification could improve,

- ewe selection decisions that include breeding history, progeny performance and survival
- progeny selection decisions based on performance and pedigree that include environmental considerations such as litter size and age of dam.

For example, often a heavier ewe with a single poor lamb is retained and a light ewe that reared twins is removed from the flock purely on visual assessment. Producers are also seeking to more readily link progeny to their dams to discover and monitor the full implications of the ewes' body weight changes on progeny performance and survival. The aim of this part of the trial was to compare the detection efficiency, accuracy and costs of three pedigree identification methods in a large 'commercial' merino breeding operation. The three pedigree identification methods compared in the trial were visual dam identification/tag at birth, DNA based parentage tests, and Pedigree Matchmaker.

From 1167 ewes Artificially Inseminated, 968 lambs were born in the trial. For each of the three identification methods the trial attempted to identify the sire and dam of each lamb. Results include percentage of lambs that had a sire and dam identified using each method, percentage of accurate identification of sire and dam, start-up and annual costs for each method and labour hours required for each method.

<table>
<thead>
<tr>
<th></th>
<th>Visual ID/Tag at birth</th>
<th>DNA parentage test</th>
<th>Pedigree Matchmaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sire identified %</td>
<td>99.5%</td>
<td>98.6%</td>
<td>N/A</td>
</tr>
<tr>
<td>Dam identified %</td>
<td>99.7%</td>
<td>98.1%</td>
<td>92.6%</td>
</tr>
<tr>
<td>Accuracy of Sire %</td>
<td>87.8%</td>
<td>99.6%</td>
<td>N/A</td>
</tr>
<tr>
<td>Accuracy of dam %</td>
<td>85.0%</td>
<td>97.8%</td>
<td>85.1%</td>
</tr>
<tr>
<td>Trial Capital costs</td>
<td>$1176</td>
<td>$15312</td>
<td>$3350</td>
</tr>
<tr>
<td>Trial Annual costs</td>
<td>$9683</td>
<td>$15566</td>
<td>$3610</td>
</tr>
<tr>
<td>Annual cost per lambs weaned</td>
<td>$12.50</td>
<td>$20.00</td>
<td>$4.65</td>
</tr>
<tr>
<td>Annual labour hours</td>
<td>268</td>
<td>27</td>
<td>18</td>
</tr>
</tbody>
</table>

Summary of results

Capital and annual costs for each method show that the most accurate method (DNA) is also significantly more expensive at the current cost of $17 per test. The Visual ID method requires significantly more time and labour input but is the only method that can capture birth traits and date of birth. The PMM method has a lower level of accuracy than DNA but comes with the least annual cost and much lower time and labour costs compared to Visual ID.

Through the use of electronic identification tags large volumes of data can be recorded and stored on individual animals. This can include pedigree, breeding history and performance
data. The ability to capture this information at a reasonable cost, store it and access it when required in a form that is meaningful is the key to improving livestock management, making genetic gain and improving profitability for sheep producers.

**Walkover weighing**

The collection of sheep body weights is a very important tool to monitor and manage sheep performance and health. A manager’s ability to make proactive decisions based on accurate objective continuous real-time information could improve productivity, profitability and animal welfare outcomes. This project attempted to demonstrate the ability to achieve these outcomes in a large commercial Merino operation. Walk over weighing (WOW) systems allow real time body weight information to be automatically transmitted directly from the paddock to the manager. This continuous flow of information without the need to muster the mob to yards and manually weigh each sheep allows real savings in time and labour as well as reduced stress on the animals and associated possible production losses.

The 2013 drop lambs that were used in the pedigree identification project above were used in the WOW project after they were weaned. The lambs were weaned on the 24th December 2013. The WOW system was installed and became operational on the 6th March 2014. Overall, 39495 weights were collected for 767 lambs (mob total 772 lambs) over 79 days during the period 6th March 2014 to 29th August 2014.

During the above operational period, data was collected in the paddock, transmitted to Sapien Technology in Melbourne, analysed and uploaded to the internet where it could be accessed by smartphone the following day. This was a fully automated system where information collected on one day was able to be accessed by smartphone the next. This was a successful “end to end” result for the WOW system and allowed information on individual and mob performance to be accessed easily by smartphone in real time. The major problem for the trial is that the weights transmitted did not correlate when compared to the actual manual weights. We believe these inaccurate weights resulted from a combination of poor crate design, software and hardware weigh data difficulties and the whole system not being robust enough to cope with the environmental conditions (significant mud build up during winter) and ability to be moved and reconstructed frequently as the mob changed paddocks (portability).

A new weigh crate was designed by the steering committee, constructed by Proway and installed on site on the 24th February 2015. This has resolved the structural, mud build-up, and portability issues previously experienced. A new scale head and data transmitter were also installed with the new crate however to date some software difficulties have not yet allowed continuous transmission of accurate weights. We believe with further development these difficulties will be resolved and a complete system will be commercially available in the near future. The ability to remotely monitor weight gains and losses from the paddock allows proactive management decisions and could therefore improve productivity, sheep health and profitability.

Much interest has been shown in the above projects by sheep producers with over 30000 having the opportunity to access information over the life of the project.
Table of Contents

Abstract .................................................................................................................................................. 2
Executive summary ................................................................................................................................. 3
  Commercial Pedigree Identification ..................................................................................................... 3
  Walkover weighing ............................................................................................................................... 4
  1. Background ..................................................................................................................................... 7
  2. Project objectives ............................................................................................................................. 8
     Aim ................................................................................................................................................... 8
     Objectives ....................................................................................................................................... 8
  3. Methodology .................................................................................................................................... 8
     Commercial Pedigree Identification ................................................................................................. 8
        Visual ID/Tag at birth ...................................................................................................................... 9
        DNA Parentage Test ..................................................................................................................... 10
        Pedigree Matchmaker ................................................................................................................... 11
        Results analysis methodology ...................................................................................................... 11
     Walk over Weighing (WOW) ........................................................................................................ 12
  4. Results ............................................................................................................................................ 15
     Commercial Pedigree Identification ................................................................................................. 15
        Sire Identification Rate (Number of lambs that had a sire identified) ........................................... 15
        Dam Identification Rate (Number of lambs that had a dam identified) ......................................... 15
        Sire Accuracy (How accurately was the sire identified) ................................................................. 16
        Dam Accuracy (How accurately was the dam identified) ............................................................... 17
        Set up/Capital Costs ....................................................................................................................... 18
        On-going/Annual Costs .................................................................................................................. 19
     Walk over Weighing ........................................................................................................................ 20
     Communication and extension ........................................................................................................ 25
  5. Discussion ........................................................................................................................................ 26
     Commercial Pedigree Identification ................................................................................................. 26
        Identification (how successful was each method in allocating a sire or dam) ................................ 26
        Accuracy (how successful was each method in accurately identifying the sire and dam) .......... 26
        Costs ............................................................................................................................................. 28
     Walk over Weighing ........................................................................................................................ 28
  6. Conclusion ...................................................................................................................................... 29
Objective 1 ........................................................................................................................................... 29
Implementation of 'real-time' data collection, evaluation & monitoring systems .......... 29

