Final report

Accelerating rates of genetic gain of MerinoLink members by utilising DNA testing and genetic tools

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Abstract:

Background: Historically, the Merino industry has had low rates of genetic gain caused by distrust in inaccurate Australian Sheep Breeding Values. The main driver of inaccurate breeding values was caused by a lack of pedigree in performance recorded sheep and the quality of data submissions. This project used the catalyst of co-funded genotyping to help Merino breeders double the rate of genetic gain in five years aligning to MLAs National Livestock Genetic Consortium strategic plan of doubling the rate of genetic gain within that time period.

Methods: Intensive mentoring by a scientist and genetics service provider gave both breeders and their genetics service providers the opportunity to upskill and network through private meetings and group workshops. Using better knowledge and more accurate breeding values, breeders were better able to increase genetic gain in their flocks.

Results: The collective group was able to increase the rate of genetic gain by 134% in the duration of the project compared to the previous five years.

Discussion: Collectively, the project participants sell up to 10,000 rams annually, over 15,000 units of semen and run 500,000 commercial Merinos. Group members are directly influencing the genetic improvement of around two million commercial Merinos bred annually. The geneflow benefits of this accelerated genetic improvement multiplied by commercial Merino ewes is estimated to be worth an extra $44 million dollars in a ten-year period and an extra $333 million dollars in a twenty-year period if the rate of genetic gain is maintained. The Meat & Livestock Australia Donor Company co-invested $1.55 million dollars over the life of the project equated to a 28:1 and 215:1 return on investment, respectively.

Conclusion: This project forms a framework to demonstrate that rates of genetic gain can be improved via co-investment models, relationship building and upskilling of people.

Executive summary

Background

Historically, the Merino industry has had low rates of genetic gain caused by distrust in inaccurate Australian Sheep Breeding Values (Granleese et al. 2018). The main driver of inaccurate breeding values was caused by a lack of pedigree in performance recorded sheep (Stephen and Brown 2019). This project was developed to double the rate of genetic gain in a group of Merino breeders that represented a cross section of the industry. This was facilitated by co-funded DNA testing and capacity building of sheep breeders and professional genetics service providers. Knowledge and genetic gain are permanent and cumulative meaning the legacy of this project will continue to build through years.

Objectives

- Increase the number of Merino sheep in seedstock flocks with full pedigree (achieved)
- Double the rate of genetic gain in seedstock Merino flocks (achieved)
- Capacity build seedstock and commercial breeders (achieved)
- Capacity build genetics service providers (achieved)

Methodology

- Co-funded genotyping to allow breeders obtain full pedigree on all lambs for one year
- Intensive mentoring by a scientist and genetics service provider gave both breeders and genetics service providers the opportunity to upskill and network through private meetings and group workshops.
- Using better knowledge and more accurate breeding values, breeders were better able to increase genetic gain in their flocks.

Results/key findings

The collective group moved from 12% sire and dam pedigree allocation to 68% sire and dam pedigree allocation. The collective group were able to increase the rate of genetic gain by 134% in the duration of the project compared to the previous five years rate of genetic gain. A network of sheep breeders and service providers has established with maturing relationships wishing to continue the group's activities.

Benefits to industry

The group are directly influencing the genetic improvement of around two million commercial Merinos bred annually. The geneflow benefits of this accelerated genetic improvement multiplied by commercial Merino ewes is estimated to be worth an extra $44 million dollars in a ten-year period and an extra $333 million dollars in a twenty-year period if rate of genetic gain is maintained. The Meat & Livestock Donor Company (MDC) co-invested 1.55 million dollars over the life of the project equated to a 28:1 and 215:1 return on investment, respectively.

Future research and recommendations

- This project has provided a framework for future projects where adoption of genetics tools is low in seedstock and commercial breeding enterprises

- The adoption model implemented by this project would be repeatable across more sheep, cattle and goat groups who require help accelerating rates of genetic gain
- Similar projects like this would be a sage investment by the National Livestock Genetics Consortium

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1. Background

1.1 Low rates of genetic gain in Merino industry

1.1.1 Lack of trust in Australian Sheep Breeding Values

There was a good industry cross section of breeders in the project with a range of high to low genetic gain being achieved. Many breeders within the project that had low rates of genetic gain was often because they did not use Australian Sheep Breeding Values (ASBVs) in the selection criterion when selecting future sires and dams. This lack of trust was driven by breeders perception that the ASBVs on the sheep were not a good reflection of the true genetic merit. And this mistrust was well founded given the key pillars of ASBV calculation (pedigree, fixed effects, full cohort submission, sire linkage across studs, years and management groups, well-structured management groups) were often partial or not complete, creating bias in ASBVs when calculated. This group was representative of the entire database and proved a useful group to test how the rate of genetic gain could be improved.

1.1.2 Cost of low rate of genetic gain in the Merino industry

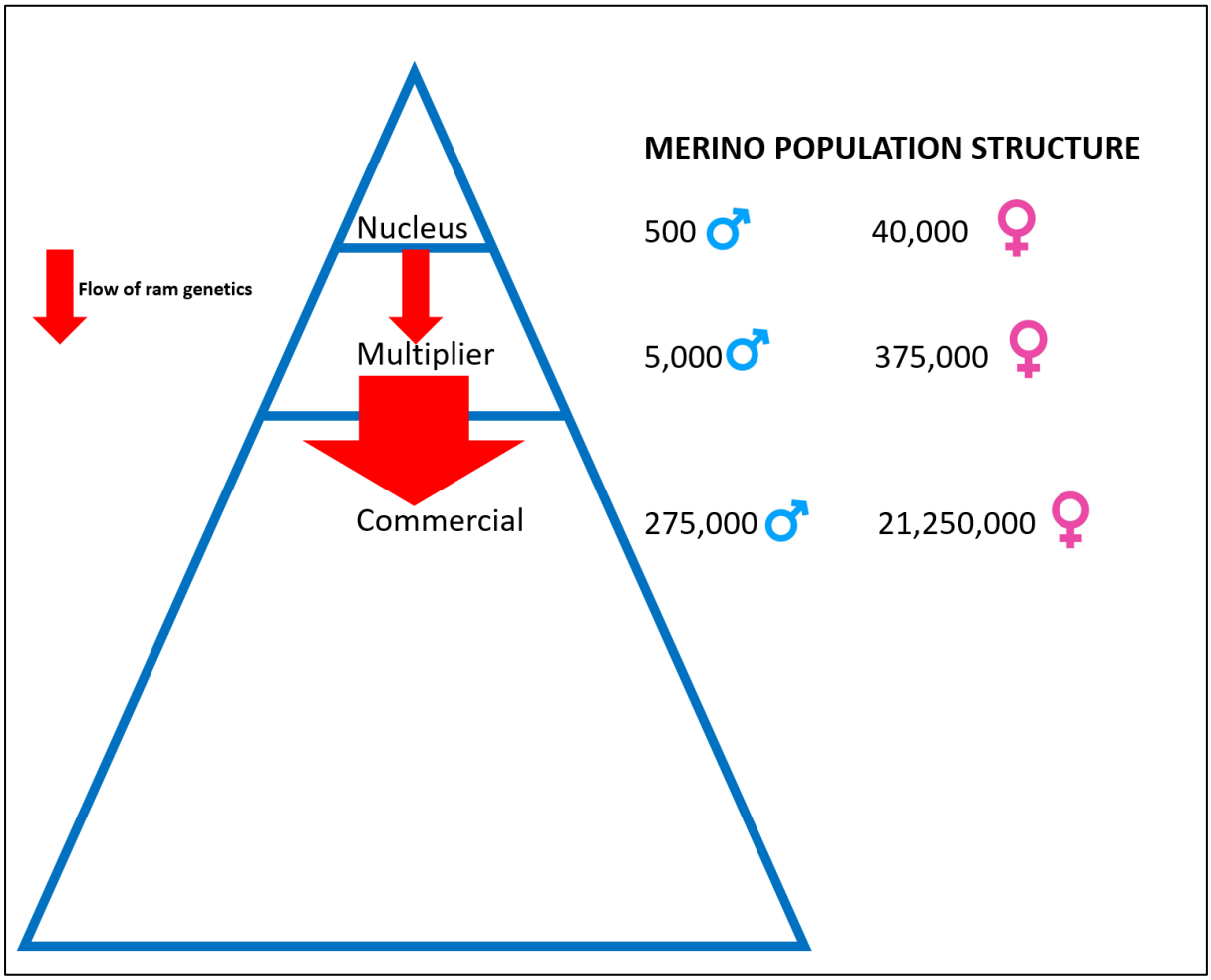
Genetic gain has been linked directly to on-farm profitability in all livestock species. This is because efficiencies can be improved in a permanent and cumulative way when using genetic selection tools on livestock. In 2022 there was an estimated 42.5million Merino breeding ewes in Australia (MLA and AWI 2022). In 2017, MLAs National Livestock Genetics Consortium (NLGC) set a goal of doubling the rate of genetic gain in the commercial livestock industry. For Merinos, this goal is considered to be easily achievable when rates of genetic gain have been historically low compared to other livestock sectors. Using Geneflow modelling (Hill 1974) with a cumulative discount of expression of 7%, it is estimated that if the rate of genetic gain doubled over a 10-year period by the Merino industry would cumulatively increase gross-profit by $500m. Over a 20-year period gross-profits would increase by $6.4b cumulatively.

1.2 Opportunities to increase the rate of adoption of genetic and genomic tools

1.2.1 Seedstock breeders

All classic breeding programs have a top-down tiered structure where most genetic flow happens in a downwards direction starting at the seedstock nucleus (Figure 1). Given rams can mate up to 100 ewes each year, they have a large influence on the genetic direction of flocks. With the flow of genetics, Figure 1 demonstrates that if genetic gain can be accelerated in the nucleus, flocks in the “Multiplier” and hence “commercial” tiers will follow at a similar long-term speed. Thus, there was an opportunity to gather a group of breeders from within the nucleus to accelerate rates of genetic gain that would effectively increase the rate of gain across the entire industry.

Figure 1: Basic structure of Merino population demonstrating flow of genetics into commercial flock



1.2.2 Commercial breeders

In addition to seedstock Merino breeders, there were opportunities to engage with commercial producers to use technologies available to increase the profitability on-farm with better genetic selection decisions. Benchmarking technologies include ASBVs, RamSelect.com.au's "Ram Team Manager" and the genomic benchmarking "Flock Profile" (Swan et al. 2018). All of these technologies were available from the beginning of the project and an opportunity presented itself to best advise commercial Merino breeders how to use and incorporate the technologies available to help on-farm profitability for their production system.

1.2.3 Genetics advisors and service providers

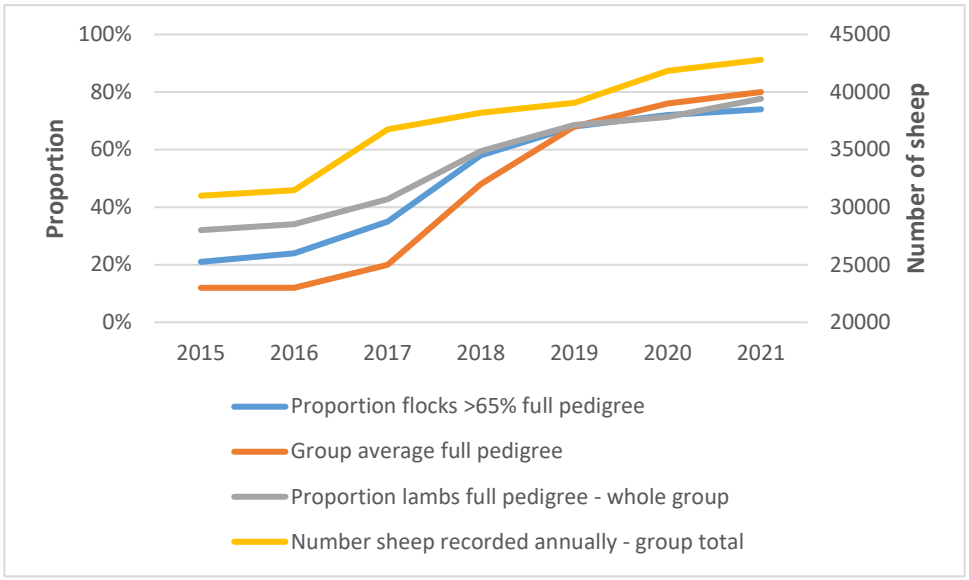
Genetics service providers and advisors have a network of seedstock and commercial breeding clients who pay for services such as data processing and breeding program advice. Given the service provider's reach to many breeders, upskilling this network would help disseminate information to their clients and help increase the rate of genetic gain. Upskilling is often best achieved when using their own client's issues rather than using hypothetical scenario teaching.

2. Objectives

2.1 To increase the number of Merino ram breeders submitting full pedigree data to Sheep Genetics by 100% (greater than 95% full pedigree flocks). The impact will be to increase the accuracy of ASBV's and genetic gain.

As of the 2021 drop the proportional increase of flocks submitting sheep with full pedigree (>65% full pedigree) compared to 2017 increased by 111% (Figure 1). However, the group fell short of achieving 95% full pedigree flocks with 20 out of 25 flocks (or 80%) reaching the >65% full pedigree threshold by the cessation of the project. This was caused through various reasons such as not all progeny being allocated parentage 100% of the time, some breeders chose to transition to full DNA pedigree (adding an age group each year) and lack of adoption. Lack of adoption can be categorised as 1) a lack of engagement from the beginning of the project,never taking up the offer of subsidised genomic testing; and 2) failing to follow-on with genomic testing after the subsidised initial year. It should be noted that there was an incremental increase in the number of sheep entered annually into the Sheep Genetics database by the project participants.

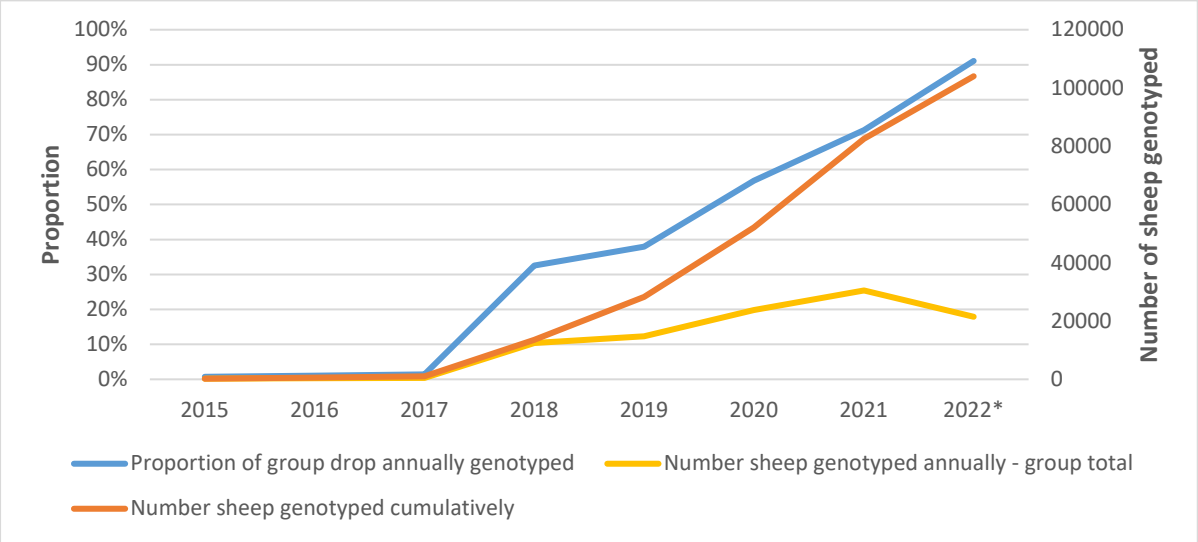
Figure 2: Proportion of sheep within the project with full pedigree year-by year and annual count sheep within the group entered into Sheep Genetics



2.2 To increase the use of genomic testing by Merino ram breeders to select stud sires. The impact will improve ASBV accuracy and increase selection response.

By June 30, 2022, the group had low density genomic tested (15k or 50k SNP panel) 104,025 individuals. Through 2017 and 2018 the main animals genomic tested were sires only. Through 2019 to 2021 we observed the group use genomic testing on entire drops of males and progress to ewe lambs as well. In 2021 71% of the entire drop of the collective group were genomic tested (Figure 3). The use of genomic testing in young rams and ewes allowed more accurate selection of ram lambs and ewe lambs to decrease generation interval and hence increase the rate of genetic gain.

Figure 3: Number of sheep genomic tested leading up to and then through life of the project.*Note that only half of the 2022 drop were submitted to Sheep Genetics by the end of the project (July 2022) and it is expected that more than 35,000 genomic tests are conducted in the 2022 drop



2.3 To increase the number of Merino ram breeders that use MateSel to maximise genetic gain.

The main use of MateSel (Kinghorn 2011) is to optimise genetic gain while maintaining long-term coancestry to limit inbreeding and issues associated. For optimal results using MateSel a depth of pedigree on the sire and dam side is necessary. Given this limitation only three breeders (or 12%) used MateSel in 2017 and prior. As a depth of pedigree increased and education of the benefits of MateSel were conveyed through the life of the project more participants were able to utilise MateSel. At the conclusion of the project fourteen breeders or 54% of the group were actively using MateSel. The power of MateSel can be demonstrated with three of the participating breeders who started to use the tool during the project and the predicted and actual outcomes from the 2021 drop mating, presented in Table 1. The mating included artificial insemination, single sire and syndicate joining groups. The first flock achieved 77% of the ewes joined to the MateSel allocated sire while the other two flocks only achieve 36% and 28% respectively. The low number of allocated joinings can be explained by the higher use of syndicate joined mobs, however the grouping of sires in the syndicate resulted in very close predicted and actual outcomes. Interesting the level of inbreeding remained consistent between the predicted and actual mating outcome.

Table 1: Comparison between MateSel Prediction and Actual Mating Outcome

2021 Drop	Flock A		Flock B		Flock C	
	Predicted	Actual	Predicted	Actual	Predicted	Actual
Inbreeding	0.027	0.028	0.008	0.008	0.025	0.021
MP+	178	179	157	158	177	176
DP+	186	186	162	163	172	172
PWT	6.6	6.5	4.3	4.3	3.2	3.1
YWT	9.2	9.1	6.2	6.2	5.0	4.8

2021 Drop	Flock A		Flock B		Flock C	
	Predicted	Actual	Predicted	Actual	Predicted	Actual
YEMD	0.7	0.6	0.5	0.5	-0.4	-0.4
YFAT	0.5	0.4	0.2	0.3	-0.3	-0.3
YCFW	22.9	23.5	18.4	18.0	24.6	24.8
YFD	-1.1	-1.2	-1.0	-1.0	-1.9	-1.9
YSS	1.7	1.4	1.6	1.8	1.5	1.4
YSL	10.8	10.0	10.9	10.8	4.9	5.0
EBWR	-0.4	-0.4	-0.5	-0.5	0.3	0.3
EBCOV	-0.3	-0.3	-0.3	-0.3	0.0	0.0
WR	0.16	0.16	0.07	0.09	0.08	0.08

2.4 To increase the number of commercial Merino breeders using the Flock Profile test to benchmark their genetic progress and target ram selection by incorporating the information in the RamSelect App.

There were 65 commercial breeding participants in the project. Each project participant did a Flock Profile test on their 2017 or 2018 drop and then a second test on their 2021 drop. This was done to estimate genetic change in their commercial flocks. Any commercial breeder who purchased rams with ASBVs had their ram team entered into RamSelect.com.au's "Ram Team Manager". This was initially carried out by the project team, but later in the project were assigned to a genetic service provider as part of their upskilling and professional development. Each year as rams were purchased, died, or were culled a service provider would update the Ram Team so better ram purchase decisions could be made on sale day. While Flock Profile was useful in informing genetic estimates of their respective flocks to use as a benchmark, the Ram Team Manager in RamSelect.com.au was an important next step for breeders buying rams with ASBVs to ensure their breeding objective was being met. This coupled with the "Smart Ram Buying" method was an effective way to ensure genetic gain was being made in their flocks through improving their ram team year on year.

2.5 To explore the use of the Flock Profile test by ram breeders and their clients to better tailor ram selection to client needs and measure changes in genetic merit and changes in breeding programs over time.

Initially the project was set up for breeders to bring 2-5 commercial clients with them. Only five studs followed through on this commitment. As the project progressed, it was found to be more beneficial for the clients to be separated from their ram source during education sessions. It was observed that ram breeders would often dominate a group session with more technical questions and their clients were not as comfortable to speak freely. The project commercial breeder education workshops had much freer dialogue when there were just commercial breeders in the room. From Year two onwards, the project team then held annual commercial ram breeder and ram buyer workshops separate to ram breeder workshops. Content was then more applicable and targeted to the audience which gave a better learning experience for all parties.