Objective 2 ........................................................................................................................................... 29
Evaluation of commercial pedigree identification technologies and techniques .......... 29

Objective 3 ........................................................................................................................................... 30
Evaluation of proactive management decisions and economic benefits ................. 30

Objective 4 ........................................................................................................................................... 30
Extension to the Commercial & Stud Industry of the Findings ................................. 30

7. Appendices ....................................................................................................................................... 31
1. **Background**

This trial was run in conjunction with the 2013 Elders Victorian Sire Evaluation program at ‘Wando Estate’, 1550 Edenhope-Casterton Rd, Wando, Victoria. The Elders Victorian Sire Evaluation is run under the umbrella of The Australian Merino Sire Evaluation Association (AMSEA), a not-for-profit organisation that oversees Merino Sire Evaluation across a range of sites located throughout Australia. These sites provide unique opportunities for ram breeders to compare genetic performance of individual rams with those from other ram breeding flocks. One of the benefits of being involved in these evaluations is that they enhance linkage between flocks that are using Sheep Genetics.

AMSEA collates analyses and publishes data from all sire evaluation sites to form the national publication Merino Superior Sires. AMSEA is also the governing body that determines the requirements for how each site is operated.

Traditionally sire evaluation sites lamb sire groups separately to establish progeny sire pedigree before they are combined into one mob, and their performance evaluated in a commercial management situation.

With the development of improved DNA based parentage tests, and other technologies such as Pedigree Matchmaker (PMM), alternate systems are available to producers to capture pedigree information. This trial was established to compare three alternate methods – visual dam identification, DNA based parentage tests, and Pedigree Matchmaker. The traditional sire group lambing can be allied with these methods to establish full sire and dam pedigree, however the DNA based testing can provide that without the need to separate sire groups at lambing.

Typically managers of sheep rely on their judgment and experience in evaluating how their sheep are performing. By the time even the most skilled managers identify a production problem, the impact could potentially have a detrimental outcome to productivity and profit. Strategic condition scoring and weighing of sheep are two of the current best practice management yardsticks, but this approach is reflective and leads to reactive management decisions. A manager’s ability to make proactive decisions based on objective continuous real-time information would assist productivity, profitability and animal welfare outcomes.

Although big differences in performances between individual sheep in a mob are known, without full pedigree and individual performance analysis it is often hard to differentiate between environmental and genetic effects. Traditionally in commercial sheep flocks, establishing full pedigree has been considered too time consuming and expensive without a justifiable business model that demonstrates that better selection, and subsequent genetic gain, is feasible. For example a heavier ewe with a poor lamb is kept and a light ewe that had great twins finds herself culled.

With the development of improved DNA based parentage tests, and other technologies like pedigree matchmaker, systems are now available to more readily identify full pedigree. Producers are also seeking to more readily link progeny to their dams to discover and monitor the full implications of the ewes’ body weight changes on progeny performance and survival.
In the case of the demonstration of ‘Pedigree Matchmaker’ (PMM) as a viable commercial pedigree identification method, the management of single and multiple bearing ewes as separate groups post pregnancy scanning creates the opportunity to compare the relative effectiveness of this method for ‘twins’ vs. ‘singles’. The ‘accurate’ DNA based parentage testing will presumably give a comparative measure of the accuracy of dam identification using PMM for each group.

The Elders Balmoral Sire Evaluation group offered an excellent conduit to both the commercial and seed stock sectors of the Australian sheep industry, to evaluate commercial pedigree identification systems, and relate them to enhanced flock performance through the use of real-time monitoring technologies.

Tom Silcock, Chair of the Elders Victoria Sire Evaluation Group is the Project Leader. Project Managers are Steve and Debbie Milne from Richmond Hill Agribusiness Pty Ltd. The initial steering committee for the project was Tom Silcock, Steve and Debbie Milne, Michael Craig (Treasurer EVSEG), Rosey Leeming (Member EVSEG), Robert Wyld (Sapien Technology), Bill Murray (Exacta Livestock) and Peter Bailey (Vic DEPI). Funding for the project was provided by Meat and Livestock Australia, Victorian Department of Environment and Primary Industries, Australian Wool Innovation Limited and matching in kind donations from industry.

2. Project objectives

Aim

To demonstrate ‘proof of concept’ of pedigree identification techniques and ‘real-time’ data collection as linked activities, and evaluate their effectiveness in relation to proactive flock management, improved genetic gain, and improved productivity and profitability.

Objectives

1. Implementation of ‘real-time’ data collection, evaluation & monitoring systems
2. Evaluation of commercial pedigree identification technologies and techniques
3. Evaluation of proactive management decisions and economic benefits
4. Extension to the Commercial & Stud Industry of the Findings

3. Methodology

Commercial Pedigree Identification

A total of 1167 merino ewes were Artificially Inseminated to 19 sires in April 2013. The ewes were pregnancy scanned on June the 3rd 2014 with 564 being identified as carrying a single lamb and 234 ewes were scanned in lamb with twins. There were 4 ewes having triplets and 365 dry ewes. Dry ewes and ewes bearing triplets were removed from the trial. One sire only had 2 ewes in lamb and was removed from the trial leaving 18 sires in the trial. At lambing 936 lambs were recorded with a further 32 dead lambs not recorded (total lambs 968).
The three pedigree capture methods compared in the trial were visual matching of lambs with dams at birth (Visual ID/Tag at birth), DNA based parentage test, and Pedigree Matchmaker.

**Visual ID/Tag at birth**

On July 31<sup>st</sup> 2013 the pregnant ewes were weighed and allocated a visual ID number by tagging them with an individually numbered ‘Flexible Size 3’ cattle tag supplied by Leader Products®. This was linked to an already existing RFID (electronic) tag using an Allflex® stick reader and a Trutest® XR3000 indicator.

On July the 23<sup>rd</sup> the twin bearing ewes were split into their joining sire groups, with the single bearing ewes being split on July the 26<sup>th</sup>. Wando Estate has a drought containment paddock setup which allowed each single/twin joining sire group to be allocated a small lambing paddock (36 individual lambing paddocks).

There were a few early lambs that were identified by Wando Estate staff however the bulk of lambing commenced on August the 31<sup>st</sup>. Visual matching of lambs with their dams continued until lambing ceased on September the 9<sup>th</sup>. The lambs were tagged with a Leader Products® Jumbo EID Sheep Tags. Pedigree and other lambing information were recorded using a Datamar® GES3S Universal Portable Tag Reader.

At the height of lambing, the task of identifying dams, tagging lambs and recording lambing information was full time during daylight hours. This visual matching required a team of between one and five people. Considerable difficulties were experienced reading the cattle tags in the ewes ears. The tags were too small and only numbered on one side. Some of the tags were inserted without enough thought to their readability. In addition some had the numbers obscured with mud. A number on both sides and bigger tags would have overcome much of this issue. Results from the dam visual identification and tagging at birth were received from the contractor on the 10<sup>th</sup> September 2013.
DNA Parentage Test

All but 2 of the sires involved in the trial had previously had DNA samples submitted to the Sheep CRC for assessment through either the 50k SNP (Single Nucleotide Polymorphism) genomic test. The results of this test can also be used for the associated parentage test. DNA had to be extracted from semen for the two sires that had not previously been tested. This did cause some delay in the parentage results being available.

Blood samples were taken from the 798 ewes that were included in the trial on July the 31st 2013 using the Sheep CRC Sheep Genomic Test blood cards. These blood cards were matched to the visual ID allocated on that day for the Visual ID method described previously. The samples were taken with the ewes restrained in a ‘VE machine’ with pre-lambing vaccination and drench given at the same time. These ‘blood cards’ were submitted prior to lambing to allow the ewe flock DNA data base to be built prior to lambing.

The DNA samples from the lambs were taken on the 14th of October 2013. This was combined with ear notching, scoring the lambs for breech cover and wrinkle and pigmentation scoring. The lambs were identified by their EID, with barcode labels being printed and attached to the blood cards. This was done using an Allflex® stick reader and a Zebra® barcode printer, with the lambs restrained in a rotating lamb marking cradle. The ewes that had been drafted from their lambs were simultaneously assessed as wet and dry, with the dry ewes removed from the mob.

The blood samples were despatched to the Sheep CRC on the 25th November. After DNA samples and parentage test results were obtained from the two previously untested sires, the DNA based parentage results for the lambs were received on March the 18th 2014.
Following joining, training commenced to familiarise the trial ewe flock with the equipment used for Pedigree Matchmaker data capture. To facilitate the capture of dam and lamb IDs (using EID technology) the animals must pass through a short race equipped with an EID panel reader and a data collector. Initial training was done using a trailer with a mesh floor which was able to be lowered to ground level. A loose mineral lick was placed in the middle of the trailer to encourage the ewes to walk onto and through the trailer. This training continued until just prior to lambing.

Following lambing and the boxing of the single and twin bearing ewes and their lambs back into two mobs, two purpose built Proway® Walk Over Weighing (WOW) crates were introduced into the trial. Training of the ewes and lambs continued through mustering each mob into a holding laneway/paddock and then allowing them at will to return to their paddocks only through the crate. These crates are adjustable for width and initially were set on their widest setting and over the course of the next week were gradually narrowed until they were approximately 300mm wide at the base, allowing only single file access. The crates were then moved to become the access point in a fence around the water troughs with a mineral lick as an added attractant placed inside the fence.

Each crate was equipped with a Sapien Pedigreescan® panel reader and data collector supplied by Sapien Technology. The panel reader captured the electronic tag number of each ewe and lamb as they passed through the crate. Data was downloaded and emailed to Sapien on 16/10/13, 23/10/13, 29/10/13, 4/11/13, 14/11/13, 24/11/13, 3/12/14, 10/12/13 and 24/12/13. Data analysis and results were undertaken by Bill Murray from Exact Livestock and received on 9th January 2014.

**Results analysis methodology**

The first analysis looked at how many live lambs actually had a sire or dam identified for them by each pedigree capture method and was a simple percentage of number identified by number available for identification. Dam identification success rate used the same method.
To assess accuracy of sire identification for the DNA method, the DNA result was compared to the AI sire records for each ewe. The results reflect the percentage of the same sire identified by DNA and AI sire records. The Visual ID method was compared to the DNA records and results reflect the percentage of records that were the same.

Given the accuracy of the sire DNA test the DNA dam records were used as the benchmark to compare the other two methods.

Cost analysis was split into start-up/capital costs and ongoing/annual costs. Actual costs incurred by the trial have been recorded and may not reflect the costs incurred by other farmers in their own operations. Annual costs were divided by the number of lambs weaned (778) to give a dollar comparison per lamb.

Labour hours reflect the actual labour hours undertaken in the trial by contractors, staff at Wando Estate and volunteers assisting with the project.

**Walk over Weighing (WOW)**

The WOW system was installed and commenced data transmission on the 6th March 2014. The Proway crate used in the Pedigree Matchmaker dam identification project was used with Trutest weigh bars attached. A Trutest XR3000 scale head with walk over weighing capacity collected weights and a purpose built Sapien Technology telemetry system automatically transmitted the weights to the Sapien office in Melbourne via transmission to the homestead and then via the internet. A purpose designed Sapien software program then automatically analysed the raw data and reported it via a WOW app created by Sapien for this project.

Using this system, data was transmitted for the following periods,

- 6th March 2014 to 10th April 2014. Field day held on the 11th April with the lambs and the WOW unit on display. The WOW system was not re-connected and operational until the 20th May 2014 (delays due to flat batteries and lambs placed in containment paddocks).
- 20th May 2014 to 2nd July 2014. From the 2nd July, it was decided to wait until the paddocks dried up as mud build up was effecting the data quality due to poor crate design.
- 29th August to 26th September. From the 26th September it became apparent that the weights were inaccurate and there were significant issues affecting data quality with both the crate design and the operation of the WOW software program in the XR3000.