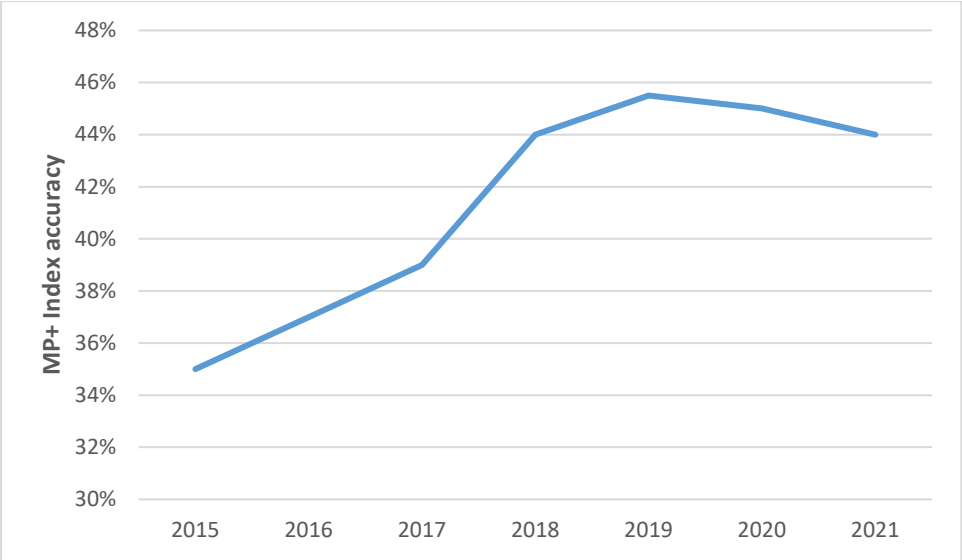
2.6 To facilitate data collection and genomic testing to enhance the existing genomic reference population.

As outlined in 2.2, over 100,000 sheep have been genomic tested in the life of the project of which 14,000 were co-funded. This demonstrates the group's collective commitment to continue genomic testing and seeing the benefits this technology has brought them. With "Single-Step" analysis being implemented in the MERINOSELECT analysis, it was important that high quality data was collected side-by-side with the genomic testing to help underpin this significant genomic reference population. Figure 4 demonstrates the Merino Production Plus (MP+) collective group's average index accuracy has climbed since the project began. The MP+ index has a large reproduction economic weighting. We therefore expect the accuracy to increase in the 2020 and 2021 drops over time as their reproductive data flows in. This is a simple metric to demonstrate the group has not only collected more pedigree but are doing a better and more complete job of collecting performance data and important information such as fixed effects (e.g., date of birth, birth type, rear type, age of dam) that help underpin high accuracy data sets. Figure 4 demonstrates a rapid increase in index accuracy once full pedigree and better data collection practices were undertaken. The small drop-off is explained by ewes born in 2020 and 2021 not having reproduction data recorded due to them not yet having the opportunity to have this data entered at the time of the final report being written. In time we expect 2020 and 2021 drops to have the same or even higher index accuracy once the females' reproduction data is entered into Sheep Genetics.

2.7 To test the concept for ram breeders to carry out genomic testing only, without phenotypic measurement, whilst being supported by an industry run reference flock that they are linked to (strategic linkage).

There are currently no commercially available technologies to run this concept. However, there was a group of ram breeders who bred rams for their own commercial enterprise who expressed a desire to have this option in their breeding program where they wish to genetically benchmark within their flock and full submission to Sheep Genetics involves the collection of more data then what was is currently captured. The concept would be a powerful tool in the industry with a significant number of breeders that either artificially inseminate their ram breeding nucleus to high-ranking rams from the Sheep Genetics population (multipliers – Figure 1) or buying high genetic merit sale rams to naturally mate over their ram breeding nucleus. The project leaders suggest a genomic test for a "clean skin" individual Merino at a price point that does not discourage performance recording would have significant benefits to the Merino industry.

Figure 4: Average Merino Production Plus (MP+) index accuracy of project group over years for each respective year drop



2.8 To provide an extension process to guide, facilitate and explore optimal use of DNA testing for both parentage and genomic selection, as well as for mate selection, and explore future opportunities with the project participants.

An extensive extension process was carried out through the life of the project. Having a combination of scientists, genetics service providers and Sheep Genetics employees help bridge gaps between each organisation as well as with breeders. With these "barriers" broken down there was effective communication flow between all invested parties. This information flow allowed upskilling of breeders, genetic service providers and scientists. The project used all communication methods available. A summary of the project extension is listed below

- 10 Ram breeder workshops
- 50+ 1-on-1 ram breeder meetings
- 3 MateSel training workshops
- 6 Commercial ram breeder workshops
- 14 Commercial breeder workshops
- 3 "Train the trainer" workshops
- 1000+ Phone calls
- 1000+ Emails

2.9 Train and mentor service providers in the application of DNA testing and genomic selection in Merino breeding programs.

This project engaged a total of 16 genetics service providers. These genetics service providers were existing service providers of ram breeders in the project or invited to the project as breeders decided to engage a service provider. Collectively, the group of service providers contributed to handling over half the MERINOSELECT and LAMBPLAN data submission of the ram breeders participating in the project. Service providers were trained in the following breeding program design areas:

- Optimal use of low-density genomic testing
- Benefits of measuring full pedigree for genetic evaluation

- Use RAMping Up genetic gain and Data Quality Score reports supplied by Sheep Genetics
- Establishing and maintaining a breeding nucleus performance when recording progeny
- Establishing and maintaining a breeding nucleus performance when not recording progeny
- Optimal nucleus structure
- Geneflow principal
- MateSel training
- How to use Flock Profile and RamSelect.com.au Ram Team Manager optimally
- Setting S.M.A.R.T. breeding objectives
- Smart ram buying principals
- Running workshops with project participants both in person and/or online

The project team found the most effective method to train genetic service providers is to use their clients' issues and questions rather than working through hypothetical situations as they are invested in the outcome.

3. Methodology

3.1 Ram Breeders

The project originally engaged with 30 different Merino ram breeders from Western Australia, Victoria and New South Wales. Genetic service providers already engaged by a breeder participant were encouraged to participate in the project. By the completion of the project 26 ram breeders remained.

3.1.1 Genotyping

Ram breeders were initially engaged in the project by offering co-funded genomic testing with the ambition of gaining full pedigree on progeny of their respective flocks. Furthermore, sires at each stud would be low-density genomic tested to help form better linkage to the genomic reference population with "single-step" genetic evaluation (Boener and Johnston 2019) being developed at the time. Flocks that were already recording full pedigree had the offer of also genomic testing all existing sires as well as the top 20% of their drop to help increase the rate of genetic gain facilitated through more accurate ASBVs in younger sheep.

3.1.2 1-on-1 meetings

At the beginning of the project each ram breeder had an on-farm visit from project leaders. These one on one visits followed a forensic look into data quality analytics which identified strengths and opportunities. These visits allowed ram breeders to express their desires from the project in the comfort of their environment. This step was a crucial building block in building trust between themselves and project leaders. For breeders who were already collecting full pedigree, these meetings were quite technical in how they could further accelerate their rate of genetic gain. For breeders who had poor/low data quality and/or low rates of genetic gain, this was a safe environment for them to "vent" their frustration with the genetic evaluation and benchmarking of their sheep. After listening, project leaders were then able to systematically work through why each measurement or data submission method was not giving the best possible estimate of genetic merit for their animals and develop pathways for improvements. For these participants the meetings were crucial for stepping through at the respective breeder's own pace as to why ASBVs require a depth of pedigree, full cohort submission and capturing of fix-effects (e.g., accurate date of birth, birth type and rear

type). Once this process was undertaken there was little hesitancy to reconciliate the investment of DNA testing each year.

Through the life of the project, ram breeders had options to book one on one meetings with project leaders. Some ram breeders took advantage of this engaging in up to three or four formal meetings while others did not take up this opportunity as frequently or at all. It was hard to ascertain why the breeders did not request follow-up meetings as they often did not provide feedback.

3.1.3 Workshops

A total of 10 ram breeder workshops were hosted through the life of the project. Annual ram breeder workshops were held in Wagga Wagga, NSW for eastern states ram breeders and Esperance, WA for Western Australian ram breeders. Prior to the workshops project leaders called breeders asking if they would like to cover any topic or concern. The project also invited a scientist from AGBU and the Sheep Genetics team to present and/or attend. This was mutually beneficial as the ram breeder group was one of the only Merino groups to road-test new tools and/or data analysis upgrades. Once requests from breeders and invited guests were taken into consideration, project leaders would then formulate a program for the workshops. The project leaders were not afraid to experiment with content and delivery where valuable lessons were learnt. The workshop program evolved with the project to capture the progression of the participants.

The beginning of the project workshops would centre around the following key aspects:

- Why pedigree is important to ASBV calculation and what happens when we don't have it
- Full cohort data submission vs selective data submission
- What is genomics, how does it work and how to use it
- Why are fixed effects important in ASBV calculations
- Reviewing a RAMping up genetic gain report
- Setting a S.M.A.R.T. breeding objective
- How to select for genetic improvement
- What is MateSel

Each ram breeder workshop would start at lunch time and run through to the following day lunch. This allowed all participants (i.e., ram breeders, scientists, genetics service providers and Sheep Genetics staff) to network through meal breaks as well as a group dinner. This aspect of the project allowed relationships to form and build trust via personal connection.

As the project progressed, the project leaders had to negotiate the 2018-2020 drought as well as the global COVID-19 pandemic. The pandemic restricted travel which meant the project team had to deliver annual workshops on online platforms in 2020 in New South Wales and 2020-22 for Western Australia participants. Valuable lessons were learnt on how to deliver online workshops, lecturing online should be avoided and interactive sessions are both engaging and an excellent method for facilitating peer-to-peer learning.

Both pre and post workshop evaluation forms were handed to ram breeders. They were asked to give scores of knowledge of ASBVs (score out of 10) as well as feedback on the workshop (score out of 10 and written). This helped the project team objectively track progress of the education aspect of the project as well as help improve future education sessions.

By the end of the project the annual ram breeder's workshop content evolved with the group's building knowledge as well as lessons learned from project leaders. In the final two years the workshops followed the following format:

- Project update
- Science update
- Sheep Genetics update
- Reviewing a RAMping up genetic gain report and road-testing the new data quality score report
- Reviewing progress on S.M.A.R.T. breeding objective
- Open participant interviews on a whiteboard (x4)
- Plan for next 12 months

From 2019 onwards, there was a MateSel training workshop facilitated by the project and run by Sheep Genetics.

3.1.4 Phone calls

Through the life of the project, project leaders were available to be contacted at any time to ask for advice. Some ram breeder participants took advantage of this, calling up to five times a week. This aspect of project leaders constantly being available to talk about data collection, ASBVs and breeding program design continued to build trust with as well as better management and selection decisions. For a six-week period in September – October 2019, the project leaders recorded a communication log. In this period 164 calls totalling 71 hours were made between project leaders and ram breeders or between project leaders. This time included content only for project time and did not include any private consulting.

3.1.5 Emails

Like phone calls, project leaders were available at any time via email. Some ram breeder participants preferred this method of contact. In the same six-week period as the call-log, project leaders were sent 74 emails which took 23 hours to read and compile responses.

3.2 Commercial Ram Breeders

The project engaged with 16 commercial Merino ram breeders from Western Australia and New South Wales. Any participant who already employed a genetics service provider were encouraged to participate. The aim was to increase usage of benchmarking tools such as Flock Profile and RamSelect.com.au's Ram Team Manager. Originally, these commercial ram breeders were not in their own group and were included in the commercial ram buyer group. After the first year of workshops, it was clear to the project leaders that the commercial ram breeders in the project should be separated from commercial ram buyers as they had different needs and level of questions. Furthermore, after the second year the project team decided to split the 16 commercial ram breeders into another two groups being A) performance and/or pedigree recorders and B) non-performance recorders, allowing for more targeted information and messages.

3.2.1 Flock Profile

To incentivise commercial ram breeders to join the project a subsided Flock Profile test was offered to participants to test 2017 drop lambs of their nucleus. A second subsidised test was offered to test their 2021 drop nucleus lambs. As these commercial ram breeders were not entering data into Sheep Genetics at the beginning of the project, this was a method to estimate genetic change in their ram breeding nucleus.

3.2.2 Workshops

A total of six workshops were undertaken through the life of the project. Two-to-three-hour annual workshops were offered in-person in 2018, 2019 and 2022. In-between the workshops were offered online due to participant availability as well as COVID-19 travel restrictions. Any genetics service provider who had a client in the project were also invited to attend. As workshops progressed, it became evident there were three types of commercial ram breeders. The three types were:

- Commercial ram breeders collecting pedigree and data
- Commercial ram breeders collecting data only
- Commercial ram breeders no performance recording

Like the ram breeder workshops, content delivered changed as the participant's knowledge increased. The project team discovered the most effective method of teaching was to go through each person's breeding program on a whiteboard in front of the group. Given each participant faced similar challenges and/or had similar issues, this was an effective method as messages were repeated in different ways. In the last two years we had external genetic service providers upskilling in the project, delivering some of the whiteboard sessions, guided by the project leaders.

Typical commercial ram breeder sessions covered the key components:

- Setting and/or reviewing a S.M.A.R.T. breeding objective
- Why ASBVs and genetic gain are important to profitability
- Breeding program design
- Optimising measurement practices
- Optimised nucleus structure
- RamSelect.com.au Ram Team Manager
- Flock Profile

All attendees filled out a questionnaire with scores of 1 to 10 as well as written feedback both before and after workshops so project leaders could assess the workshops and use this information to make the next workshop a better experience.

3.2.3 Transition to Sheep Genetics

One of the commercial ram breeder sub-groups were breeders who were performance recording and collecting pedigree on each year's nucleus lambs. From 2019 -2021, MLA introduced the accelerated adoption initiative to support producers through drought seasons. Part of this initiative saw a price freeze on Sheep Genetics membership costs, this was a good incentive to encourage breeders to enter data into Sheep Genetics. This helped breeders make more informed selection decisions for their ram breeding nucleus. Some of this group originally entered the project collecting the required data to

enter Sheep Genetics but had not made the final step, while some commercial ram breeders progressed from collecting only sire pedigree to collecting all required data to enter Sheep Genetics during the project. A single workshop a year was inadequate training required to participate effectively in Sheep Genetics. However the workshops were a catalyst for these commercial ram breeders to engage a genetic service provider outside of the project. Commercial ram breeders could see the value in performance and pedigree recording and hiring a genetic service provider to manage data and assist in measurement calendars and genomic testing pipelines.

3.3 Commercial Breeders

The original project aim was to engage 200 commercial ram buyers to increase adoption of genetic benchmarking tools available to commercial breeders such as Flock Profile and RamSelect.com.au's Ram Team Manager. In development of the project each ram breeder committed to bringing 2-5 of their clients and two client groups were to participate in the project (Wool Broking Firm and ASHEEP). In reality, only five ram breeders engaged clients only bringing two or three clients each. The majority of the commercial breeders were engaged via MerinoLink network, genetic service provider's networks and the Western Australia ASHEEP network. In total, the project engaged with 65 commercial Merino breeders (including the 16 commercial ram breeders outlined in 3.2) spread across Western Australia, Victoria, and New South Wales. Genetics service providers already employed or engaged by a participant were encouraged to participate in the project activities. As mentioned in 3.2, commercial ram breeders were separated from commercial ram buyers as their needs were different.

3.3.1 Flock Profile

Like commercial ram breeders in this project, to incentivise commercial ram buyers to join the project a subsided Flock Profile test was offered to participants to test 2017 drop lambs of their commercial flock. A second subsidised test was offered to test their 2021 drop commercial born lambs. This was a method to estimate genetic change in their commercial flock.

3.3.2 Workshops

A total of 14 annual in-person and/or online workshops were offered in south-west NSW and in Esperance, WA. Like the ram breeder group, COVID travel restrictions meant 2020 and 2021 workshops were delivered on online platforms. Workshops were usually 2-3 hours in length for in-person workshops. Online workshops had a maximum of four participants with open-interview style format. Online workshops would only go for a maximum of 2 hours. As the projects progressed the information taught and shared became more complex. In 2021 and 2022 all commercial ram buyer workshops were run by non-project genetics service providers. Topics covered in workshops often covered:

- What is an ASBV
- How do we use ASBVs
- S.M.A.R.T. breeding objectives
- Why Ram Teams will steer the future of your flock
- Using RamSelect.com.au's "Ram Team Manager"
- Reviewing ram teams
- Smart ram buying principles

- Breeding program design

In addition, genetic service providers were asked if they would take charge of commercial breeders Ram Teams and be available to provide guided advice as professional development. All service providers working with commercial ram buyers accepted these tasks.

All attendees filled out a questionnaire with scores of 1 to 10 as well as written feedback both before and after workshops so project leaders could assess the workshops and use this information to make the next workshop a better experience.

3.3.3 Smart Ram Buying Principles

The "Smart Ram Buying" principles was established as part of the project where commercial ram buyers had ram team averages stored in RamSelect.com.au's Ram Team Manager. Once their ram teams were up to date with previous year's purchases and any deaths or culling, participants were then able to have a baseline on which rams they could purchase at a ram sale or by private treat to help increase the ram team merit. This process involved working with a genetics service provider to review a catalogue of rams and highlight the rams that would advance the genetic merit of their ram team to achieve their breeding objective. The goal was to A) simplify sale day only needing to visually inspect a proportion of sale ram vs the entire sale and B) make sure the correct rams were being purchased in line with their breeding objective.

This procedure was part of the "Train-the-Trainer" sessions where all external genetic service providers were taught how to deliver both privately and in a group. The project leaders recommend this as an essential component of ensuring genetic progress in a commercial operation.

3.4 Genetics Service Providers

3.4.1 Workshop contributions

The project engaged with 16 different genetics service providers. Any participant (ram breeder or commercial breeder) who already employed a genetics service provider were encouraged to participate in workshops in conjunction with their clients. Furthermore, the project ran "train-the-trainer" workshops for delivery of commercial breeder workshops. In 2020 and 2021 the genetics service providers who wanted to upskill and participate were assigned groups of commercial breeders and delivered workshops and assisted their clients in updating ram teams on the RamSelect.com.au ram team tracker. They were also trained to help explain genetic change when comparing Flock Profile results.

3.4.2 Working side-by-side with clients

Previous research completed by the Sheep CRC (Granleese 2017) demonstrated the most effective method of upskilling genetics service providers is to use their clients' problems to teach. Hence any genetics service provider whose client was in the project were actively encouraged to attend and participate in workshops and any private meetings. If any meeting was scheduled an invitation was extended to the respective genetics service provider. Issues that were often worked through with their ram breeders were:

- Data issues as diagnosed with Sheep Genetics' RAMping Up report

- Breeding program design
- Use of MateSel
- Optimal use of genomics

Issues that were often worked through with their commercial breeders were:

- Optimum population structure
- Use of selection tools
- Use of genetic benchmark tools
- How Flock Profile works and how to interpret results

3.5 Scientists

3.5.1 Workshops

Each year an external scientist to the project from the Animal Genetics and Breeding Unit (AGBU) was invited to participate in the annual ram breeder workshops. If time permitted, they were invited to commercial ram breeder workshops as well. This provided a previously unavailable platform to present research and analysis updates to a group of Merino breeders. With the scientists staying for the duration of the annual workshop this was an excellent opportunity for relationships to be formed between scientists, breeders, and project staff.

3.5.2 Data collected by group for genetic evaluation

Because of networking and interactions, the ram breeder group could collectively decide if they could help fill data gaps in the MERINOSELECT genetic evaluation. As a group, they decided to collect enough data to help fill the void of a lack of data for:

- Breech wrinkle
- Dag
- Genomic reference data
- Horn/Poll genomic test validation
- Neck “wattle” mutation
- Reproduction traits

3.6 Scientific papers

3.6.1 Scientific papers

Project leaders plan to write a peer-reviewed article to be submitted to the Journal of Animal Science to give a detailed outline, results, and discussion of the project. This is planned to be submitted in the second half of 2022.

3.6.2 Conferences

Progress and final papers were important methods to update the scientific audience lessons and results of this large-scale genetic adoption project. Papers and presentations were written and presented to Association for the Advancement of Animal Breeding and Genetics (AAABG) 2019 and

2021 in Armidale and Adelaide, respectively. An overview with results were presented in Rotterdam in 2022 at the World Congress on Genetics Applied to Livestock Production.

3.7 Industry presentations

3.7.1 Industry presentations

Presentations were given at the annual MerinoLink Conference in Goulburn 2018, Armidale 2019, and Wagga Wagga 2021. Furthermore, the project was presented to a group of Goat breeders in 2022 in Bourke. These presentations were pivotal to conveying the progress of the group's members as a collective and the benefits of finding like-minded people.

3.7.2 Academic presentations

Presentations were given to the Animal and Genetics Breeding Unit "Seminar Series" each year from 2018 to 2022. Two additional presentations were delivered to the University of New England "Science Seminar Series" in 2018 and 2019. These presentations were useful tools to help convey to scientists both effective and ineffective methods of adoption from project experiences.

3.8 Case Studies

3.8.1 Video

Three video case studies of two ram breeders and one commercial breeder were created at the finalisation of the project. The videos provide an overview of each project and their journey through the project. The case studies included:

- Bella Lana Poll Merino Stud – https://youtu.be/R8cTrHvtqEw
- Rocklyn Poll Merino Stud – https://youtu.be/BvBehhHl1qg
- Dugald Campbell – commercial breeder - https://youtu.be/6kzWKvOQ8m0
- The DNA Project – video pending, written report submitted.

3.8.2 Written

Each video was accompanied with a written case study. A further two case studies will be written about Elise Bowen – service provider and Scott Welke of Westwood Poll Rams. These case studies are found in the Appendix A, B and C of this report.

3.9 Evaluation

3.9.1 Participant evaluation

Participant knowledge of ASBVs and the importance of using them in breeding programs was captured through the life of the project. Common questions were asked through the life of the project so the project team could capture objectively whether understanding of ASBVs, adoption of tools was improved. Pre and post-workshop evaluation forms were completed by project participants. Questions were rated out of 10 with one being the lowest and 10 the highest. Questions asked are displayed in

3.9.2 Genetic change

With most of the investment and effort going into the ram breeder group, the project leaders were able to benchmark and capture genetic change using the following methods:

- Genetic change through the project vs pre-project genetic change
- Proportion of full pedigree collected over time
- Data quality score
- Contribution to the MERINOSELECT database

The project also had methods to capture genetic change in commercial breeders. The team could capture the progress made in Flock Profile and how the change overlays with ram team changes.

3.9.3 Use of commercial tools

The project collected details of how many commercial producers used the following:

- RamSelect.com.au “Ram Team Manager”
- Flock Profile
- “Smart Ram Buying” method

4. Results

4.1 Ram Breeders

4.1.1 Rates of genetic gain

Rates of genetic gain were measured in two five-year periods. From 2012-2017 were the baseline years prior to the project starting while drops 2018-2021 were included in the project period. Genetic gain was monitored using the “Merino Production Plus” or the “Dual Purpose Plus” economic index. Each breeder was assigned a respective economic index depending on which one most closely aligned with each respective breeding objective. Overall, in this period the ram breeders as a collective group increased genetic gain by 134% (Figure 5). Ram breeders with historically low rates of genetic gain had greater potential to increase their rate of gain by using high ranking outside sires (Figure 6).

A question posed is whether the group’s average rate of project genetic gain is sustainable or whether the gain is somewhat compensatory as demonstrated on the left-hand side of Figure 6. The right-hand side of Figure 6 shows flocks who were achieving the highest rates of genetic gain prior to the project beginning. Three of the top 6 flocks sat in the top flock percentiles prior to the project beginning. Hence they needed to generate gain within their own flock selection. We can see that these flocks were still able to accelerate their rates of genetic gain which suggests that the average rate of gain achieved across the project of 4.9 index points to be sustainable as long as breeders continue to engage with genetic service providers.

Figure 5: Ram breeder group average annual genetic gain pre-project (2012-2017) compared to genetic gain during project (2017-2021)

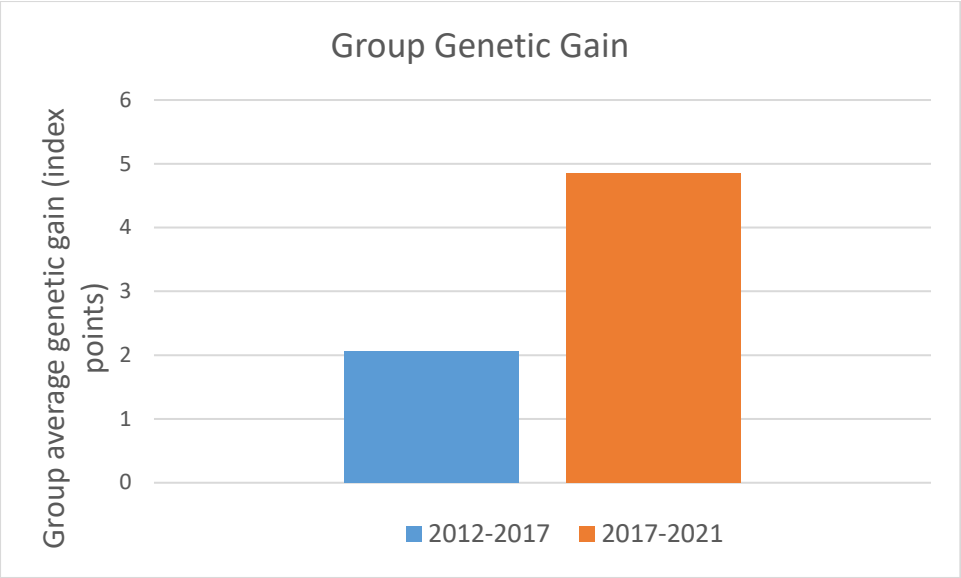
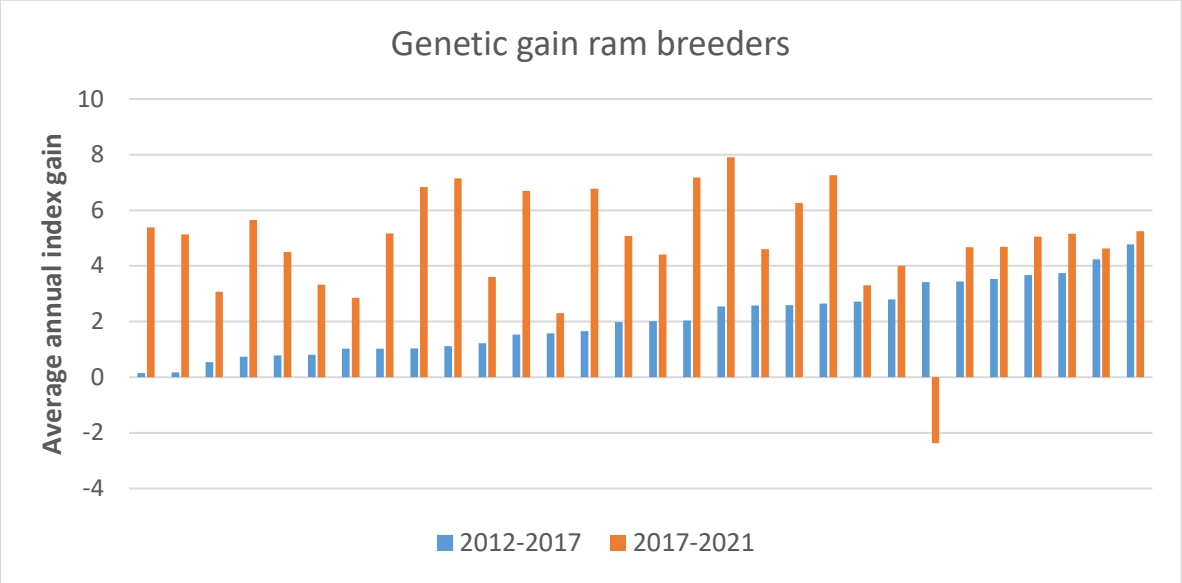
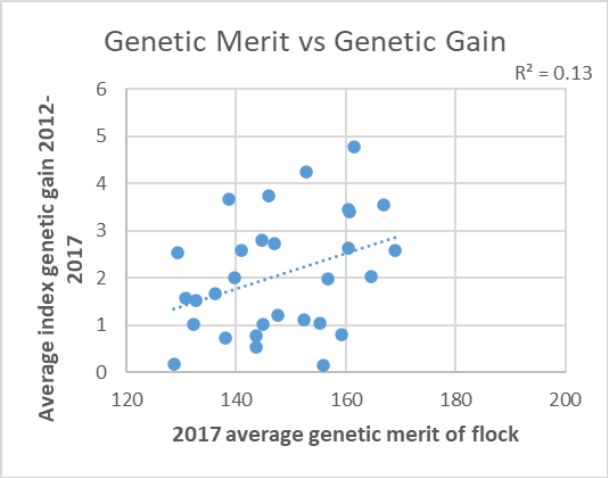


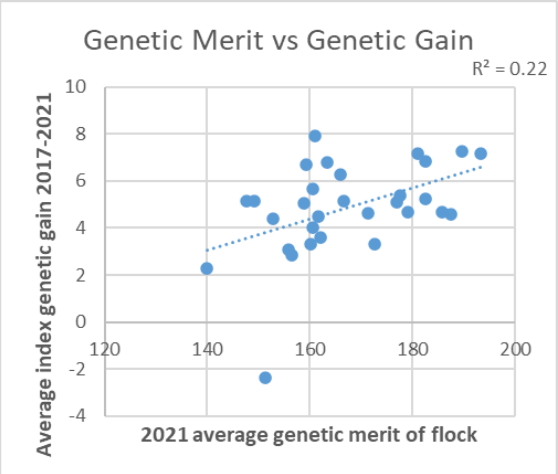
Figure 6: Annual average genetic gain pre-project (2012-2017) and during project (2017-2021) for each ram breeder



Prior to the project, the group's rate of genetic gain (average genetic gain 2012-2017) had a weak relationship with average genetic merit (2017 drop) of their flock (Figure 7A). This demonstrated that the project was wise to engage with ram breeders of all levels of flock genetic merit. By the end of the project the relationship had strengthened (Figure 7B). As time progresses and ram breeders continue to pursue genetic gain, it is expected this relationship will continue to strengthen (i.e., R^2 value gets higher on the x~y plots). The strengthening of this relationship will continue to encourage or incentivise breeders to achieve genetic gain if they have ambitions of being a high genetic merit flock.

Figure 7A: Average genetic merit (2017 drop) of each flock compared to their respective annual five year genetic gain from 2012 to 2017
Figure 7B: Average genetic merit (2021 drop) of each flock compared to their respective annual four year genetic gain from 2017 to 2021





4.1.2 Number of genotypes – project and self-funded

Through the life of the project over 92,668 parentage tests were undertaken, of which 57,311 were project co-funded. Furthermore, 104,025 low density 15k or 50k genomic tests were used of which 14,502 were project co-funded (Table 2). Given the price change of genomic testing from 2019 onwards, many breeders used the new 50k low density genomic test to obtain parentage and to also contribute to the calculation of ASBVs rather than using just a parentage test. The popularity of using this method is demonstrated in Figure 8. Furthermore, the extensive use of genomic testing meant that the flocks became part of the genomics reference population with the implementation of "Single-Step" analysis (Boerner and Johnston 2019) in MERINOSELECT. It should be notes that only half of the 2022 drop were submitted to Sheep Genetics by the end of the project (July 2022) and it is expected that more than 35,000 genomic tests are conducted in the 2022 drop and over 90% of the project drop are genomic tested as indicated in Figure 8.

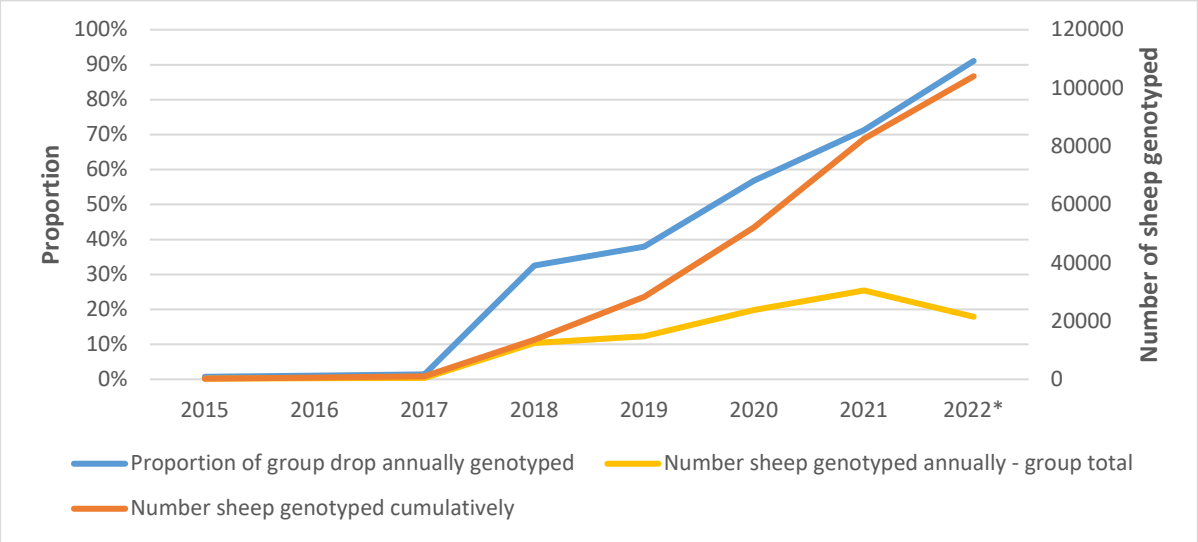
The dramatic rise of genomic testing has enabled breeders to more accurately select ram lambs to join and more recently, ewe lambs.

Table 2: Number of genomic tests and TSUs project funded or self-funded through the life of the project

	Parent Test	15k/50k Tests	Flock Profile	TSUs*
Project Funded (50:50)	57,311	14,502	119	74,193
100 % Self-funded	35,357	89,523	9	115,090
Total	92,668	104,025	128	189,283

*Note: blood card numbers were not captured during the project as they were provided free by the Sheep CRC.

Figure 8: Number of sheep genomic tested leading up to and then through life of the project. Note that only half of the 2022 drop were submitted to Sheep Genetics by the end of the project (July 2022) and it is expected that more than 35,000 genomic tests are conducted in the 2022 drop



4.1.3 Data quality

The proportion of flocks within the group collecting more than 65% pedigree was 80% by the end of the project (Figure 9). This is coupled with a year-on-year increase in the number of sheep submitted to Sheep Genetics within the group of ram breeders. Furthermore prior to the project it could be observed that many ram breeders within the group were selectively submitting animals into the Sheep Genetics database. This can be determined by assessing the male to female ratio. We would expect a ratio of 1 (i.e., 50% males and females). Leading into the project the group average ratio was 0.78 in 2015 (Figure 10). Additionally, it is also observed that the standard deviation of that average was close to 1 (Figure 10). The selective submission of animals causes bias in ASBV calculation and a further mistrust in the ASBVs that the ram breeders were getting calculated. In 2018 at the beginning of the project, the group had a spike in ratio and a plunge in standard deviation after intensive one-on-one sessions were walked through (Figure 10). By the end of the project the ratio was close to 1 with the standard deviation below 0.1 (Figure 10). While all participating studs were not perfect at the end of the project most of the group moved towards full cohort submission.

With almost every breeder increasing genomic testing and better data quality, this created a more comprehensive genomic reference population for the Merino industry. Increased accuracy on younger selection candidates was facilitated by genomic selection and underpinned on better data quality collected within each breeding flock. The result was accelerated rates of genetic gain

Figure 9: Proportion of group whose flock has greater than 65% of full pedigree, proportion of the collective group population with full pedigree, number of sheep submitted to Sheep Genetics each year

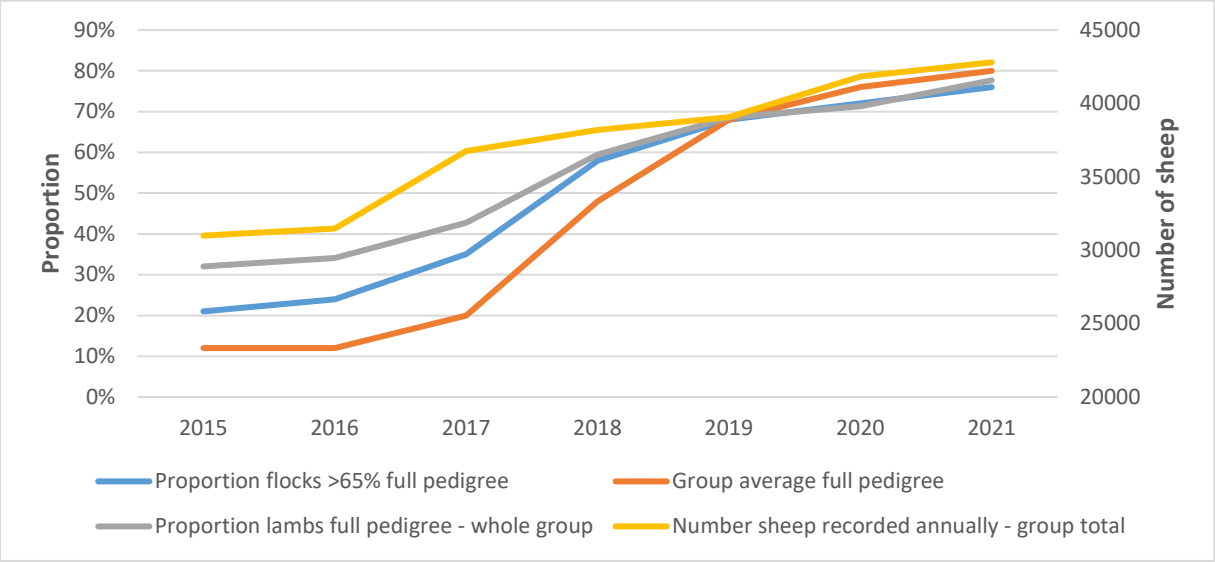
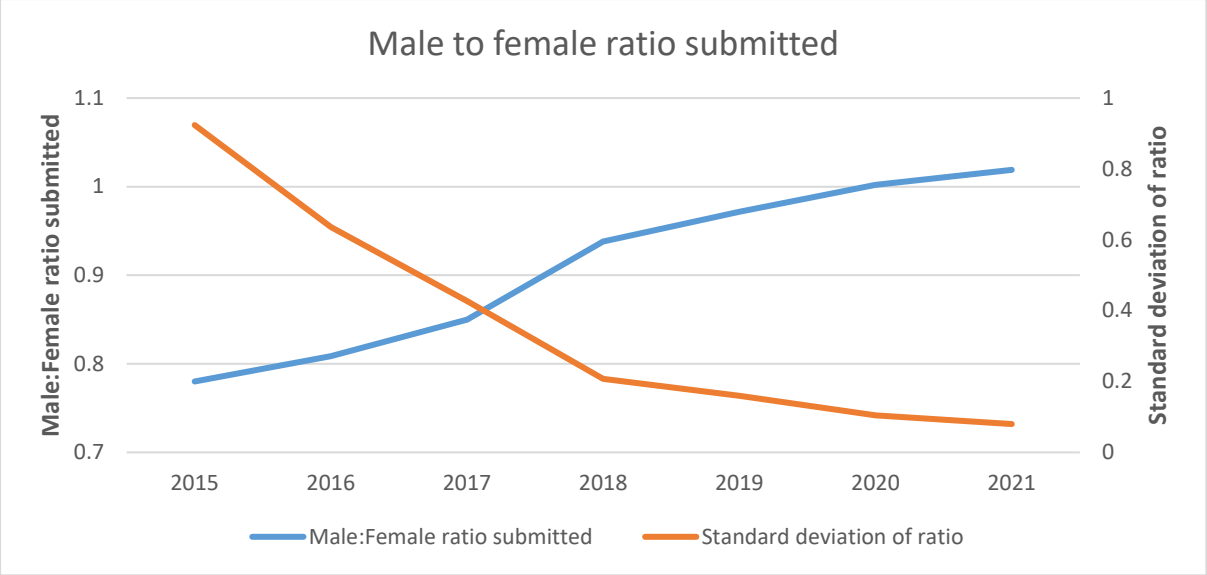


Figure 10: Group average male to female ratio over years (primary axis) and standard deviation of ratio (secondary axis)



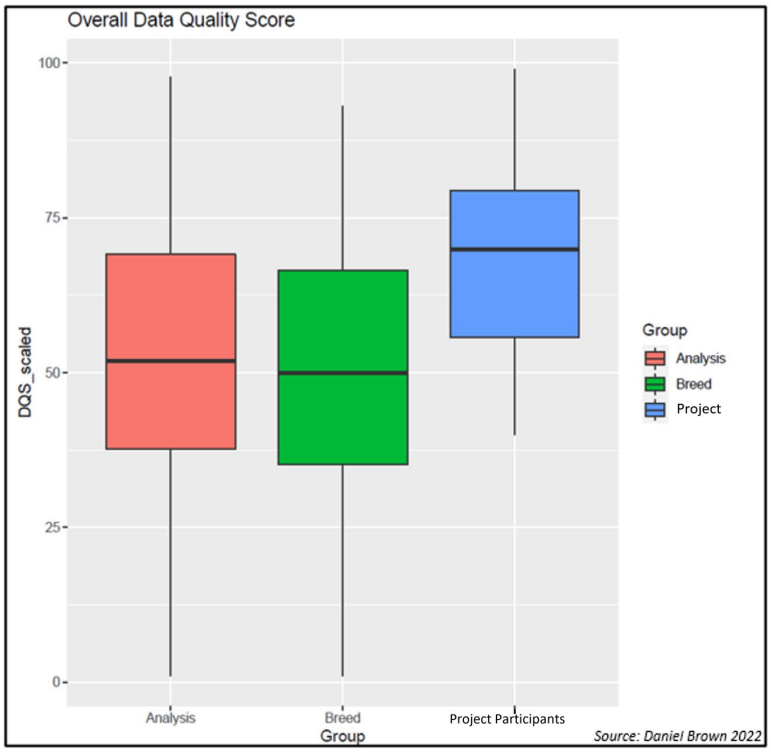
In 2021 AGBU created a "Data Quality Score" system (Guy and Brown 2021) with the ram breeder group in this project used as a test-group. Once the product was finalised, the product was implemented routinely by Sheep Genetics. The Data Quality Score (DQS) describes the overall quality of a flock's data. It is made up of measures of data quantity, quality, and timeliness of data submission. This includes measures of:

- The amount of data, including the number of animals and traits being recorded
- Completeness and accuracy of records, including how well pedigree, birth date and birth types and performance traits are recorded
- Data structure, including progeny numbers and sire representation across groups, and linkage

- Timeliness, which is a measure of how promptly data is submitted to the evaluation from time of collection

By the end of the project, average data quality score is 20 percentile points higher than the rest of the MERINOSELECT database (Figure 11). While some breeders have to continue to improve their data quality score, there are no breeders sitting in the 40th percentile or lower (Figure 11).