Since 26th September, “Sapien Technology” have designed and created a new scale head and data collector “Kool weigh” for walk over weighing. This equipment was to have been installed in December 2014. At installation on the 18th December 2014, it became apparent that the existing Proway crate was broken and required modification. It was decided not to install the new electronic equipment until the crate could be modified.

A new crate was designed by Rob Wyld from Sapien Technology with input from the steering committee and constructed by Proway Livestock Equipment. This crate is an all in one design with the crate attached to the trailer and the tow bar forming the base of the transmission mast. The scale head, electronics, battery and solar panel are also part of the unit. This means one person is able to easily move the unit from paddock to paddock. It was installed with the new “Koolweigh” scale head and electronics on the 24th February 2015. This new system has resolved the crate structural and portability issues previously experienced.

Some difficulties were experienced with the software in the new electronics unit and a replacement unit was installed on the 26th March 2015. Although data has been transmitted since that date, continuing software problems have failed to be resolved prior to the end date of this project on 1st May 2015. It is expected with further development that these difficulties will be resolved and a commercial system will soon be available.
See Appendix 1. This video shows the sheep in March 2014 accessing a water trough through this trials first WOW system.

See Appendix 2. This video shows the sheep on the 26th March 2015 accessing a mineral lick after a software update when the new WOW system was replaced in their paddock.

See Appendix 3. This video shows the new WOW system in the paddock on the 31st March 2015. Note sheep are accessing a water trough through the crate even though the fence was open to the trough opposite the crate.
4. Results

Commercial Pedigree Identification

Sire Identification Rate (Number of lambs that had a sire identified)
Prior to lambing the ewes were drafted into sire groups and then into separate paddocks for each sire. They were also split into ewes bearing twins and ewes with singles for each sire (36 separate lambing paddocks). As the lambs were tagged at birth the sire was recorded for each lamb based on their paddock allocation. The sire of each lamb was also identified using the Sheep CRC DNA based parentage test. Pedigree Matchmaker does not identify sires.

Table 1: Sire Identification Rate

<table>
<thead>
<tr>
<th>Sire Identification Rate</th>
<th>Visual ID/Tag at Birth</th>
<th>DNA Parentage Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of lamb records</td>
<td>936</td>
<td>808</td>
</tr>
<tr>
<td>Sire recorded</td>
<td>931</td>
<td>797</td>
</tr>
<tr>
<td>Sire not recorded</td>
<td>5 *</td>
<td>11 **</td>
</tr>
<tr>
<td>Identification Rate</td>
<td>99.5%</td>
<td>98.6%</td>
</tr>
</tbody>
</table>

*Visual ID/Tag at Birth - the 5 unrecorded sires were a tagging error noted by the contactor.

**DNA sires not recorded – the reasons for the 11 unrecorded sires were,

- 1 blood card with no ID,
- 6 blood card ID errors (duplicate bar code labels on the blood cards),
- 3 failed tests (genotyping result not good enough to generate a sire result),
- 1 sire unallocated (stray lamb - the sire and dam of this lamb were unknown to the trial. This lamb was found in the mob when taking the blood samples for the DNA tests on the 14th October 2013. It did not have a tag but was given a new EID tag to enable a blood card to be identified. It is most likely to have been a stray from outside the trial)

Dam Identification Rate (Number of lambs that had a dam identified)
Each ewe was tagged with small sized Leader® cattle tag to allow visual identification in a ‘paddock’ situation. Dams were visually identified when tagging the lambs soon after birth, by the DNA based parentage test and by the Pedigree Matchmaker (PMM) system.

Table 2: Dam Identification Rate

<table>
<thead>
<tr>
<th>Dam Identification Rate</th>
<th>Visual ID/Tag at Birth</th>
<th>DNA Parentage Test</th>
<th>Pedigree Matchmaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of lamb records</td>
<td>936</td>
<td>808</td>
<td>787</td>
</tr>
<tr>
<td>Dam recorded</td>
<td>933</td>
<td>793</td>
<td>729</td>
</tr>
<tr>
<td>Dam not recorded</td>
<td>3 *</td>
<td>15 **</td>
<td>58 ***</td>
</tr>
<tr>
<td>Identification Success Rate</td>
<td>99.7%</td>
<td>98.1%</td>
<td>92.6%</td>
</tr>
</tbody>
</table>
* Visual ID/Tag at Birth - 3 lambs did not have a dam recorded when tagging the lambs at birth.

**DNA dams not recorded – the reasons for the 15 unrecorded dams were,

- 1 blood card with no ID,
- 6 blood card ID errors (duplicate labels),
- 3 failed tests (genotyping result not good enough to generate a dam result),
- 3 dams unallocated - dams were not in system,
- 1 unallocated dam – genotyping result too close to identify,
- 1 dam unallocated (stray lamb, as above)

***PMM - 787 lambs had either a PMM record and/or had a weight recorded at weaning on the 24th December 2013, 58 lambs did not have a dam recorded.

Sire Accuracy (How accurately was the sire identified)

Sire allocation accuracy was determined for the DNA method by comparing the AI records for each ewe (At AI which ewe was joined to which sire) with the DNA test results. For Visual ID the sire recorded at birth for each lamb was compared with the DNA test sire results and the ewe AI records.

Table 3: Sire Identification Accuracy

<table>
<thead>
<tr>
<th>Sire Identification Accuracy</th>
<th>DNA Test compared to Dam AI records</th>
<th>Visual ID/Tag at Birth compared to DNA records</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of records available for comparison</td>
<td>808</td>
<td>796</td>
</tr>
<tr>
<td>Incorrect Sire</td>
<td>14 *</td>
<td>97 **</td>
</tr>
<tr>
<td>Correct Sire</td>
<td>794</td>
<td>699</td>
</tr>
<tr>
<td>Sire Accuracy</td>
<td>98.3%</td>
<td>87.8% ***</td>
</tr>
</tbody>
</table>

*** If the sire tag error had not occurred, the accuracy rate of sire identification by Visual ID/Tag at Birth would have been 98.7% compared to the DNA results.

* DNA test – reasons for the 14 incorrect sire results,

- 11 sires were unrecorded (see Table 1. Sire identification rate)
- 3 incorrect sire results were caused by incorrect ewe identification when the ewes were DNA tested.
  - 2 ewes were identified with the same visual tag number 664 for the ewe DNA tests. They were in fact 664 and 614. The ewe DNA test blood cards were identified by hand writing the visual tag number on the blood cards. Either the blood cards had the incorrect tag number written on them or were transcribed incorrectly for the DNA test. This resulted in one ewe identified as 664 that should have been 614, with twin lambs not matching the AI sire records.
  - 1 Dam visual ID number incorrect (Dam ID number 98 instead of 96).

**Visual ID/Tag at birth – reasons for the 97 incorrect sire results,
• Of the 97 incorrect sires, 87 of these were caused by incorrect identification of the sire, there appears to have been a direct swap between two of the sires. The lambs were tagged with the same colour sire tag as their ewes. The ewes were tagged at AI with a coloured sire tag in addition to their electronic tag. It appears that although the correct sire was identified to the correct ewe by the electronic tags at AI, the coloured sire tags were swapped over for two of the sires.

• Of the remaining 10 incorrect sires, 5 of these were noted at lambing by the contractor as his mistake and he was unable to identify the sire. The sire identification of the remaining 5 lambs was incorrect.

**Dam Accuracy (How accurately was the dam identified)**

Dam accuracy for Visual ID/Tagging at birth method and PMM method has been compared to the results from the DNA test where a correct dam identification result was available. Given the accuracy of the Sire DNA test, the Dam DNA test has been assumed to be the most accurate identification of the dam.

**Table 4: Dam Identification Accuracy**

<table>
<thead>
<tr>
<th>Dam Accuracy</th>
<th>DNA Test compared to Dam AI records</th>
<th>Visual ID/Tag at birth compared to DNA test</th>
<th>PMM compared to DNA test**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of records available for comparison</td>
<td>808</td>
<td>791</td>
<td>772</td>
</tr>
<tr>
<td>Incorrect Dam</td>
<td>18 *</td>
<td>119 **</td>
<td>115 ***</td>
</tr>
<tr>
<td>Correct Dam</td>
<td>790</td>
<td>672</td>
<td>657</td>
</tr>
<tr>
<td><strong>DAM Accuracy</strong></td>
<td><strong>97.8%</strong></td>
<td><strong>85.0%</strong></td>
<td><strong>85.1%</strong></td>
</tr>
<tr>
<td>Number of single lamb records available for comparison</td>
<td></td>
<td>479</td>
<td>472</td>
</tr>
<tr>
<td>Single lamb with incorrect dam</td>
<td></td>
<td>58</td>
<td>53</td>
</tr>
<tr>
<td>Single lamb with correct dam</td>
<td></td>
<td>420</td>
<td>419</td>
</tr>
<tr>
<td><strong>Single lamb dam accuracy</strong></td>
<td><strong>87.7%</strong></td>
<td><strong>88.8%</strong></td>
<td></td>
</tr>
<tr>
<td>Number of twin lamb records available for comparison</td>
<td>313</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>Twin lamb with incorrect dam</td>
<td></td>
<td>61</td>
<td>62</td>
</tr>
<tr>
<td>Twin lamb with correct dam</td>
<td></td>
<td>252</td>
<td>238</td>
</tr>
<tr>
<td><strong>Twin lamb dam accuracy</strong></td>
<td><strong>80.5%</strong></td>
<td></td>
<td><strong>79.3%</strong></td>
</tr>
</tbody>
</table>

*A DNA test – reasons for the 18 incorrect dam results,*

- 15 dams were unrecorded (see Table 2. Dam Identification rate)
- 3 incorrect dam results were caused by incorrect ewe identification when the ewes were DNA tested.
  - 2 ewes were identified with the same visual tag number 664 for the ewe DNA tests. They were in fact 664 and 614. The ewe DNA test blood cards were identified by hand writing the visual tag number on the blood cards. Either the blood cards had the incorrect tag number written on them or were transcribed incorrectly for the DNA test. This resulted in one ewe identified as 664 that should have been 614, with twin lambs not matching the AI sire records.
1. Dam visual ID number incorrect (Dam ID number 98 instead of 96).

- Therefore, of the 18 inaccurate dam DNA results, 14 of the 18 appear to be due to human error with the other 4 the result of DNA test failure.

** Visual ID/Tag at Birth - reasons for inaccurate identification of dams include,

- Difficulty reading the ewe Visual ID tags,
  - Tag numbers were too small
  - Tag numbers were only printed on one side of the tag
  - Placement of the tags in the ewes ears was sometimes poor – tag obscured by wool or at a poor angle
  - Tag number obscured by mud

- Mismothering
  - Ewes lambed in very small lambing paddocks (36)
  - Ewes were highly socialised and all lambed over a very short time (AI program)

*** For the PMM comparison, lambs were included if there was a DNA result and either a PMM record for them or they had a weaning weight recorded after the PMM data collection had been completed. Accuracy was affected by the number of lambs that did not have a dam identified as well as the number identified to the wrong ewe.

### Set up/Capital Costs

<table>
<thead>
<tr>
<th>Visual ID/Tag at birth</th>
<th>$</th>
<th>DNA</th>
<th>$</th>
<th>PMM</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour - tag ewes with visual tags (8 hours x 3 people @ $30)</td>
<td>$720</td>
<td>Parentage test ewes (798 ewes @ $17 per test) **</td>
<td>$13,566</td>
<td>Pro way crates x 2 ($900 per crate) ***</td>
<td>$1,800</td>
</tr>
<tr>
<td>Leader cattle tags (800 @ $0.57)</td>
<td>$456</td>
<td>Labour - blood sample collection (8 hours x 3 people @ $30)</td>
<td>$720</td>
<td>Deep cell batteries x 2 ($250 per battery)</td>
<td>$500</td>
</tr>
<tr>
<td>Fencing, water and labour for lambing paddocks *</td>
<td>$0</td>
<td>Electronic tags for ewes (800 @ $0.90)</td>
<td>$720</td>
<td>Train ewes - labour (11 hours) @ $30) ****</td>
<td>$330</td>
</tr>
<tr>
<td>Parentage test sires (18 @ $17 per test) **</td>
<td>$306</td>
<td>Electronic tags for ewes (800 @ $0.90)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Trial Capital Costs</strong></td>
<td>$1,176</td>
<td>$15,312</td>
<td>$3,350</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*For this trial pre-existing lambing paddocks (36) were utilised. If these were not in existence, there would be the additional cost of erecting appropriate fences, water points and labour required for same. These costs could vary enormously for every farm so no attempt has been made to estimate this capital cost for the Visual ID/Tag at birth method.