Figure 11: Boxplot of data quality scores of Merino analyses excluding ram breeder group (red), "medium" type Merino (green) and DNA project ram breeder group (blue). N.b to read a boxplot, the solid horizontal line is the group average, the coloured box is the 25-75 percentile of group and the "whiskers are the top and bottom value. If any dots appear on a boxplot graph, they are a statistical outlier



By the end of the project the ram breeder group's Merino Production Plus index accuracy was 5% (or 15% comparatively) higher compared to the rest of the database (Figure 12). This increase in accuracy and hence data quality score is attributed by the collective group's higher level of pedigree (Figure 9), more complete cohorts of drops (Figure 10) and more effective records (Figure 13).

Source: Daniel Brown 2022

Figure 12: Boxplot of Merino Production Plus economic index accuracy of Merino Select database excluding ram breeder group (red), "medium" type Merino (green) and DNA project ram breeder group (blue)

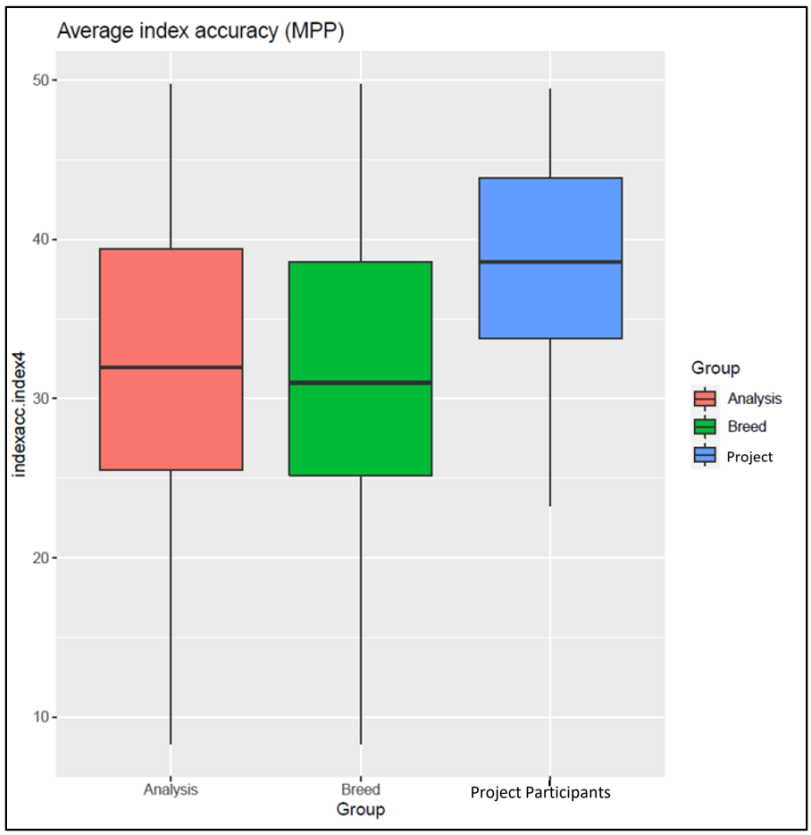
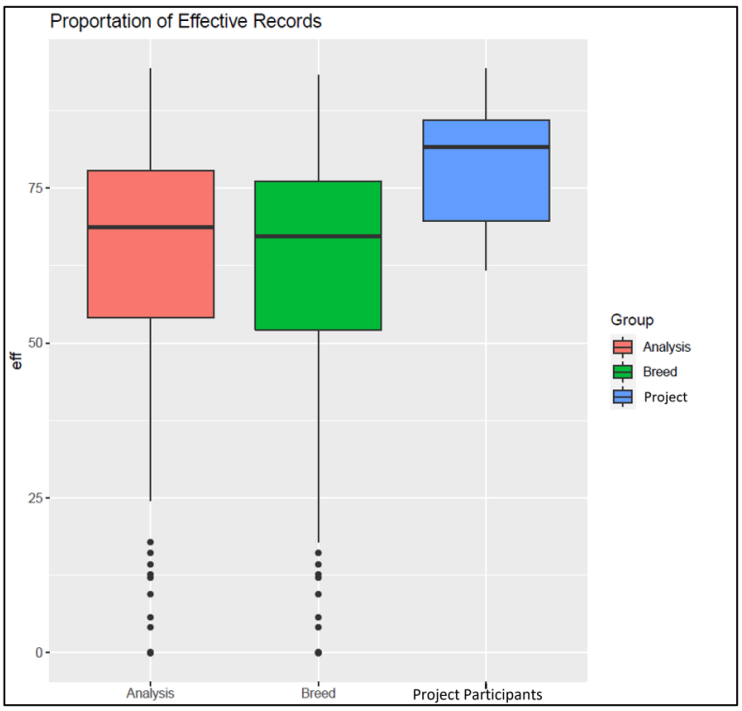


Figure 13: Boxplot of effective records of Merino Select database excluding ram breeder group (red), "medium" type Merino (green) and DNA project ram breeder group (blue)



Source: Daniel Brown 2022

4.1.4 Workshop attendance and feedback

The project goal for workshop attendance was 80%. At the beginning of the project, in-person only workshops was the available option. Online meeting platform technologies fast-tracked with the advent of COVID-19 saw online workshops integrated into the program as a delivery option. By the end of the project, ram breeder workshops were offered as hybrid events where people could attend in-person or online. For all ten ram breeder workshops that were offered across the life of the project, an average attendance of 82% was achieved (Table 3).

At the start of the project the focus of the workshop was the importance of sire and dam pedigree, understanding fixed effects and utilising ASBVs for ram and ewe selection. At the conclusion of the project the focus moved to more strategic use of genomics in the breeding program design and increasing the number of traits being measured for example health and welfare traits.

Through the project ram breeders were asked to fill out feedback forms pre and post workshop (Table 4). The project team used the feedback to assist with setting the workshop agendas as the group progressed and evolved. As the project progressed, the ram breeders as a group increased their knowledge of ASBVs by 25%, better understood the use of MateSel by 102%, increased the importance of ASBVs in selection by 35% and 82% on rams and ewes, respectively (Table 4).

It should be noted that the attendance at the workshops varied over the project due to availability, with numbers of participants, captured in Table 3. Project participants also encouraged new staff working for them to attend the workshops for professional development and extend their understanding of the importance of data collection.

Table 3: Attendance of ram breeder workshops

Workshop	Location	Ram Breeders	Service Providers	Sheep Genetics	AGBU
June 2018	Goulburn	20	5	2	1
August 2018	Esperance	3	1	0	0
November 2018	Wagga Wagga	14	3	2	1
June 2019	Wagga Wagga	23	6	2	1
August 2019	Esperance	6	2	1	0
November 2019	MateSel Dubbo	5	1	1	0
June 2020	Online	20	6	1	1
July 2020	Small group online	22	4	1	0
November 2020	MateSel Online	6	2	1	0
June 2021	Wagga Wagga/hybrid	15	4	2	1
August 2021	Esperance/hybrid	5	2	0	0
November 2021	MateSel Online	3	2	1	0
March 2022	Wagga Wagga/hybrid	18	5	3	1
March 2022	Esperance/hybrid	5	3	1	0

Table 4: Group average responses to question prior to first workshop in 2018 compared to the group average responses to the final 2022 ram breeder workshop

Pre-project - 2018	Before	After	Post-Project - 2022
Are you recording all the traits that align with your breeding objective?	7.9	8.3	After today's workshop, will you collect more traits that align with your breeding objective?
How would you rate your current knowledge of ASBVs?	7.1	8.9	How would you rate your current knowledge of ASBVs?
How would you rate your current use of ASBVs when selecting your rams for your ram breeding operation?	7.2	9.7	After today's workshop how do you rate the importance of using ASBVs in ram selection to reach your breeding objective
How would you rate your current use of ASBVs when selecting your ewes for your ram breeding operation?	5.2	9.5	After today's workshop how do you rate the importance of using ASBVs in ewe selection to reach your breeding objective
Rate the importance of recording and submitting sire pedigree	9.5		
Rate the importance of recording and submitting Dam Pedigree	9.5		
How important do you see the collection of fixed effects is in your breeding program?	8.6		
Are you using the sheep genetics website/database to search and sort animals to purchase and/or source semen?	7.0	9.0	How confident are you following today's workshop in being able to improve your utilisation of ASBV's for ram and ewe selection?
How would you rate your current knowledge of MateSel?	4.1	8.3	After today's workshop, how confident do you feel to use MateSel in making the best possible mating decisions?
How would you rate your current use of MateSel?	2.9		
How would you rate your current knowledge of the RamSelect App	3.8		
How would you rate your current use of the RamSelect app?	2.8		
How would you rate your current knowledge of the Flock Profile test?	6.0		
How would you rate your knowledge of Genomics?	6.0	7.9	After today's workshop how do you rate your understanding of genomics and its use in your breeding program?
		9.0	How would you rate your overall satisfaction with the workshop?
		9.7	How would you rate the relevance of today's workshop to your breeding operation?
		9.0	How would you rate your confidence in achieving your expectations from the overall project?
		9.9	**How would you rate your overall satisfaction with the DNA Project?**

4.1.5 Attitudes to practice change

Prior to the project beginning, many ram breeders who were entering data into Sheep Genetics and receiving ASBVs were frustrated that ASBVs calculated were not a good reflection of the true genetic merit of their animals. Supporting evidence of practice change is outlined in the case studies in Appendix A and B which provide an overall sentiment of the group and their attitudes to change. To assist in changing attitudes, Project leaders worked through the following process (in an important order):

1) Allowed breeders to give a background of their farming operation (this is comfortable ground for ram breeders and eases the breeder in opening up) and their breeding objective in a face-to-face meeting on farm
2) Project leaders asked how the breeder felt about the genetic evaluation
3) Allowing breeders to freely and safely express their anger, disappointment and/or frustration
4) Project leaders (service provider and scientist) were able to empathise and validate those feelings
5) Project leaders asked what measurement practices, data submission practices and kind of pedigree was being undertaken
6) With this knowledge project leaders were then able to explain in a detailed response exactly why their ASBVs were not as accurate as they could be, and what on-farm changes they could make to rectify this

These key steps were critical to building trust between breeders and project leaders. Independence of project leaders from genotyping companies and Sheep Genetics mixed with honesty, empathy, patience in explaining and individual workshop sessions further added to the trust built between parties.

4.1.6 Emerging traits

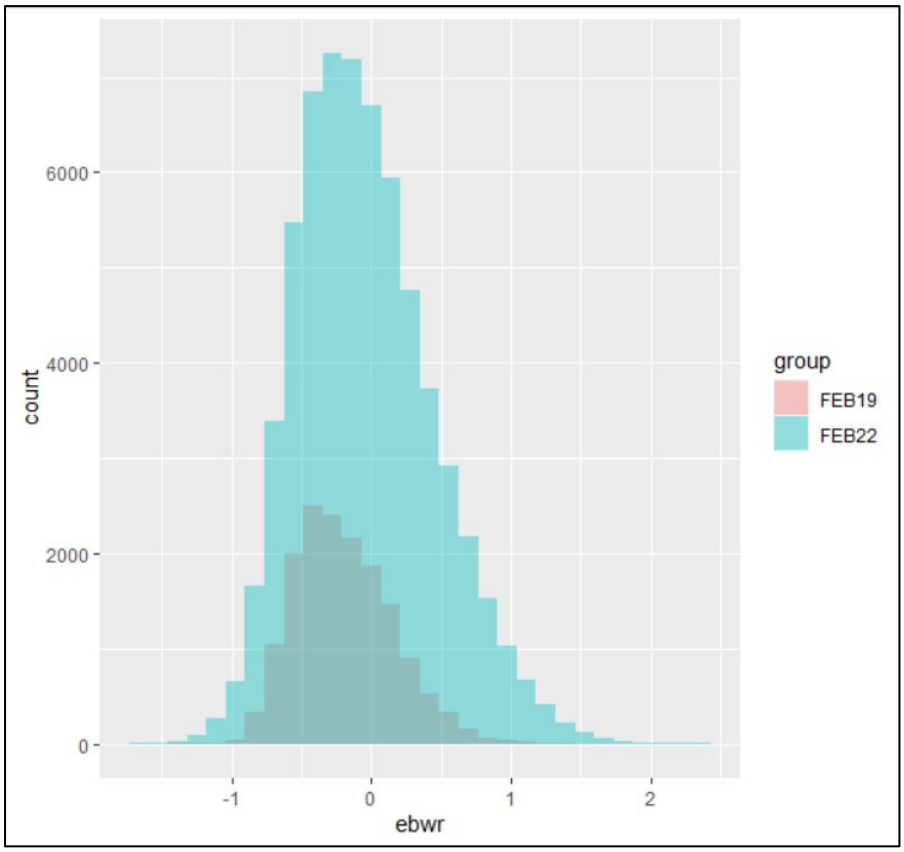
As a group, the ram breeders agreed that mulesing may no longer be a viable option to prevent flystrike. Many breeders within the group took it upon themselves to start measuring and selecting for flystrike indicator traits to allow more accurate genetic selection for animals that have a reduced flystrike risk. Traits included early breech wrinkle, body wrinkle, breech cover and dag score. Figure 14 demonstrates that at the beginning of the project (2000-2018) the group had only collectively measured 28,649 early breech wrinkle records. In the three years after number of records increased to 84,551 , almost a 200% increase (Table 4). The group now have contributed 37% of the early breech wrinkle records to the MERINOSELECT database. With extra measurements being made across a wider genetic base, coupled with selection meant that the spread of genetic merit (horizontal axis of Figure 14) was much larger than 2019. This allows faster genetic progress to be made for this particular trait. While not as extreme for other flystrike indicator traits, similar trends were observed (Table 5).

Table 5: Summary of flystrike indicator traits measured by project participants and how much they contributed to the total MERINOSELECT database as a group

	Nr recorded since 2000	Nr recorded project duration	Proportion contributing to MERINOSELECT since 2000	Proportion contributing to MERINOSELECT in project duration
EBWR	84551	62721	37%	41%
LBDWR	24047	14507	24%	36%
EBCOV	54169	36458	19%	24%

LDAG	25004	15473	16%	22%

Figure 14: Histogram of spread of early breech wrinkle ASBVs within the ram breeder group in 2019 (pink) and by the end of the project (blue)

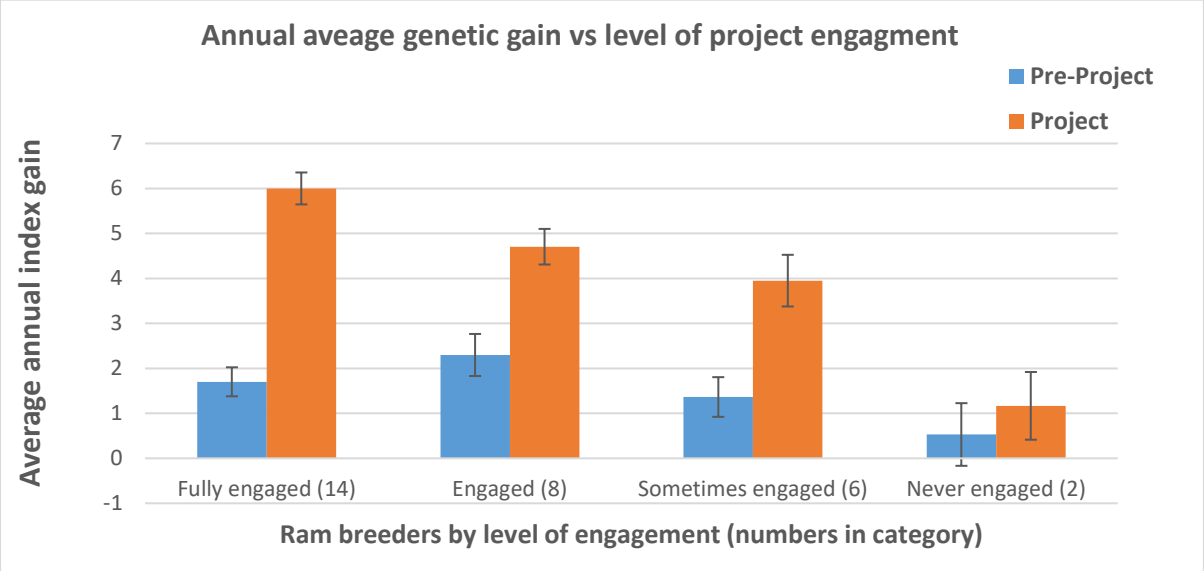


4.1.7 Project engagement vs genetic gain

Stephen et al (2019) concluded that ram breeders who actively engage in upskilling activities offered by Sheep Genetics or genetics advisors have higher rates of genetic gain. The project team found ram breeders who were more engaged with the project were achieving higher rates of genetic gain. A subjective score of engagement in the project was assigned to each breeder described in Figure 15. The score allows the project team to demonstrate that the more breeders were engaged in the project, the more genetic gain they achieve. It also shows that the rate of pre-existing gain prior to the project was not a determining factor of project genetic improvement. Breeders who were fully engaged in the project were utilising tools available well such as MateSel, genomic selection in conjunction with ram and ewe lamb matings as well as seeking professional breeding program advice.

Source: Daniel Brown 2022

Figure 15: Blue bars represent five-year average annual genetic gain (2012-2017) pre-project and orange bars represent three-year average annual genetic gain (2017-2020) during project for studs grouped by project engagement. 1 – Highly engaged: attends all workshops, calls project leaders, asks for one-on-one meetings; 2 – Engaged: Attends most workshops and/or some extra meetings; 3 – Sometimes engaged: Sporadic attendance to workshops, rarely uses extra opportunities; 4 – Never engaged: Do not turn up to any workshops or extra activities.