** Based on current parentage test cost $17 per test

*** This trial used the Pro way crates for the Pedigree Matchmaker comparison. These crates are not necessary for this process, any materials could be used to construct a race 1.5m in length that allows single file access to an attractant.
**** The number of hours spent training the ewes would vary with the equipment in use and the number of ewes to be trained. More ewes require more time.

### On-going/Annual Costs

<table>
<thead>
<tr>
<th>Visual ID/ Tag at birth</th>
<th>DNA</th>
<th>PMM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour - draft ewes for lambing (49.5 hours @ $30)</td>
<td>$1,485</td>
<td>Parentage test lambs (808 lambs @ $17 per test)</td>
<td>$13,736</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Labour - data collection (33 hours for the trial, usually 6 hours @ $30 per hour)</td>
<td>$180</td>
</tr>
<tr>
<td>Labour - tag lambs at birth (212.5 hours @ $30)</td>
<td>$6,375</td>
<td>Labour - blood sample collection (lambs) (8 hours x 3 people @ $30)</td>
<td>$720</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Labour - train ewes (5 hours @ $30)</td>
<td>$150</td>
</tr>
<tr>
<td>Labour - data (6 hours @$100)</td>
<td>$600</td>
<td>Labour - data (3 hours @ $100)</td>
<td>$300</td>
</tr>
<tr>
<td>EID tags (1200 tags @$0.90)</td>
<td>$1,080</td>
<td>Attractant - Mineral lick, molasses **</td>
<td>$1,000</td>
</tr>
<tr>
<td>Leader cattle tags for retained breeding ewes (250 @ $0.57)</td>
<td>$143</td>
<td>PMM data analysis</td>
<td>$300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EID tags (1000 tags @$0.90)</td>
<td>$900</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Labour - data (3 hours @ $100)</td>
<td>$300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment hire ($110 per week for 6 weeks)</td>
<td>$660</td>
</tr>
</tbody>
</table>

Total Annual Labour = 268 hours

Total Annual Labour = 27 hours

Total Annual Labour = 18 hours

Total Trial Annual Costs $9,683 $15,566 $3,610

Cost per lambs weaned (778) $12.50 $20.00 $4.65

*As this was a trial situation, data was collected more frequently to ensure results were obtained than would be the case in a commercial situation. The number of hours data collection would normally take was estimated by Rob Wyld from his extensive commercial experience and was included as the annual labour cost for data collection above.

**The attractants of molasses and a mineral lick were required in this trial as water alone was ineffective due to the amount of water lying in the paddocks during a wet spring. Under different climatic situations water alone may have provided the necessary attractant for the sheep to pass through the crate or race and could have removed this cost.

*** The Pedigreescan data collector is now available for hire, removing the necessity of purchasing this equipment.
Walkover Weighing

The Walkover Weighing (WOW) system became operational on the 6th March 2014. It automatically collected and transmitted lamb weights for the periods,

- 6th March 2014 to 10th April 2014. Field day held on the 11th April with the lambs and the WOW unit on display. The WOW system was not re-connected and operational until the 20th May 2014 (delays due to flat batteries and lambs placed in containment paddocks).
- 20th May 2014 to 2nd July 2014. From the 2nd July, it was decided to wait until the paddocks dried up as mud build up was effecting the data quality due to poor crate design.
- 29th August to 26th September. From the 26th September it became apparent that the weights were inaccurate and there were significant issues affecting data quality with both the crate design and the operation of the WOW software program in the XR3000.

Overall, 39495 weights were collected for 767 lambs (mob total 772 lambs) over 79 days for the period 6th March 2014 to 29th August 2014. The average number of weights collected per lamb was 51 with the maximum number being 449 for one lamb and the minimum, 1 weight collected for 1 lamb.

Manual body weights of the lambs were taken on the 24/12/2013, 3/4/2014, 29/8/2014, 16/10/2014 and 19/12/2014. WOW weights taken on the 2nd and 3rd April 2014 were averaged for each lamb for the day and then correlated with the manual weight taken on the 3rd April 2014 (303 WOW weights on the 2nd April and 49 WOW weights on the 3rd April). The correlations were 0.25 and 0.4 respectively. This is a poor result and reflects the advice from Sapien Technology that the weights collected were erratic and unreliable.
This graph shows the total number of weights collected per lamb. The majority of lambs recorded between 20 and 90 weights each for the 79 days that weights were recorded.

This graph shows an average of the body weights collected each day and clearly shows the inaccurate weights collected after the 30th August 2014. These inaccurate weights were due we think to mud build up, structural faults in the crate as well as software problems in the XR3000.
This graph shows the number of weights collected for each day weights were collected. It shows there is a large variation in the number of weights collected per day and may be related to the original crate structural difficulties, rotational grazing and the difficulties of moving the original crate from paddock to paddock.
The table above shows the correlation between the adjusted WOW weights captured on the 3rd April 2014 and the manual weights taken on the 3rd April 2014 for those lambs.

Following the redesign and construction of the new crate and the creation of the new scale head (Koolweigh), the new system was installed on the 24th February 2015. Some software difficulties were encountered and a new electronics unit was installed on the 26th March.
2015. Unfortunately the new software has not proven able to sustain operation or provide reliable results prior to the project finishing on the 1st May 2015. (Another unit is awaiting installation but was not completed prior to the finishing date of the project) Development will continue and we believe a viable system will soon be commercially available.

The pictures below are screenshots of the Sapien Technology “WOW App” of data available on the 7th April 2015. The App homepage (top left) gives a summary of the data available. By clicking on each section (Missing, Attendance and Weight Gain) more details and the parameters set for each section are available.
Communication and extension

Information and results were distributed as follows,

1. Reports in the Balmoral Sire Evaluation Group Newsletters in December 2013, April 2014, July 2014 and will be included in the May 2015 newsletter. These Newsletters were sent to the Group membership (250 members) and are available to anyone on the Group website [http://www.balmoralbreeders.com.au/newsletters.html](http://www.balmoralbreeders.com.au/newsletters.html)

2. Display and presentations at the Balmoral Sire Evaluation Group Field days held at Wando Estate in April 2014 and April 2015. These field days were well publicised and open to anyone to attend, approximately 80 sheep producers attended each field day.

3. Displays in 2014 and 2015 at Bendigo Sheep and Wool Show (attended by over 5000 farmers each year), Balmoral Show (attended by over 500 farmers each year) and Hamilton Sheepvention (attended by over 25000 farmers each year). These shows provided opportunities for sheep producers to access information, see equipment and discuss results.

4. Presentation at the Trangie Field day by Tom Silcock (Chair) on the 19th June 2014 (approximately 80 sheep producers).

5. WOW video and information on display at the Sapien site at the Lambex conference in Adelaide 2014 (attended by more than 900 delegates).
5. Discussion

Commercial Pedigree Identification

No method was 100% perfect in either being able to identify the sire or dam for each lamb or for the accuracy of sire and dam identification.

Identification (how successful was each method in allocating a sire or dam)

Given that the ewes were lambed in joining sire groups you would expect that the sire identification rate for the Visual ID method would be high. In fact it would have been the expected 100% except that the contractor collecting the lambing data was unsure for 5 lambs and so did not assign them a sire.

Identification results were a number of reasons that 11 of the lambs that had DNA samples taken for parentage testing had no result at all. A stray lamb appeared in the mob the day the lambs were DNA tested. It had no tag but had previously had one. It was thought therefore that it belonged in the mob and so was given a replacement tag and was subsequently DNA tested. It would appear however that this lamb was a stray as the sire and dam were also unknown to the trial. The seven blood cards that either had repeated or missing barcode labels can be put down to operator error. The fact that there were only 3 failed tests and one test with a dam that was too close to identify from 808 samples collected, shows that the technology is relatively robust and easy to use.

As is noted in the results there were a number of reasons that 11 of the lambs that had DNA samples taken for parentage testing had no result at all. A stray lamb appeared in the mob the day the lambs were DNA tested. It had no tag but had previously had one. It was thought therefore that it belonged in the mob and so was given a replacement tag and was subsequently DNA tested. It would appear however that this lamb was a stray as the sire and dam were also unknown to the trial. The seven blood cards that either had repeated or missing barcode labels can be put down to operator error. The fact that there were only 3 failed tests and one test with a dam that was too close to identify from 808 samples collected, shows that the technology is relatively robust and easy to use.

Accuracy (how successful was each method in accurately identifying the sire and dam)

The first task when assessing the accuracy of the various methods was to set a benchmark for comparison. The benchmark chosen was the DNA based test. To assess the sire accuracy for the DNA test, the results were compared to the ewe AI records. Apart from the 11 tests where no result was recorded, only 3 were incorrect. These were the result of dam tag identification errors. Dam visual tag numbers were handwritten on the DNA blood cards and the error could have been the result of incorrect transcription when identifying the blood cards or a transcription error in the laboratory.
The Visual ID method had a sire accuracy of 87.8%. Given that the ewes were drafted into joining sire groups it would have been expected that this would have been 100% however a check of sire allocation in this instance against both DNA and AI records revealed that for the 97 incorrect sires, 87 of these were caused by incorrect identification of the joining sire group. This incorrect identification shows a direct swap between two of the sires. If this error had not occurred the accuracy rate would have been 98.7% for tagging at birth compared to the DNA test. Of the remaining 10 incorrect sires, 5 of these were noted at lambing by the contractor as his mistake as he was unable to identify the sire and were therefore incorrect. The other 5 lambs had an incorrect sire allocated to them. Correcting for the joining sire tag error would have resulted in an accuracy of 98.7%. This correction is considered valid because it is considered normal that a check of joining records would be common practice in any breeding program wishing to record pedigree. It is important to note in this instance that the swap between the two sire’s would not have been identified without the comparison with the DNA test results.

The dam allocation accuracy in the Visual ID method had an overall accuracy of 85.0% when compared with the DNA records, with singles and twins being 87.7% and 80.5% respectively. There may be a number of reasons for this. The lambing team noted that the visual tags were difficult to read because they were too small and were often contaminated by mud etc. It was also noted that they only had the VID on one side and in some cases were badly positioned in the ewe’s ear, making accurate identification difficult. In addition to these factors there was, given the intensive nature of the lambing paddocks considerable opportunity for mismothering. The small size of the paddocks meant that the ewes were highly socialised and in close proximity at the point of lambing. This mismothering might be expected to increase with an increase in litter size and this is supported by the comparative accuracies for the single and twin lamb dam allocations.

The Pedigree Matchmaker method can only capture dam pedigree. The sire allocation must be sourced from joining records or DNA. For the PMM comparison, lambs were included if there was a DNA result and either a PMM record for them or they had a weaning weight recorded after the PMM data collection had been completed – 772 lambs in total. (There were in fact 787 lambs recorded by PMM at some time, however there were only 772 of them with a successful DNA test for comparison) This gave an overall accuracy of 85.1% when compared with the DNA record. The singles and twin result was 88.3% and 79.3% respectively. There were 58 lambs that PMM was unable to allocate a dam for. These lambs had either not accessed the PMM race or were unable to be associated with a dam (i.e. they had not achieved a level of association with a dam that was acceptable to the PMM analysis) but did have a weaning weight recorded after the PMM data capture had finished. Of the lambs that were allocated a dam by PMM 91.5% matched the DNA analysis. As with the Visual ID method there is significant evidence of mismothering in the PMM data, perhaps increased, in this case, due to the fact that the ewes had been confined in small areas during lambing. In a larger commercial lambing situation this mismothering may not be as pronounced.

Of the 808 lambs that were available for a DNA test on October the 31st, 793 of them were allocated a dam. A comparison of AI records and the DNA results for those 793 lambs show an accuracy of 99.6%. It would appear that the 3 tests that incorrectly identified the dam were due to ewe ID numbers being duplicated or incorrect. Fifteen tests were unsuccessful in identifying the dam - 1 blood card with no ID, 6 blood cards with ID errors
(duplicate labels), 3 failed tests (genotyping result not good enough to generate a dam result), 5 unallocated dams (4 dams not in system and 1 too close to identify). These 15 unsuccessful tests demonstrate that although the DNA Parentage test is very accurate, there are a number of reasons that the test can 'fail'. In this case despite the fact that the trial use EIDs linked to a barcode printer to identify the blood cards, missing and repeated labels meant 7 tests were unsuccessful. The 4 dams not in the system would indicate that their DNA test ‘failed’ and so the ‘success’ rate of identifying dam pedigree for a lamb is dependent on two separate sample collections and DNA analyses. Despite the fact that the DNA parentage test uses 182 SNP ‘markers’ the testing was unable to identify the dam of one lamb because genetically it was ‘too close’ to another. This problem has in the main been alleviated with the new SNP technology used in the Sheep CRC test because it uses more markers than previous testing techniques.