4.1.8 Attrition rate

The project started with thirty ram breeders. Through the project, the ram breeders had to negotiate the 2018-2020 drought. This was followed by the COVID-19 pandemic. Both events were financially and/or mentally unsettling. This project facilitated a network of support for like-minded people and a reason the group members who engaged became a close network. Often project leaders were taking phone calls that had nothing to do with sheep breeding and were often used as a pillar of support. At the conclusion of the project 26 breeders remained. The reasons for the four ram breeders leaving were:

- Never used subsided genomic testing and rarely/never engaged in project (x1)
- Geographical isolation and never used subsided genomic testing (x1)
- Sold stud due to personal reasons (x2)

Given the trying times the project participants needed to navigate, the ram breeders should be commended on committing to the end of the project. The existing and engaged ram breeders have expressed a desire to keep their group together independently. This is because they can see the merit of networking, sharing ideas and staying up to date with current research.

4.2 Commercial Ram Breeders

4.2.1 Metric of where breeders started and finished

At the beginning of the project, it became clear that the project was working with two distinct commercial breeder groups, those that purchased rams and those who were breeding their own rams. With this, the project team split the commercial breeders into two groups to focus on specific aspects relating to their operations. There were 16 commercial breeders engaged in the project that were breeding their own rams.

At the start of the project all the commercial ram breeders were given the opportunity to conduct a Flock Profile test, of the commercial ram breeders 9 out of the initial 16 did a Flock Profile test, 8 out of the 16 flocks started DNA Parentage testing dams and females and 50K Genomic testing males and began getting genetic benchmarking via ASBVs. A further single flock mother up lambs to dams to obtain pedigree.

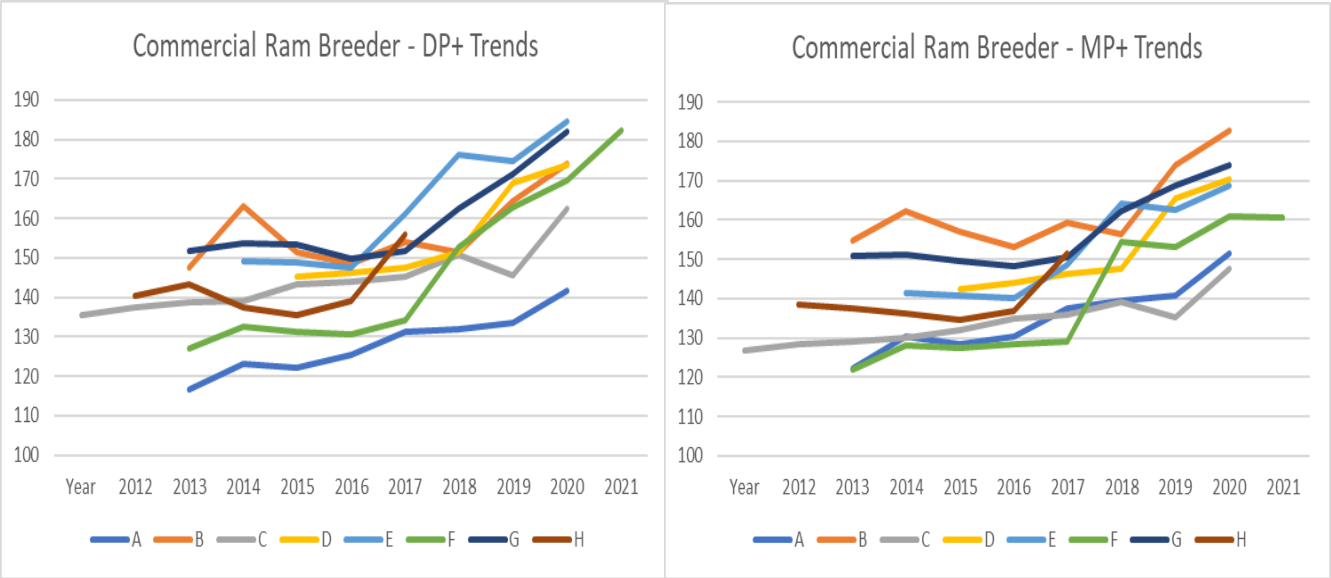
Many of the commercial ram breeders had open nucleus flocks, upgrading maiden ewes from the commercial tier each year. Over the course of the project, most breeders gained an understanding of the benefits of closing their ram breeding nucleus to better manage genetic gain to maximise their return on investment.

4.2.1.1 Commercial ram breeders who began submitting data into Sheep Genetics

Nine of the commercial ram breeders started submitting data into Sheep Genetics because of the DNA Project supporting full DNA pedigree on progeny. Many of the breeders were already using artificial insemination to bring in superior genetics generating young rams to be used in their commercial multiplier flock. These breeders were often at scale where buying rams at a desired high genetic merit scale was either unattainable and/or unaffordable.

The majority of the commercial ram breeders started entering data into Sheep Genetics with the 2018 and 2019 drops (with genetic merit estimated on their mixed age dams). Figures 16 and 17 show the genetic trends for the DP+ and MP+ indexes of eight of the nine flocks. While it is somewhat unfair to compare genetic trends when data on drops only started in 2018 or 2019, Figures 16 and 17 demonstrate an acceleration of genetic trend after 2018. One flock is not reported as it has been a closed flock for over 30 years and does not have enough linkage to obtain ASBVs at this stage.

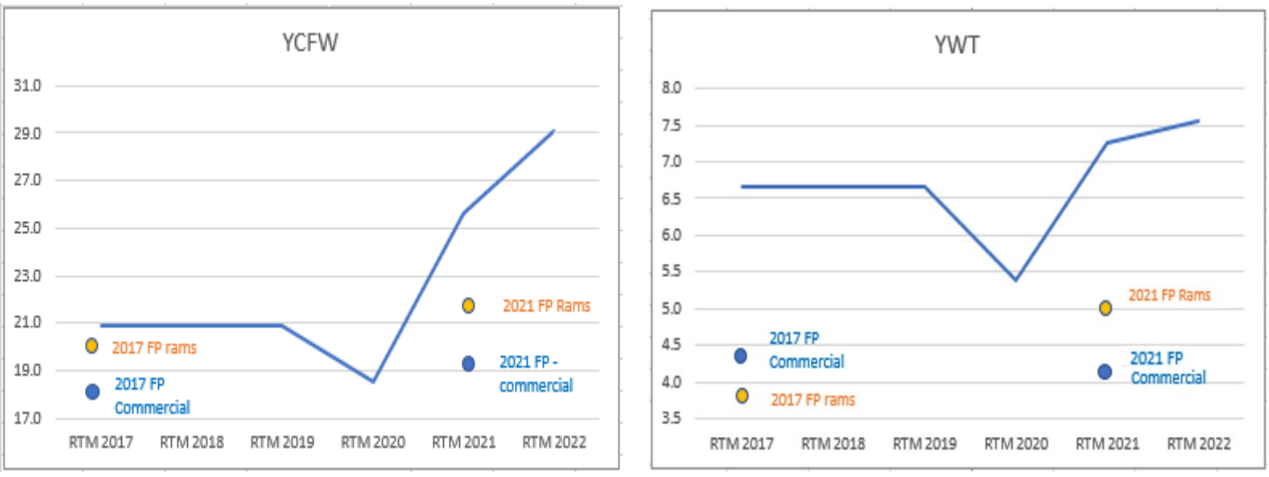
Figures 16 and 17: Commercial ram breeders' genetic trends for DP+ and MP+



4.2.1.2 Commercial ram breeders not performance recording

One of the 16 commercial ram breeders did not performance record during the project. This breeder selected sires based on visual assessment up until 2020 joining. Prior to the project they ran an "open" female nucleus promoting 50% maiden ewes to the ram breeding nucleus. At the beginning of the project, they conducted a Flock Profile test on their 2017 nucleus born lambs and commercial born lambs. They were concerned that the nucleus lambs were only partially better than commercial born lambs (Figures 18 and 19). Project leaders encouraged them to "close" their female side of the nucleus, to ensure the nucleus ewes were sired by high-ranking sires. In 2021 they retested nucleus and commercial flocks and were pleased to see A) genetic improvement in both the commercial and nucleus ewes as well as a larger gap between nucleus and commercial (Figures 18 and 19). This was also overlayed with a rapid improvement in ram teams in the nucleus which also helped accelerate gain (Figures 18 and 19).

Figures 18 and 19: Flock Profile results for commercial ram breeder not performance recording for their nucleus and commercial flocks.



The line in each graph represents the ram team average for nucleus as stored in RamSelect.com.au "Ram Team Manager"

4.2.2 Flock profile

Graphs derived from RamSelect.com.au's Ram Team Manager are shown in Figures 18 and 19. The blue line is the ram team average for yearling clean fleece weight and yearling weight for a particular breeder. Some commercial ram breeders who did not enter data into Sheep Genetics conducted Flock Profile tests on their 2017 and 2021 drops. The project team were then able to overlay the Flock Profile benchmark for each trait (coloured dots) for each breeder (Figures 18 and 19) on the ram team average. This tool demonstrated to commercial ram breeders that ram selection was crucial to achieving genetic gain.

Most commercial ram breeders who conducted a Flock Profile test at the beginning of the project and then started submitting data into Sheep Genetic did not do a second Flock Profile as the genetic trends were calculated and reported based on ASBVS generated by Sheep Genetics.

4.2.3 Open vs Closed nucleus

Through the life of the project, project leaders and genetics service providers engaged in the project, encouraged ram breeders breeding their own rams to "close" the ewe portion of their ram breeding nucleus. This meant ewes from the commercial flock could not be "promoted" up into the nucleus because often the ewes being promoted were of lower genetic merit than that of ewes born in the nucleus (often sired by very high genetic merit sires). The project leaders often observed at the beginning of the project that there was little genetic difference between commercial and nucleus tiers of their breeding program from Flock Profile estimates due to inaccurate promotion of commercial tier born ewes entering the ram breeding nucleus. Of the 16 commercial ram breeders, 9 closed their nucleus and by the end of the project saw improvement in their genetic estimate from the initial Flock Profile tests which enabled more rapid genetic gain as displayed in Figures 16 and 17.

4.2.4 Engagement and data collection

Nine of the commercial ram breeders started submitting data into Sheep Genetics during the DNA Project Part of the process with these breeders was to develop a data collection calendar and timeline to when they would require the ASBVs to make ram and ewe selection decisions. Ram Team Manager was manually updated by the project team as many of these flocks have private viewing on Sheep Genetics and are unable to utilise RamSelect.com.au. Two breeders were already submitting data to Sheep Genetics however with sire only pedigree from AI programs. The project provided the opportunity to genotype the ewes in the ram breeding nucleus to start to collect full pedigree. The majority of the commercial ram breeders have transitioned each year to genotype ewes and in 2022 are achieving full pedigree on 80% of their ram breeding nucleus progeny. Four of the commercial ram breeders have started to use MateSel as part of their selection and breeding program.

4.2.5 Attrition rate

Like the ram breeder group, the commercial ram breeder group went through a series of climatic and social challenges. Through the project there were three commercial ram breeders who departed the project for the following reasons.

- Never used subsided genomic testing and rarely/never engaged in project (2)

- Sold farm due to personal reasons (1)

4.2.6 Workshop attendance and feedback

The geographic distances between the Commercial ram breeders made it challenging for them to attend in person many of the workshop activities (Figure 20). COVID provided a good opportunity for the project team to group the commercial ram breeders into 3 groups and provide small group sessions online tailed to their needs. The 3 groups included:

- Those submitting data to Sheep Genetics
- Those thinking or preparing to submit data to Sheep Genetics
- Those not interested in submitting data to Sheep Genetics or a completely closed flock without linkage

Figure 20: Locations of commercial ram breeders in project

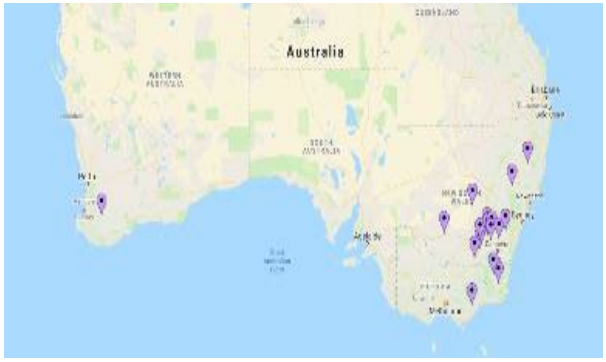


Table 6: Attendance of commercial ram breeder workshops

Workshop	Location	Commercial Ram Breeder	Service Providers	Sheep Genetics	AGBU
November 2018	Wagga Wagga	10	2	0	0
August 2019	Yass	11	3	1	1
June 2020	Online small groups	14	2	0	0
June 2021	Online small groups	12	3	0	0
March 2022	Wagga Wagga	6	2	1	0

Workshops with commercial ram breeders were offered annually which were usually well attended (Table 6). Through the project commercial ram breeders were asked to fill out feedback forms pre and post workshop (Table 7). The project team used the feedback to assist with setting the workshop agenda as the group progressed and evolved. Through the project the commercial ram breeders as a group increased their knowledge of ASBVs by 57%, better understood the use of RamSelect.com.au by 200%, increased the confidence in using ASBVs in purchasing sires by 108% (Table 7).

Table 7: Pre and post workshop mean responses for commercial ram breeders

Pre-project - 2018	Before	After	Post-Project - 2022
How would you rate your understanding of ASBVs?	5.6	8.8	After today's workshop, how would you rate your understanding of

Pre-project - 2018	Before	After	Post-Project - 2022
			Australian Sheep Breeding Values (ASBVs)?
How would you rate your current use of ASBVs when purchasing rams/semen?	4.6	9.6	After today's workshop, how confident are you in using Australian Sheep Breeding Values (ASBV's) when purchasing rams/semen?
How would you rate your knowledge of the RamSelect website?	2.9	8.7	After today's workshop, how would you rate your knowledge of the RamSelect App?
How would you rate your current use of the RamSelect website?	2.5	8.7	How confident are you following today's workshop in being able to improve your utilisation of the RamSelect App?
How would you rate your current knowledge of the Flock Profile test and its results?	4.6	9.3	How confident are you following today's workshop in being able to interpret and utilise the Flock Profile tests results?
How would you rate your use of ewe replacement selection tools?	4.2	8.7	After today's workshop how confident are you in utilising additional tools to select your replacement ewes?
		9.3	How would you rate your overall satisfaction with the workshop?
		9.7	How would you rate the relevance of today's workshop to your breeding operation?
		9.6	How do you rate the importance of the project

4.3 Commercial Ram Buyers

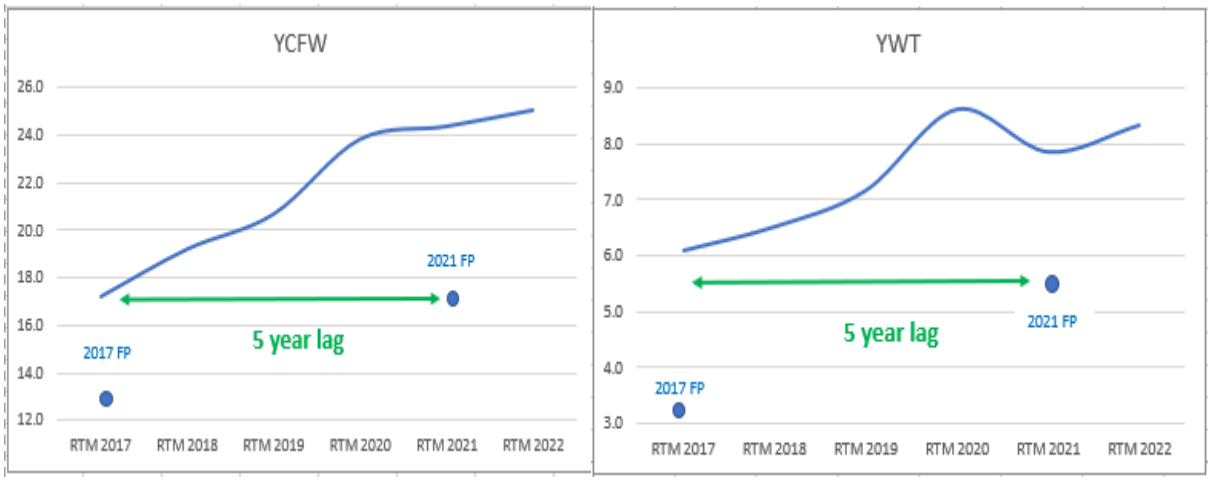
4.3.1 Flock Profile

Each project of the 49 commercial ram buyers did a Flock Profile test on their 2017 or 2018 drop and then a second test on their 2021 drop. This was done to estimate genetic change in their commercial flocks. Any commercial breeder who bought rams with ASBVs had their ram team entered into RamSelect.com.au's "Ram Team Manager". Once the second Flock Profile was conducted, the project team put together genetic trend reports for each participant. If the participant was using rams with ASBVs the Ram Team Manager was overlayed in the same results to give context of genetic lag of ram team average to the drop estimate. Below are several examples of commercial breeders and how flock profile influenced the breeding decisions.

4.3.1.1 Changed ram source

The genetic trend of the ram team manager for a commercial flock that had changed ram source just prior to the project commencing is demonstrated in Figures 21 and 22. Their breeding objective focused on increasing fleece weight and increasing growth gradually. The flock profile results indicate a 5-year genetic lag between the ram team and the progeny genetic merit/performance.

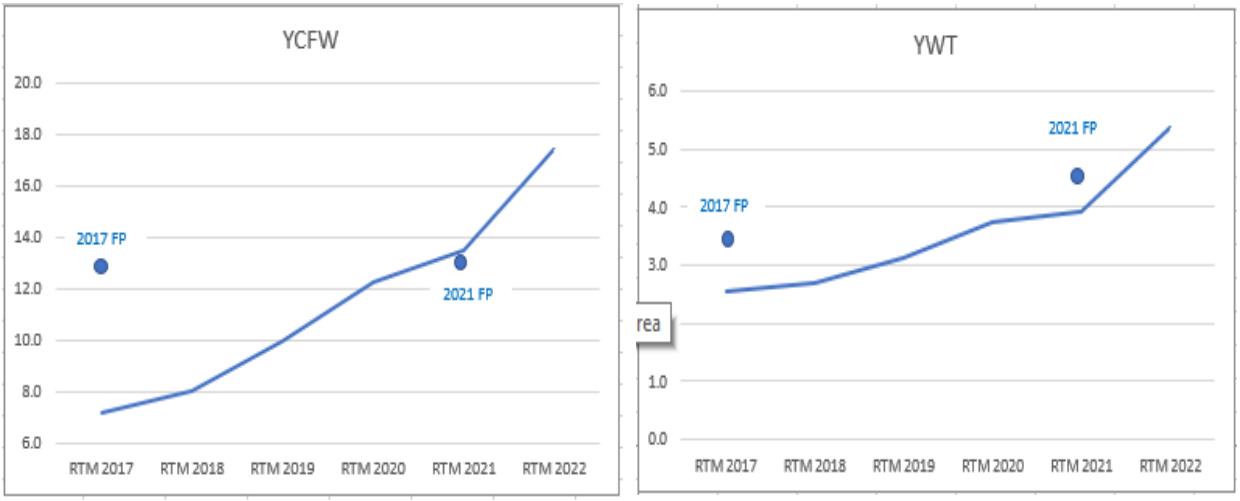
Figures 21 and 22: Example of commercial breeder who changed ram sources for yearling clean fleece weight (YCFW) and yearling weight (YWT) traits, the two Flock Profile tests (blue dots) and the ram team average (blue line)



4.3.1.2 Sourcing rams from stud with historically (but now improving) data quality

Several commercial ram buyer participants were purchasing rams from ram breeders who had low data quality. Their Ram Team Manager trend lines reflected poorly on the actual merit as indicated by the Flock Profile. In the example in Figures 23 and 24, the Flock Profile provides a good benchmark to check where the commercial flock sits compared to MERINOSELECT database. As the ram source has improved their data quality the trend lines of the ram team aligns more closely to the flock profile results.

Figures 23 and 24: Example of commercial breeder who sourced rams with low data quality for yearling clean fleece weight (YCFW) and yearling weight (YWT) traits, the two Flock Profile tests (blue dots) and the ram team average (blue line)

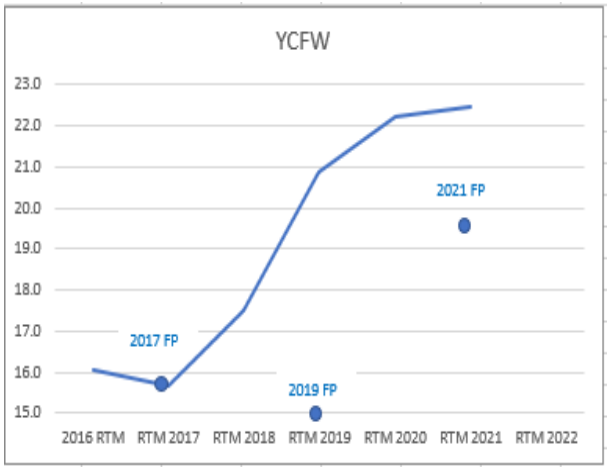


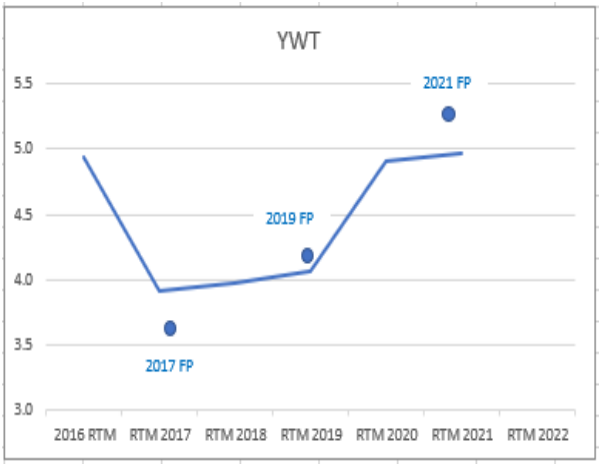
4.3.1.3 Commercial breeder who was breeding own rams and then started purchasing rams

The final example of Figures 25 and 26 below is a commercial breeder who conducted an additional Flock Profile in 2019 in the middle of the project. The breeder was historically breeding their own rams prior to the project. Their method was to select ewes from the commercial flock and then purchased

a high merit ram to then breed rams. The idea of 2019 drop Flock Profile test was to investigate if any additional change was achieved when they began to purchase rams. When the 2019 Flock Profile results were returned there was confusion over why their Flock Profile were not progressing as expected for key traits in their breeding objective after purchasing and mating high genetic merit rams (Figures 25 and 26). After further investigation, what was not captured in the Ram Team Manager was the remaining home-bred rams and the genetic lag they were contributing to the test 2019 drop. By 2021, the home-bred rams had exited the breeding ram team. The 2021 Flock Profile test provided evidence that once lower home-bred genetic merit rams exited, this provided a lift in genetic estimate (Figures 25 and 26). Also if the homebred rams are not as related to the reference population in which the genetic estimates in flock profile are derived from, the results can fluctuate. As the ram team changes and becomes more related to the reference the accuracy of the flock profile improves. This is a good example of the power of the Ram Team Manager and how it can be used to help explain the impact of genetic lag and managing on-farm ram batteries as well as new acquisitions.

Figures 25 and 26: Example of commercial breeder who began buying rams from a high genetic merit stud after breeding own rams for yearling clean fleece weight (YCFW) and yearling weight (YWT) traits. The three Flock Profile tests (blue dots) and the ram team average (blue line) give genetic estimates for each trait





4.3.2 Ram Team Manager

Where commercial breeders were purchasing rams with ASBVs, Ram Team Manager in RamSelect.com.au was populated and maintained over the course of the project by the project team. Project participants were shown how to do this themselves or given the option for the team to do this, Only four commercial participants chose to do this themselves. Most of the commercial ram breeders run mixed farming enterprises, limiting time and capacity to update the Ram team Manager, therefore often requesting assistance. With data from the Ram Team Manager overlaid with their respective S.M.A.R.T. breeding objective, commercial breeders were able to track their ram team progress. The project team in conjunction with genetic service providers were able to give colour-coded tables to easily identify progress in key production traits (Figure 27).

Figure 27: An example of a table that commercial breeders received in 2022 from the project team with ram team averages from RamSelect.com.au Ram Team Manager.

ASBV	Description	Units	Breeding Objective	Team Ave 2021	Team Avg. 2020 Joined	Team Avg. 2020	Team Avg. 2019	Team Avg. 2018
yfd	**Yearling Fibre Diameter**	µm	**Maintain**	**-1.2**	-0.9	-0.8	-0.7	-0.7
ysl	Yearling Staple Length	mm	Increase	8.4	8.6	7.1	7.3	7.8
ycfw	**Yearling Clean Fleece Weight**	%	**Increase**	**24.5**	**23.8**	**19.5**	**18.4**	**18.2**
pwt	Post Weaning Weight	kg	Increase	**5.7**	6.1			
ywt	**Yearling Weight**	kg	**Increase**	**8.3**	**8.9**	**7.5**	**6.6**	**6.2**
yemd	Yearling Eye Muscle Depth	mm		**0.7**	0.6	0.6	0.4	0.4
yfat	Yearling Fat Depth	mm		**0.1**	0.0	0.0	-0.2	-0.2
nlw	Number of Lambs Weaned	%	Increase	**2.0**	2.0	-1.4	-2.6	-3.6
ebwr	**Early Breech Wrinkle**	score	**Decrease**	**-0.3**	**-0.2**			
ywec	Yearling Worm Egg Count	%		-7.4	-9.6	-8.8	-9.8	-9.7
FP+	Fibre Production Plus Index	score		152	149	136	134	133
MP+	**Merino Production Plus Index**	score	**Increase**	**168**	**165**	**148**	**144**	**141**
DP+	Dual Purpose Plus Index	score		**172**	**168**	148	143	139

Green text denotes 2021 ram team has improved from the previous years, red has declined and black denotes no major change. Bold numbering denotes traits that are included in their breeding objective

4.3.3 Workshop attendance

Table 8: Attendance of commercial ram buyer workshops

Workshop	Location	Commercial Ram Buyer	Service Providers	Sheep Genetics
August 2018	Esperance	22	2	0
November 2018	Wagga/Young	15	2	0
August 2019	Yass	11	3	1
August 2019	Esperance	18	3	0
June 2020	Online small groups	14	2	0
August 2020	Esperance/Online	15	1	0
June 2021	Online small groups	12	3	0
August 2020	Esperance/Online	15	1	0
March 2022	Wagga Wagga	6	2	1
August 2020	Esperance/Online	14	1	0

Workshops with commercial ram buyers were offered annually either in the eastern state's clusters or with the ASHEEP group in Esperance, WA. Attendance as a percentage of participants was lower than ram breeders and commercial ram breeders (Table 8). This group also had the least amount of money invested in the project. Through the project commercial ram buyers were asked to fill out feedback forms pre and post workshop (Table 8). The project team used the feedback to assist with setting the workshop agenda as the group progressed and evolved. Through the project the commercial ram breeders as a group increased their knowledge of ASBVs by 28%, better understood the use of RamSelect.com.au by 105%, increased the confidence in using ASBVs in purchasing by 49% (Table 9).

Table 9: Pre and post project average responses for commercial breeders – scores out of 10

Pre-project - 2018	Before	After	Post-Project - 2022
How would you rate your current knowledge of ASBV's?	6.9	8.8	After participating in the DNA Project, how would you rate your understanding of Australian Sheep Breeding Values (ASBVs)?
How would you rate your current use of ASBV's when purchasing rams?	5.9	8.8	After participating in the DNA Project, how confident are you in using Australian Sheep Breeding Values (ASBV's) when purchasing rams?
How would you rate your current knowledge of the RamSelect app?	3.6	7.4	After participating in the DNA Project, how would you rate your knowledge of the RamSelect Website?
How would you rate your current use of the RamSelect app?	1.9	7.4	How confident are you following your participation in the DNA Project in being able to improve your utilisation of the RamSelect Website?
How would you rate your current knowledge of the Flock Profile results?	2.5	8.3	How confident are you following your participation in the DNA Project in being able to interpret and utilise the Flock Profile test results?
How would you rate your use of ewe replacement selection tools?	3.7	7.6	After participating in the DNA Project, how confident are you in utilising additional tools to select your replacement ewes?
		8.4	How would you rate your overall satisfaction with the DNA Project's annual workshop program?
		9.2	How would you rate the relevance of the DNA Projects workshop topics to your breeding operation?

4.3.4 Engagement with Service Providers

During the DNA Project four service providers were either working with project participants or had shown interest in the DNA Project initially, were engaged in a Train the Trainer Zoom meeting in June 2020 to then assist the project team deliver the commercial ram buyer workshops. In addition to presenting to the commercial ram buyer small groups, the Service Providers were encouraged to continue contact with the commercial breeders to build on their client base and provide additional services outside of the project scope on a private fee basis. The project aimed to facilitate the networking opportunities as well as professional development of the service providers.

All the service providers engaged felt their involvement had been worthwhile and all indicated that they would be willing and interested to participate in something similar in the future.

The success of the Service Provider and Commercial Ram Buyer engagement was partly driven by how the breeder became involved in the DNA Project, if they had come into the project due to their own interest there was a greater level of engagement, if they had been nominated by a ram breeder (client of) then there was often a lower level of engagement.

4.3.5 Attrition rate (reasons)

Retention and engagement of the commercial ram buyer was challenging if they were not purchasing rams with ASBVs. Despite hearing anecdotes and testimonials in group workshops there are several barriers to adoption of ASBVs. The project leaders recognised some contributing factors including :

- Loyalty to existing stud (studs offer social networks that can be intergenerational)
- Belief their sourcing stud are achieving gains that align with their breeding objective
- Loyalty to family tradition
- Maintaining existing relationships
- Fear of change (e.g. “type” of sheep or wool)

Reasons for breeders leaving the project included:

- Sold farm due to personal reasons (2)
- Commercial breeders purchase rams without ASBVs and were hard to engage (7)

4.4 Service Providers

4.4.1 Total number of service providers engaged

Through the life of the project, 16 genetics service providers were engaged. Seven out of these were actively involved in the DNA Project including delivering some components. This group of 7 service providers collectively manages data for:

- 103 Merino studs
- 58 non-Merino studs

Upskilling this group was of particular importance given the multiplying effect over all their ram breeding and commercial clients.

4.4.2 Attendance and engagement

Genetic service providers were invited to any workshop they had participating clients in. Their attendance is summarised in Tables 2, 4 and 6. The most effective method of upskilling was to use real problems from their clients. This method bought automatic buy-in but also had a multiplying effect as the service providers have many clients.

An aim of the project was to upskill service providers. The project team viewed this upskilling to build knowledge, problem solve data quality issues and learn breeding program design. Through the life of the project, project leaders saw an opportunity for service providers to further upskill in workshop presentation and facilitation. In 2021 a “train-the-trainer” workshop with project leaders and service providers was undertaken. These service providers then facilitated commercial buyer workshops in 2021 and 2022 as well as given individual project participants to intensively engage. This was all supervised by project leaders and assistance was only given when requested or needed. The project leaders felt that this helped further develop and fast track upskilling of service providers.

4.4.3 Feedback of genetics service providers

At the conclusion of the project genetics service providers who were engaged in the project were asked to provide written feedback on their inclusion in the project and some of the key messages they learned. In summary the group said the following:

- An opportunity to practice my extension skills
- Listening to others present always give me some improved ways of explaining concepts
- Networking with project staff and participants allowed me to feel confident to ask for help both at workshops and at other times
- Close insights to the leading (stud and commercial) breeders in the country
- Gain knowledge in use of genomics in breeding plans
- Client engagement
- The project has been a huge learning experience, not only from a technical perspective but also from a project management perspective.
- Managing expectations and dealing with situations out of our control e.g., Drought, COVID and Wet
- The project has been a huge part of my development journey as it began when I first began my journey as a consultant.
- Every year I have grown as the project has developed, picked up more skills, made incredibly important professional connections (and developed fantastic personal connections also).
- Doing a lot of the DNA testing in the first year for many of the project participants meant I was thrown in the deep end of learning the ins and outs of what works best, and it was a fantastic learning curve and now something that is second nature.
- I am incredibly grateful for the project and the involvement I had
- The ability to connect with clients with other services providers to be able to develop their skills

4.4.4 Summary of what the project has meant for the industry of genetics service providers

The genetic service provider industry continues to grow as livestock breeders continue the uptake of animal technologies. As such, genetic service providers require platforms to network and upskill. Many genetic service providers act as a gateway between Sheep Genetics, between genotyping companies, between agriculture products (e.g., ear tags, tissue sample units etc), and between testing services (e.g., wool testing services, carcase scanners, classers, online selling platforms etc). As the project was a catalyst to conduct bulk genomic testing as well as better measurement practices, new opportunities have arisen for genetics service providers and their businesses. These include:

- Increased coordination of parentage and genomic testing (both during the project timeline and continued afterwards)
- Increased coordination and undertaking of data collection
- Better accuracy in ASBVs which opens more discussions and planning on breeding objective and breeding program design
- Plans to improve technology adoption and adaptable strategies to utilise these technologies.
- Increased clientele through “word of mouth” advertising from project participants

4.3 Scientists

Scientists participating in the project gained invaluable experience working in this project. With quantitative geneticists often viewing breeding program design in a "utopian" image, the project was important for scientists to understand "utopia" needs to be balanced with commercial realities of a business. With new knowledge scientists were able to help service providers and breeders get as close to data perfection while working within the commercial limitations of each breeding program. The project was also an excellent opportunity for scientists to form closer networks with breeders and genetic service providers to the point that both parties felt comfortable either calling or emailing whenever they felt like doing so. Finally, the project provided an invaluable platform to convey scientific updates as well as collaborate to collect new and novel data. This data to analyse included fly strike indicator traits, validation of the poll/horn test and alternative methods to determine date of birth in lambs without mothering-up.

4.4 Scientific papers and presentations

Through the life of the project, project plans, progress reports and project reviews were presented to the scientific and industry audience. In this section is a summary of papers and presentations undertaken by the group.

4.4.1 Association for the Advancement of Animal Breeding and Genetics

Merinolink/UNE DNA stimulation project: Doubling the rate of genetic gain - where are we at in year 2? – 2019 - Presented by Sally Martin in Armidale, NSW.

MerinoLink/UNE DNA Stimulation Project: Doubling the rate of genetic gain – Where are we after 4 years? – 2021- Presented by Sally Martin in Adelaide, SA.

Is sex determination in Merinos heritable? – 2021 - Presented by Tom Granleese in Adelaide, SA.

4.4.2 World Congress on Genetics Applied to Livestock Production

How a group of Merino breeders increase the rate of genetic gain by 134% in five years – 2022 - Presented by Tom Granleese in Rotterdam, Netherlands.

4.4.3 MerinoLink Annual Conference

Driving Adoption in Genetics – 2018 – Presented by David Packer in Goulburn, NSW.

DNA Project Update: Doubling the Rate of Genetic Gain and What it Means for You – 2019 – Presented by Tom Granleese in Armidale, NSW.

DNA Project – DNA: A game changer! – 2021 – Presented by Sally Martin in Wagga Wagga, NSW.

DNA Project – A commercial breeder – 2022 – Presented by Danny Flannery in Wagga Wagga, NSW.

4.4.4 AGBU Seminars

UNE/Merinolink DNA stimulation project: An overview – 2018 – Presented by Tom Granleese in Armidale, NSW.

UNE/Merinolink DNA stimulation project: Where are we in year 2 -2019 - Presented by Tom Granleese in Armidale, NSW.

UNE/Merinolink DNA stimulation project: Where are we in year 3 -2020 - Presented by Tom Granleese in Armidale, NSW.

UNE/Merinolink DNA stimulation project: The project reached its goal a year early! -2021 - Presented by Tom Granleese in Armidale, NSW.

UNE/Merinolink DNA stimulation project: We increased gain by 134% in 5 years! -2022 - Presented by Tom Granleese in Armidale, NSW.

4.4.5 Sheep CRC

UNE/Merinolink DNA stimulation project: Where are we in year 2 -2019 - Presented by Sally Martin in Dubbo, NSW.

4.4.6 Journal publications

Project leaders aim to submit a full scientific journal paper into *Australian Production Science* before the end of 2022 giving a full overview, methods, and discussion of the project.

4.5 Case Studies

Eight case studies of ram breeders and commercial breeders were created in written format. Four of the case studies were accompanied by video. Full case studies can be found in the Appendix while links to videos can be found below.

4.5.1 Ralph Diprose – using genomics for ewe lamb joining - https://youtu.be/BvBehhHl1qg
4.5.2 Bella Lana – pedigree and data quality – https://youtu.be/6kzWKvOQ8m0
4.5.3 Dugald Campbell – ram selection – https://youtu.be/R8cTrHvtqEw
4.5.4 Overall Project – capture engagement – link to come; written case study submitted

5 Conclusion

5.1 Key findings

- Subsidised genotyping was an effective method to initially engage sheep breeders
- Building trust between project leaders and participants was essential to catalyse change
- The group of ram breeders increased the rate of genetic gain by 134%
- Genomic testing facilitated through improving data quality more accurate selection of younger breeding animals to help accelerate rates of genetic gain
- Ram breeders more engaged with the project had higher rates of genetic gain
- Most participants can now see the value for engaging professional advice for their breeding program
- Upskilling genetic service providers was most effective when working side-by-side clients
- Most commercial ram breeders require support with breeding program design

- Project participants were exposed to and now value key industry tools such as Ram Team Manager and MateSel, with 54% of ram breeders in the project utilising Matesel.
- Most commercial ram buyers would benefit fromattending education and training sessions or engage a service provider to help maximise ram buying potential

5.2 Benefits to industry

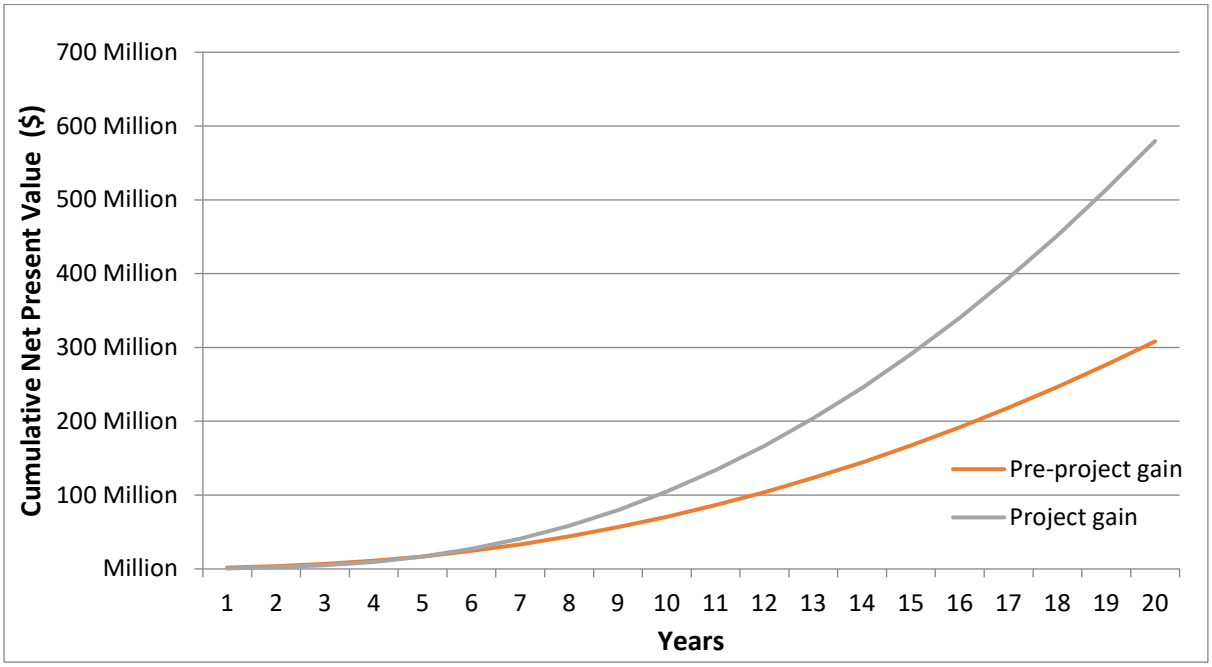
The group are directly influencing the genetic improvement of aproximately 2.5 million commercial Merinos bred annually (Table 10). The group collectively sells 10,000 ramsper annum. With 15,000 doses of semen sold annually to other studs, commercial ram breeders and commercial breeders, the number of animals indirectly influenced is far larger given most of these units of semen are breeding future sires and/or future dams of sires. This makes this cost-benefit analysis outlined below a conservative approach. Index gain is assumed to be worth $0.50 per index unit (Granleese *et al.* 2018). In section 4.1.1 above we explain that the group's genetic gains are sustainable. The sustainability assumption sit in-line with genomic testing modelling carried out by Granleese *et al.* (2019). The geneflow method (Hill 1974) was used to model the benefits of this accelerated genetic improvement multiplied by commercial Merino ewes with a generic structured commercial breeding nucleus (Table 9). Future price fluctuations in the modelling are managed by using a cumulative discount of expression method assuming a long-term interest rate of 7% (Table 9). Figure 28 demonstrates that is estimated to be worth an extra $34 million dollars in a ten-year period and an extra $272 million dollars in a twenty-year period if rate of genetic gain is maintained. The MDC co-invested $1.55 million dollars over the life of the project equated to a 22:1 and 175:1 return on investment over a 10 year and 20 year period, respectively (Figure 28).