**Costs**

Capital costs for the Visual ID/Tag at birth method were very low if no additional paddocks require construction. Only the tag and associated labour costs were required so that ewes could be visually identified in the paddock. Capital costs for the DNA tests were by far the most expensive due to the cost of the initial parentage tests required for the sires and dams. Capital costs were relatively low for Pedigree Matchmaker and could have been less if the Proway crates had not been used.

**Walk over Weighing**

The intention of the WOW trial was to investigate the feasibility of establishing an ‘end to end’ arrangement that remotely collected, analysed and displayed flock information in ‘real-time’.

To achieve this goal, it was necessary for the sheep to readily access the scales, for weights to be collected on an individual ID basis, and for that information to be analysed and reported in format which gave the livestock manager a succinct decision making tool. In addition, the equipment had to be robust, and easily moved and setup.

Given the use of the Proway crate for Pedigree Match Maker in the pedigree capture trial, the WOW trial sheep were already familiar with the scales, so no training was required to familiarise them with the equipment. However this might be a consideration in other commercial situations where this type of equipment is introduced merely for a WOW type monitoring process. The experience of this trial is that once animals become familiar with the concept of accessing feed or water via a narrow race type structure, then they are comfortable with changes of location and equipment.

The trial has demonstrated that weight and ID information is able to be remotely captured, transmitted, analysed and displayed in ‘real-time’. There is growing use of internet and smartphone Apps by primary producers. The ‘stoplight’ design of the WOW app home-screen gives producers a simple tool to assess flock weights and attendance in real-time, allowing them to make proactive management decisions. The correlations of 0.25 and 0.4 between WOW and ‘manual’ weights recorded on the 2\textsuperscript{nd} and 3\textsuperscript{rd} of April 2014 reflect the advice of Sapien Technology that the WOW weights were at times erratic and unreliable. We believe these inaccurate weights resulted from a combination of poor crate design,
XR3000 software difficulties and the whole system not being robust enough to cope with environmental conditions (significant mud build up during winter).

A potential barrier to the uptake of this form of flock monitoring is the ability to readily move the equipment as the mob is moved. The original Proway crate, which in WOW form was linked to a small trailer containing the recording and transmitting equipment, required considerable effort to pack-up, move, and set up. This meant there was often a delay in this happening when the mob was shifted, leading to a breakdown in the continuous monitoring. The design of the new crate which incorporates the scales and the recording, transmission and power source equipment in a small mobile unit, improves the portability considerably. The experience of this trial is that portability is a major issue. We believe that if the WOW system is to be widely adopted by commercial producers the system needs to be easily moved from paddock to paddock.

6. Conclusion

Objective 1

Implementation of ‘real-time’ data collection, evaluation & monitoring systems

This project successfully designed, created and implemented a Walkover Weighing end to end system. It automatically weighed sheep in the paddock and transmitted EID tag numbers and weights via the internet to Sapien Technologies in Melbourne it then automatically analysed the data and presented useful information the next day that could be accessed by smartphone. Difficulties were encountered with the crate design, portability and accuracy of weights. These have mostly been resolved with construction of a new purpose built crate and development of a new scale head. Software difficulties preventing continuous transmission of accurate weights are yet to be resolved.

The project has proven it is possible to train large numbers of commercial Merino sheep to use a walkover weigh system and provide real time information on their body weight status.

Objective 2

Evaluation of commercial pedigree identification technologies and techniques

The aim of this trial was to compare the accuracy and related costs of three method of capturing pedigree information in a ‘commercial’ situation. All three methods demonstrated an ability to capture that information, but with varying degrees of success (the percentage of lambs that had a sire or dam or both attributed to them) and accuracy (the percentage of those attributed sires and dams that proved to be correct when compared with joining or DNA records). Pedigree Matchmaker does not collect sire information so if that method is used to collect dam information it must be used in conjunction with other records to identify the sire.

It is clear from this trial that the DNA based method provided the most accurate pedigree information but it is also the most expensive to set up and on an annual basis. It is however the least time consuming and in fact the blood sample collection could be done concurrently with other activities such as lamb marking. If the cost of the test reduces from the current $17 per test, this method would be much more attractive.
Visual ID/tagging at birth and Pedigree Matchmaker were very similar in dam identification accuracy but at a much lower cost for Pedigree Matchmaker mainly due to the lower labour input required. Visual ID/tagging at birth was however the only method that could capture date of birth and other birth traits.

**Objective 3**

**Evaluation of proactive management decisions and economic benefits**

It is difficult to estimate the economic benefits of improved management decisions. However, the availability of real time data on body weights changes within a mob of sheep could be invaluable as indicators of,

- Growth rate of young sheep and condition status of older sheep
- Quality and amount of nutrition on offer within a paddock
- Presence or absence of the sheep using the system
- Possible health and welfare issues for the sheep

This ability to monitor the weight and presence of sheep without having to muster them to yards and manually weigh them means the manager is able to make proactive decisions, such as paddock rotation, supplementary feeding and health and welfare interventions. It also reduces time, labour and production loss costs incurred when mustering, droving and manually weighing sheep.

The ability to identify progeny from an individual ewe and sire through pedigree identification methods could have real benefits over time as a result of better selection decisions. These could be,

- Identification of superior animals for retention within the flock
- Improvements in flock fertility
- Increased production and profitability through improved flock performance and fertility.

These long term benefits were not able to be quantified during this trial and would be difficult to measure as they would need to be compared to the results of decisions that would otherwise have been made.

**Objective 4**

**Extension to the Commercial & Stud Industry of the Findings**

This project successfully made available information and results of the project to a large number of sheep producers at a variety of conferences, shows and field days. A total of over 30000 people were given the opportunity to acquire information first hand at these venues.
7. Appendices

1. Video of WOW system in operation March 2014
2. Video of WOW system in operation 26th March 2015
3. Video of WOW system in operation 31st March 2015