Table 10: Assumptions I made in the cost benefit analysis

Assumptions	
Rams sold per year	10,000
Number of years rams mated commercially	3
Number live lambs weaned per ram commercially	75
Number of commercial lambs bred from sold rams	2,250,000
Number of commercial lambs weaned from studs commercial flocks	240,000
Total number commercial lambs weaned per year	2,490,000
Number of semen units sold annually*	15,000
$ value per index point	$0.50
$ value of genetic gain pre-project	$1.04
$ value of genetic gain project	$2.43
$ value of genetic gain post-project	$2.43
Interest rate applied to cumulative discount of expression	7%
Commercial ram replacement rate	40%
Commercial ewe replacement rate	40%
Mortality (culled or died) year-on-year (% or original of age class nr)	10%
Cast for age both sexes	6
Years before gains are realised at commercial level	4

*Note semen sales were not used in the cost-benefit analysis

Figure 28: Cumulative net present value of project following initial $1.55m MDC investment which facilitated an increase in rate genetic gain compared to if zero money was invested and rate of genetic gain prior to the project was maintained. Geneflow benefits are multiplied through the participating stud and client commercial flocks.



An increase in measurement of traits and use of genomics has allowed more genetic variation and hence higher rates of genetic gain is possible. Furthermore, higher quality data coupled with mass genomic testing has provided the Merino industry with an enviable genomic reference population.

Indirect benefits to industry are the upskilling of 16 genetic service providers who participated in the project with existing clients. These service providers are responsible for managing data as well as providing breeding program design for 161 ram breeders and 210 commercial clients. This is a significant portion of the MERINOSELECT and LAMBPLAN database.

Finally, the project provides a framework for future projects either in sheep, beef or goats where traditional rates of genetic gain is slow and adoption other genetic technologies is less then desirable.

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6 Future research and recommendations

- This project has provided a framework for future projects where adoption of genetics tools is low in seedstock and commercial breeding enterprises
- This model is repeatable in sheep and could be replicated in other livestock industries
- If another similar project was funded in Merinos, a new unique group of breeders and service providers should be engaged

7 References

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8 Appendix

a. Ralph Diprose – using genomics for ewe lamb joining

https://youtu.be/BvBehhHl1qg

Ralph Diprose, Rocklyn Merino Stud, Greenethorpe NSW

#genomics #joiningewelambs #goingpoll

Ralph lives near Greenethorpe, NSW and runs 1,000 ewes in his ram breeding operation, Rocklyn Merino Stud and 4,500 commercial ewes in a mixed farming area receiving 600mm rain on the northern end of the south west slopes and southern side of central west slopes and plains. The mixed farming operation comprises of two thirds cropping and one third Merino sheep. The main pastures include lucerne clover and chickery which fit nicely into the cropping program. The sheep enterprise complements the cropping program with young stock being able to be fattened and grown out on the grazing crops.

Introduction

Five years ago, Ralph Diprose started DNA testing as part of the **MLA/UNE/MerinoLink DNA Stimulation Project**. Ralph started off DNA Parent Testing all females and 50K Genomic testing all male progeny to provide full pedigree. Ralph has since moved to 50K Genomic testing all progeny as the price difference has reduced and the benefits gained from the 50K Genomic test is being capitalised on by joining ewe lambs.

"The DNA genomic test has enabled me to be able to select ewes out as ewe lambs to join strategically. We only have a breech score and one or two body weights at the time of selection, we are now relying on the genomics to make the ewe lamb joining decisions and these decisions are able to be made before we have collected the other data for example fleece weight and micron."

What did you want to get out of the project?

"We had been using Pedigree Match Maker (PMM) to identify the dams, and I wanted to get more information on the pedigree, when the opportunity came up that MLA would help with funding part of the DNA Project it was a good opportunity. We now have more accurate pedigree, from a relatively simple process of taking the DNA samples at lamb marking time."

"The project was not all about DNA testing. The project provided the opportunity to mix with other breeders and to find out what they had learnt along the way for example going to non-mules, joining of ewe lambs and feedback on the rams/sires that they had used, what was successful and what has not been. The project has helped me to transition into non mulesing and joining ewes with less problems than if I had just done it myself."

Outcome and key learning from the DNA Project

There were three key outcomes and learnings from the DNA Project for Ralph they include:-

1. The importance of the ewes, improving the ewe selection efficiency by having all the data on the ewes not just the rams.

2. Reducing the generation interval, comparing to some of the other flocks in the project, the age of our ewes was a little bit older. Shortening of the generation interval by using the ewe lambs has allowed me the opportunity to class out the older ewes where their ASBVs were not as good.

3. Mixing and learning from other breeders.

Using the tools

The DNA Project has provided the opportunity to identify full pedigree across age groups and to utilise breeding selection tool such as MateSel.

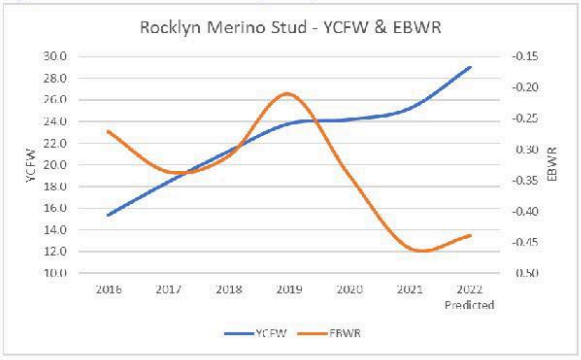
"MateSel has given me more flexibility with ram selections and choices for example if there are rams that might be higher in the micron or haven't got the growth rate, we can use MateSel to match with complementary ewes that will improve the predicted performance of the progeny, this is also translating into actual outcomes. Producing a more even line of progeny (correctively mating)."

How might you use MateSel in the future?

"*At the moment we are trying to lift the level of the whole flock. One thing I am finding it harder to do is source rams and so I am looking at going to a more complementary mating using MateSel, to mate high performing rams to high performing ewes and construct higher performing sires in the medium to long term."*

The output from the MateSel prediction (2022 joining) was an average DP+ of 188 where 850 ewes and 13 sires were used. Figures 1 and 2 show the trajectory for YCFW, EBWR and DP+.

Figure 1 – YCFW & EBWR Trajectory



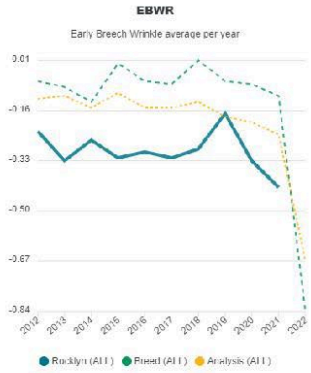
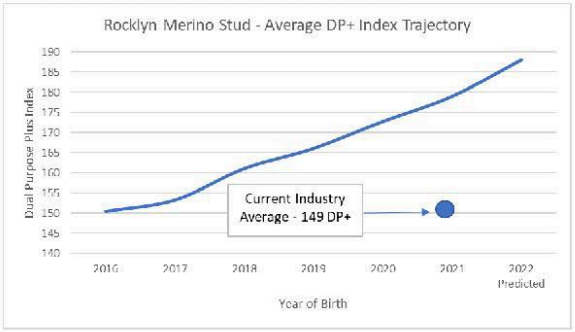
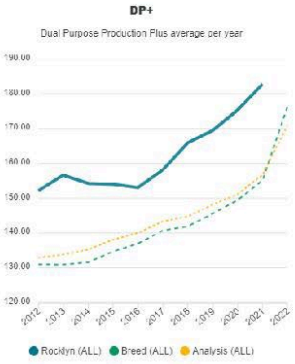
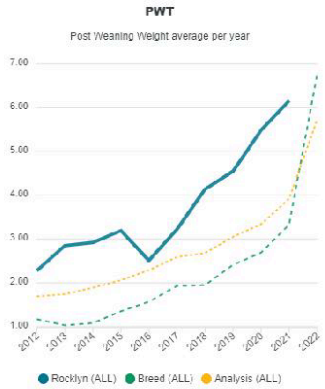


Figure 2 – Dual Purpose Plus (DP+) Trajectory





"MateSel has provided the opportunity to strategically mate ewe lambs where we are not only focusing on early growth but also the wool traits, to have a product that will withstand the extremes in weather for example in dry years not too much dust penetration and the wetter years not having too much (or any) fleece rot or weather stain. Trying to get the balance right by using all the figures."



MateSel was also used this year to increase the POLL status. The ewes were split into 2 groups – PP and PH & HH. There was one HH ram and he was only allowed to mate with PP ewes. Of the 20 selected sires 9 were PP, 10 PH and 1 HH. The current ewe (dam) POLL status is captured in the table below.

YOB	Dam POLL Status				
	HH	PH	PP	Unknown	Total
2012	1				1
2013	2				2
2014	10	6			16
2015	37	25	2	2	66
2016	24	23			47
2017	27	47	8	4	86
2018	54	87	18	2	161
2019	65	107	15	2	189
2020	56	154	66	6	282
Total	**276**	**449**	**109**	**16**	**850**
%	**32%**	**53%**	**13%**	**2%**	

The POLL status of the ewes and sires were combined to generate an estimate of the potential PP PH and HH progeny. Based on Table 3 there is an 8%, 27% and 62% chance of having HH, PH and PP progeny respectively from the 2022 joining.

Table 3 – predicted POLL status of the 2022 drop progeny

Predicted POLL Status ratios	Count Progeny	Group %	Chance of HH	Chance of PH	Chance of PP
100% PH	266	31%			266
100% PP	42	5%		42	
25% PP & HH; 50% PH	134	16%	33.5	33.5	67
50:50 PH:HH	77	9%	38.5		38.5
50:50 PH:PP	315	37%		157.5	157.5
Unsure	16	2%			
Total/Percentage	850		8%	27%	62%

Significant financial investment – do you think the investment has been worthwhile?

"Yes, looking at the genetic trend for the various traits and how they have improved and the goals that I had set are being achieved and also with the DNA testing we are able to join syndicates of rams to ewes and have the full pedigree of the progeny with the AI backups for example."

Do you feel you have achieved the goals you set out at the beginning of the project?

Yes, I was looking at the breeding objective that was set out at the beginning of the project and the time span that we thought it would take, for example 5 years down the track, and we have achieved a lot of those goals in 2 years. I have noticed just in the last 2 years with the flocks genetic trend how growth rate, eye muscle depth are really starting to climb now, using the genomic tests, cutting down on the generation interval."

Call to action

"Farming is a business so having more profitability for myself and my clients, focussing on good fertility and high fleece weights, and enough flexibility in breeding program for clients who might want to go to a 6 month shearing operation (staple length is there), go non mules (the sheep are plainer), I am lowing the micron at the moment (they can select the finer end of the rams to they will be able to capture the micron premium of 18.5 micron or less); high growth rates they can turn their wethers off as lambs earlier or join ewe lambs you can do that. The main thing is to provide the flexibility for people."

"Using ASBVs – what are you seeing translate into your commercial flock? We are seeing the emphasis that we place on post weaning weight in the ram breeding enterprise is translating into being able to turn wethers off earlier in the commercial enterprise, we are able to turn off the wethers before the ewes start lambing which helps with the stocking rate, if the wethers are out of the system before the ewes start lambing."

b. Scott Brien – pedigree and data quality

https://youtu.be/R8cTrHvtqEw

Scott & Anna Brien, Bella Lana Merino Stud, Dripstone NSW

#dataquality #matesel #breedingobjective

Scott and Anna Brien live near Dripstone, Wellington NSW and run 800 stud ewes and 4,200 commercial ewes on 2,800ha of mix farming country with his wife Anna and two of their daughters Jane and Hannah. The Brien's main farming operation is grazing Merinos (stud and commercial) with some opportunity cropping (400 ha).

Introduction

Scott's breeding objective for the ram breeding program – easy care Merino with early growth and eye muscle. *"We have been breeding rams since 2006. Breeding non mules sheep for the past 12 years, important traits for us are low breech and body wrinkle with crimpy white wool that has long staple for 6 monthly shearing,* ***we are looking for a true balance in our sheep****, we don't want one trait out weighing the other, focusing on profitability and being easy care."*

The Brien's have been 6 monthly shearing for 9 years. The main reasons for moving from 12 to 6 monthly shearing was to increase cashflow during the year – *"it was a long time to wait between wool cheques with 12 monthly shearings"*. There are also non direct financial benefits seen for example – *"there are a lot of traits that you don't see the financial benefits for example, the sheep do better with the wool off them, the financial benefits is that they rear more lambs and have less parasites in our country"*.

What did you want to get out of the project?

What were some of your frustrations before you got involved with the DNA Project? Scott *"Every year, before we got involved with Sally Martin and the DNA Project, was a frustration, we thought our ASBVs were going to improve, we thought we were using better rams, we thought we were joining them to the right ewes, but we were only guessing, we didn't have the data on all of the sheep, to get that scientific side of it right."*

Since being part of the project what are the main things that you saw you would get out of it? Scott *"We just jumped at the opportunity to be involved in the DNA Project, we could see that we had been treading water and we needed answers and this was one way of getting the answers and getting involved around like minded people and professional people who could help us as well."*

As a result of the DNA testing and the full pedigree are you seeing more accurate ASBVs? Scott *"We are definitely getting more accurate breeding values, our breeding values have gone through the roof in the last few years"*.

Going from just DNA parentage testing the ewes at the beginning of the DNA Project to now 50K Genomic testing all of the ewe progeny each year was as a direct result of the small price difference ($3.75) between the two tests. The benefits of having more accurate ASBVs on the ewe and ram lambs provides a great deal more confidence when making lamb joining decisions.

Outcome and key learning from the DNA Project

"The key learnings for me from the DNA Project have been that you have to collect data when you should collect data; we needed to employ someone who could handle the data properly and take us a step back from it; and the fact that we could use the science behind Sheep Genetics by having parentage and genomics on the ewes and rams."

- Collecting data at the right time
- Collecting data on the traits that are in the breeding objective
- Getting assistance to manage the data
- Using technology such as DNA Parentage and Genomic testing
- Having full pedigree to be able to utilise the tools provided by Sheep Genetics, including Australian Sheep Breeding Values (ASBVs) and MateSel

Did you achieve your goals set at the beginning of the project?

"We have been able to achieve our goals, it has blown me away in what we have been able to achieve in 5 years, it has exceeded what I thought would happen. It has shown me that we were lacking in the scientific area, we now have that and the visual selection on board and we are seeing improvement in both areas, and we are able to identify those better sheep and improve our flock each year now."

A Team Approach

Scott feels very fortunate to have a great team around them, Scott has his wife Anna who is always keen to progress the business, Anna does all the book work and PR for the stud. Two of the three daughters (Hannah and Jane) who are very keen to come back to the farm and are becoming more actively involved in both the stud and commercial operation.

The Brien's have formed some great partnerships with Sally Martin (SheepMetriX) and her team along with Tom Granleese (NSW DPI) through the DNA Project, both have been very generous with their knowledge "great to be hooked up with them" along with Brad Wilson from Nutrien, who is a great help and support to our operation.

Using the tools

The Brien's through the UNE/MerinoLink DNA Stimulation Project have embraced new technologies including DNA Parentage and Genomic testing to capture full pedigree. The DNA testing started back in 2018 where the Brien's tested the 2018 drop and all the potential sires and dams under the DNA Project 50:50 funding arrangement. The Brien's saw the benefits of capturing full pedigree and have been fully funding their DNA testing since.

"*Initially we were DNA Parent testing the female progeny and 50K Genomic testing the male progeny. We have since moved to fully 50K Genomic testing the female and male progeny as the price moved closer together and we wanted to be able to select ewes and rams at an earlier age. Reproduction is also an important trait that we hope to gain benefits from the genomic testing with as well."*

Now that the ram breeding flock has full pedigree it has opened up the door to utilise MateSel, a software

"We have used MateSel for the 2021 and 2022 joinings at Bella Lana we went into it with open eyes, having used the tool for the first time in 2021. It is another tool, if we don't agree with it, for example the type of ram it might allocated to a ewe if we don't agree we can over ride the selection as we visually assess each mating allocation. When we look at the predictions of what MateSel said we were going to do, the progeny performance did exactly what MateSel predicted which is amazing and has given us greater confidence in the genetic tools. We need now to be more professional in the way we use it and try and drive areas harder and not just start doing this a month before joining, we need to do this 6 months out to really drive the system and flock harder and further forward."

MateSel Predictions

The Brien's have used MateSel for the past two joinings (2021 and 2022) as a direct result from having full pedigree through DNA testing and the desire to maximise their genetic gain by utilising all the tools available. In 2022 the breeding program included joining ewe and ram lambs. Groups were set up within MateSel to maximise genetic gain while managing inbreeding and accounting for the age of sire and dam combinations (shown in Figure 1). Figure 2 shows a screen shot of the MateSel analysis.

MateSel and DNA POLL test results have also been used to speed up the transition to POLL for many flocks. By grouping the ewes and rams according to their POLL status for example PP, PH or HH and overlaying this element whilst still aiming to improve genetic gain has decreased the wastage of horn progeny. Table 1 shows the predicted outcome of POLL status for the 2022 drop, there is a 6%, 48% and 45% chance of having HH, PH and PP progeny respectively from the 2022 joining. (Note at the time of printing the actual outcome was not known).

Figure 1. Sire and Dam group allocations – 2022 joining

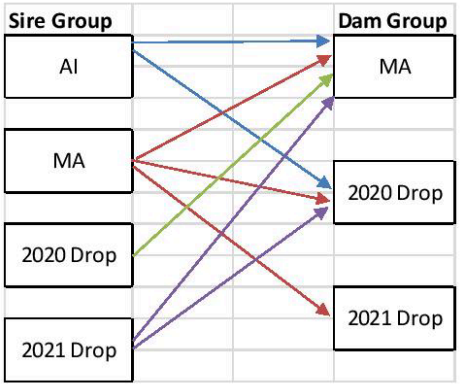


Figure 2. Screen shot of MateSel analysis

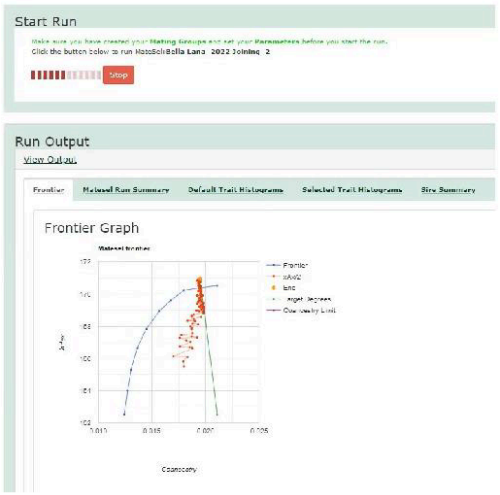


Table 1 – predicted POLL status of the 2022 drop progeny

Predicted POLL Status ratios	Count Progeny	Group %	Chance of HH	Chance of PH	Chance of PP
100% PH	143	11%			143
100% PP	261	20%		261	
25% PP & HH; 50% PH	210	16%	52.5	52.5	105
50:50 PH:HH	47	4%	23.5		23.5
50:50 PH:PP	631	49%		315.5	315.5
Unsure	8	1%			
Total/Percentage	1300		6%	48%	45%

MateSel Summary

The output from MateSel predicted an average DP+ of 169 where 1300 ewes and 24 sires were used. Figures 1, 2, 3 and 4 show the trajectory for YCFW, EBWR, YEMD, YFAT, DP+ and MP+.

Figure 1 – YCFW & EBWR Trajectory

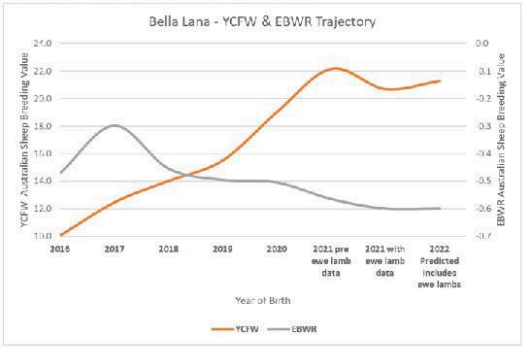


Figure 2 – YEMD and YFAT Trajectory

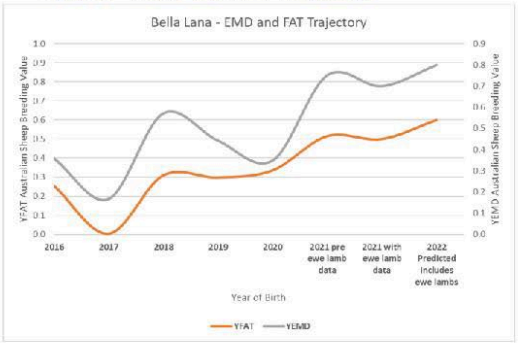


Figure 3 – Dual Purpose Plus (DP+) Trajectory

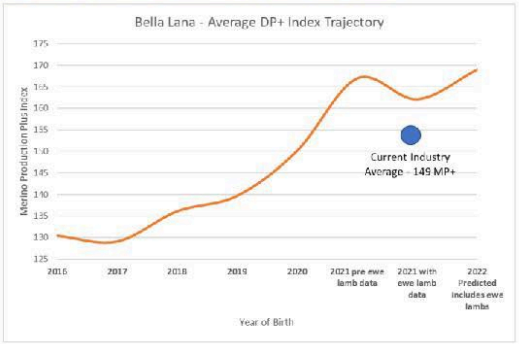
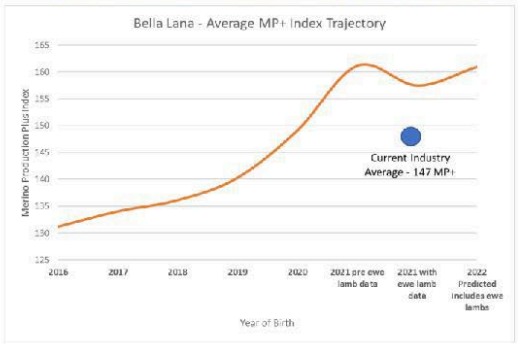
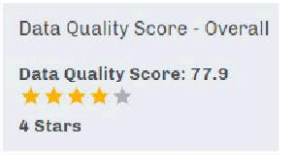


Figure 4 – Merino Production Plus (MP+) Trajectory



Data Quality

The Brien's have worked progressively to improve their data quality and now are able to use the Data Quality Score and report generated by Sheep Genetics to continue to improve the accuracy of the ASBVs.



The Data Quality Score (DQS) is a single combined score for a flock, evaluating data from the last 5 years. This score is provided as a value out of 100, where the higher the value the better the data quality, and as a star rating that reflects the range in which **Bella Lana** score fits. For example, a 4 star rating refers to a DQS that sits between 60 and 80, out of 100.

Data Quality Score: Ranges from 0 to 100, where flocks with higher scores have better quality data.

DQS Star Rating: Star rating from 1 to 5, where 5 star rating flocks have better quality data. Star ratings are allocated depending on the score. 1 star: Score 0 – 20, 2 star: Score 21 – 40, 3 star: Score 41 – 60, 4 star: Score 61 – 80, 5 star: Score 81 – 100.

DQS Distribution: This graph shows you where **Bella Lana** sits compared to other flocks. The graph also indicates the distribution of other flock's scores – how spread out the scores are and the number of flocks for each given star rating (shown in different colours)

c. Dugald Campbell – ram selection

https://youtu.be/6kzWKvOQ8m0

Dugald Campbell, Burrendong Station, Wellington NSW

#ramteammanager #ramselect #commercialramteam

Dugald Campbell with his brother Lachlan run Burrendong Station near Wellington NSW. Dugald runs 7,000 Merino ewe self replacing flock on X ha and is passionate about his breeding program. In some years there may be opportunistic joining to other breeds, however 90% of the time it will be Merino to Merino.

Introduction

"Over the last 4 years we have been tracking our ram team using the RamSelect Ram Team Manager, a lot of our rams dropped out because they were not meeting the criteria of our breeding goals so then with Sally we started to select rams, using the benchmark of the RTM out of the sale catalogue at Bella Lana to help me lift traits to meet my goals. Over the 4 years I have found that the growth and improvement in the traits has been quite dramatic."

What did you want to get out of the DNA Project?

Through an introduction to the project from his ram source, Dugald was interested in testing his young ewes with the Flock Profile to benchmark where they sat for fat, eye muscle and staple length. *"The project provided an opportunity for us to track our progress over the past 4 years and our ram selection strategies have changed dramatically because of that."*

Outcome and key learning from the DNA Project

"The rams I was selecting initially, before the DNA Project, that I would have inspected at a sale, I no longer look at, I don't waste time on animals that I thought would be good because they looked good in the wool, I had no idea that when I took the jacket off them if they would be any good. So now I am finding out with the use of Sally Martin and her team I can go into a ram sale and quickly identify my 30 or 40 rams out of the 150 that I need to spend time on, not the rest, which is massive for me and also helps to focus on my goals and the rams that will help me move forwards."

"The DNA Project included annual workshops which provided an opportunity to share with the other likeminded participants the direction and plans moving forward, this forum was a good place to bounce ideas and test the water."

"The next step for our Merino breeding business is making sure that I am getting the right wools on the sheep and that they survive and grow. We need a balanced approach because when we get extreme conditions, issues come quickly."

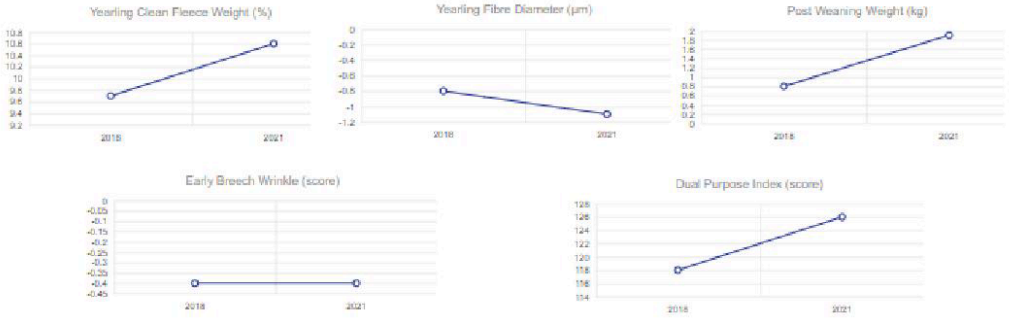
What do you do differently as a result of the project?

"The project has helped me do things like early joinings, eg ewe lamb joinings, it has helped me grow my young ewes out faster to be able to get them to joining weights. Things that my father dreamt about achieving we are achieving. And you can see this across the Merino industry. We are focusing on lamb survival which is very important to our business.

We stopped mulesing 5 years ago – to put it into context my father was a mulesing contractor (brought up with mulesing), a major change for the mindset, however definitely I am glad we stopped."

Using the tools

Flock Profile – The DNA Project introduced the Merino Flock Profile and allowed the Campbell family to gain a benchmark for traits such as growth, fleece weight, micron, fat, eye muscle and breech wrinkle. To Flock Profile tests were conducted on the 2018 and 2021 drop lambs. The initial Flock Profile gave an indication of the genetic merit of the Campbell's flock. The two Flock Profiles can be used to provide a genetic trend as seen in the graphs below. The Flock Profile provides a benchmark of the genetic merit of the ram team used 5 to 7 years ago.

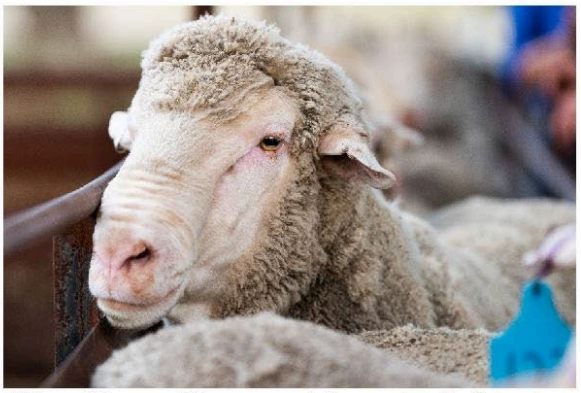


During the project Dugald also monitored his ram team using the RamSelect Ram Team Manager tool. This tool complements the Flock Profile in providing a prediction of where the genetic merit of Dugald's flock will be in 5 to 7 years time.

- Ram Team Manager

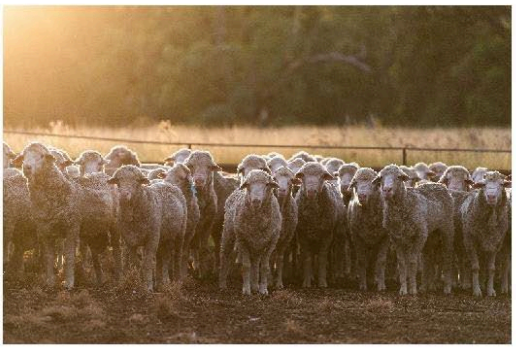
"Over the last 4 years we have been tracking our ram team using the RamSelect Ram Team Manager, a lot of our rams dropped out because they were not meeting the criteria of our breeding goals so then with Sally Martin we started to select rams, using the benchmark of the RTM out of the sale catalogue at Bella Lana to help me lift traits to meet my goals. Over the 4 years I have found that the growth and improvement in the traits has been quite dramatic.

Ram buying strategies



As a result of the DNA Project ram purchasing strategies were discussed at each annual project workshop. The commercial ram buyers breeding objective and current ram team benchmark provided a benchmark to then set targets to improve key traits in the breeding objective and focus on improving the ram team year on year.

"The rams I was selecting initially, before the DNA Project, that I would have inspected at a sale, I no longer look at, I don't waist time on animals that I thought would be good because they looked good in the wool, I had no idea that when I took the jacket off them if they would be any good. So now I am finding out with the use of Sally Martin and her team I can go into a ram sale and quickly identify my 30 or 40 rams out of the 150 that I need to spend time on, not the rest, which is massive for me and also helps to focus on my goals and the rams that will help me move forwards."



The ram buying strategies have paid off for Dugald Campbell, who initially focused on improving early growth in his lambs, *"We want to lambs to hit the ground running and compete with the meat sheep. We are getting to the stage now where we are finding our lambs are much more saleable at a much earlier stage which helps us a lot to take the pressure off our grazing country earlier".*

"In the last couple of years we have been able to turning off wether lambs earlier, and I am finding now that I can actually sell my wether lambs off their mothers because they 25 to 30kg lambs they are an easy sale."

What is the next challenge?

What do you see the next challenge for your business? *"The challenge for our business, there are two things, when you get a wet year like we have, we can not only focus on the ASBVs for eye muscle, fat and early growth, we have to also focus on making sure we have the right "skins" on our sheep to manage the wet conditions so as to manage fly strike and animal welfare."*

d. The DNA Project – capture engagement

Written provided, video to come

UNE/MerinoLink DNA Project – Case Study – The DNA Project

Introduction

The DNA Project is a collaborative project between the University of New England, MerinoLink Limited and Meat & Livestock Australia. The Project Team consisted of Dr Tom Granleese NSW DPI, Sally Martin SheepMetriX and Professor Julius van der werf UNE and great support from Sheep Genetics and AGBU staff.

The Project has evolved from cheaper DNA testing through to working with the 80 producers who were part of the project in workshop activities and one on one coaching. The project involved annual workshops over the 5-year duration of the project. A big part of the project has been the peer-to-peer learning, not only with the producers involved but also the service providers.

Sally Martin, SheepMetriX - *"At the final workshop in Wagga Wagga we were able to show case the producers that have been part of the project. Each workshop we had a number of the producers share their experiences, warts and all, the open and frank conversations was fantastic and another attribute to generating trust and peer to peer learning."* Sally Martin

Sally Martin, SheepMetriX - *"The subsidised DNA testing was only in the first year of the project and something that is really important is that since that initial support in the first year the breeders involved in the project have been funding 100% of the DNA testing themselves, they really have skin in the game and this has also been part of the adoption of this technology and how they have then been able to utilise it in their own breeding programs which has been fantastic."*

Major learning from the project

Tom Granleese, NSW DPI - *"By being able to set up a network of breeders, service providers and scientists all collaborating together they have been able to foster an environment to share and learn and that has translated to better breeding program design and higher rates of genetic gain. The more engaged people are the better the job that they are doing in regard to their breeding program design. One of the major outcomes of the project has been not only upskilling of a lot of service providers and breeders both at the stud and commercial level we have also seen the rate of genetic gain increase by 134%. This increase in gain is filtering through over 2 million commercial Merino sheep and that means that we are breeding more productive and profitable sheep on farm."*

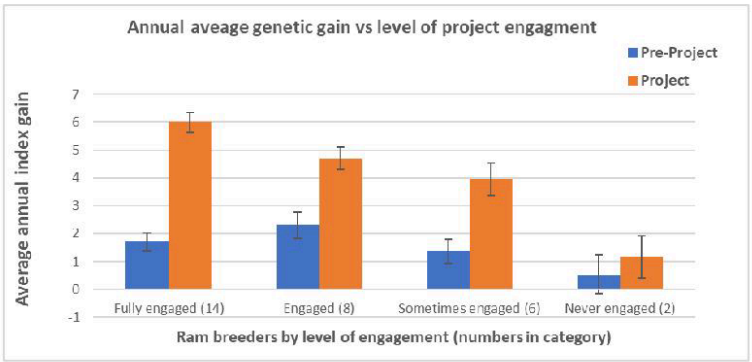


Figure 1: Blue bars represent five-year average annual genetic gain (2012-2017) pre-project and orange bars represent three-year average annual genetic gain (2017-2020) during project for studs grouped by project engagement. 1 – Highly engaged: attends all workshops, calls project leaders, asks for one-on-one meetings; 2 – Engaged: Attends most workshops and/or some extra meetings; 3 – Sometimes engaged: Sporadic attendance to workshops, rarely uses extra opportunities; 4 – Never engaged: Do not turn up to any workshops or extra activities

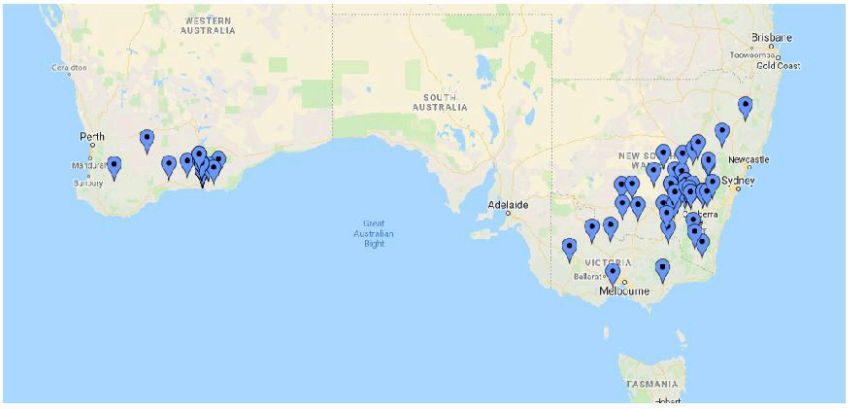
Peter Bradley, Sheep Genetics – *"The benefits from the DNA Project have been two fold, firstly it has been a fantastic professional development for the new staff within the Sheep Genetics team to be able to work closely with some very large scale ram producers to improve data submission and selection. It has also been really good from an industry perspective that we have been able to see rates of gain and not just for indexes or key production traits but also how breeders breeding objectives have shifted to incorporate new traits such as health and welfare traits and the gains that have been made in areas such as breech wrinkle through the power of recording and then selecting for that trait."*

DNA Project Participant locations

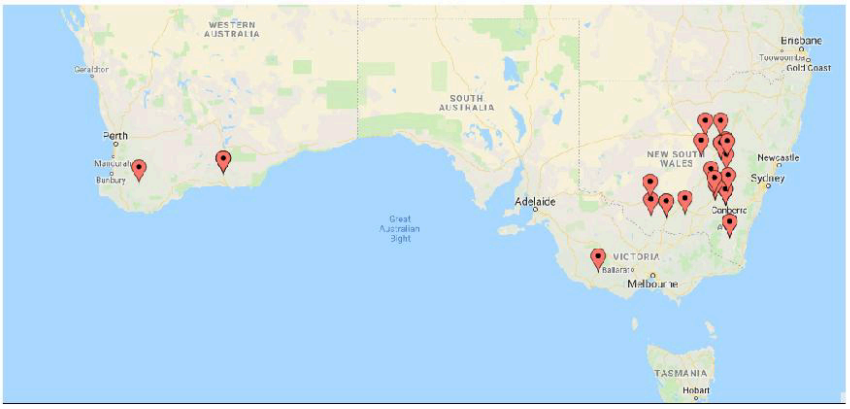
The project participants covered a large geographic area within NSW, Victoria and Western Australia. There was a large cross section of breeders involved in the project from breeders just starting to collect data to breeders that had been using ASBVs for over 30 years.

Colin McCrabb, Avenel Poll Merinos – "*When we enrolled in the DNA Project we had just started our poll Merino stud and we had no breeding values, data or any pedigree so we started with a clean slate. We used DNA for parentage and getting good quality data to generate breeding values to then provide to our clients with ASBVs as quick as we possibly could. We are well down the track now with good data, linkage with sires outside our stud, so I feel we are progressing along well, not as quick as some others who are further down the track, but we started from a very low base."*

Commercial breeders



Ram breeders



Lifting the accuracy

Anthony Close, Kurra Wirra – *"What did we want to get out of the DNA Project, was mainly around trying to lift the accuracy of our animals, we have had a long depth of pedigree for a long time but trying to get a better grasp on some hard to measure traits. We were already getting full pedigree and we were looking to take the accuracy of our data to the next level genomics and DNA testing was a really good fit to try and make sure that the top end of the sire selection and the ewes we were keeping in the stud were the best ones, spreading that bell curve on our genetic profile of our flock."*

By the end of the project the ram breeder group's Merino Production Plus index accuracy was 5% (or 15% comparatively) higher compared to the rest of the database (Figure 2).

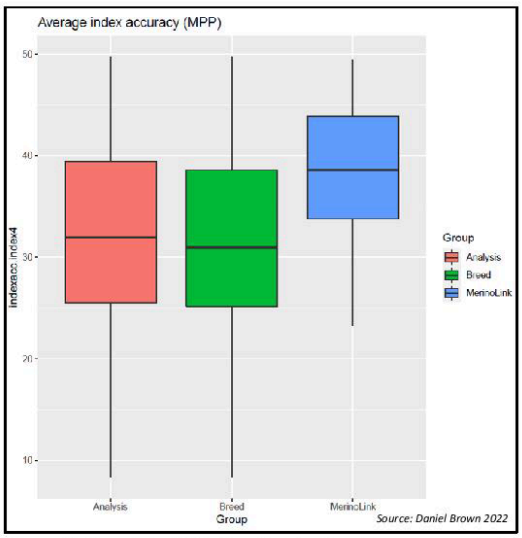


Figure 2: Boxplot of Merino Production Plus economic index accuracy of Merino Select database excluding ram breeder group (red), "medium" type Merino (green) and DNA project ram breeder group (blue)

Adoption of new technology

Daniel Brown, AGBU – *"This is an interesting project in that it brings a range of benefits to the group and also to the scientists involved with the group. The project originally started out as using new technology and working together to get access to cheaper technology (eg DNA Testing) and apply it in their breeding program. With that has come some structured learning and development individually and as a group, so with that having a support network with Sheep Genetics, myself (Daniel) and Tom Granleese as well as service providers like Sally helping them through the journey, and so we all learnt from each other and helped each other through that journey and the outcomes from working together has been quite rewarding for the individuals and the group. From an industry point of view commercial ram buyers now have access to better genetics for a wide range of traits because they have all worked together to get better outcomes."*

Number of DNA tests

Rick Baldwin, Bundilla Merinos – *"The DNA Project has not just been an investment into our operation but it is an investment into the industry. Without a doubt we have seen a return on that investment and I think the market is asking for more information and genomics provides more information. It has allowed us to have great scale and produce a lot more high quality high value animals."*

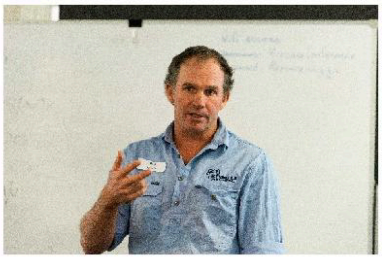


Table 1: Number of genomic tests and TSUs project funded or self-funded through the life of the project

	Parent Test	15k/50k Tests	Flock Profile	TSUs*
Project Funded	57,311	14,502	119	74,193
Self-funded	35,357	89,523	9	115,090
Total	92,668	104,025	128	189,283

*Note: bloodcard numbers were not captured during the project as they were provided free by the Sheep CRC.

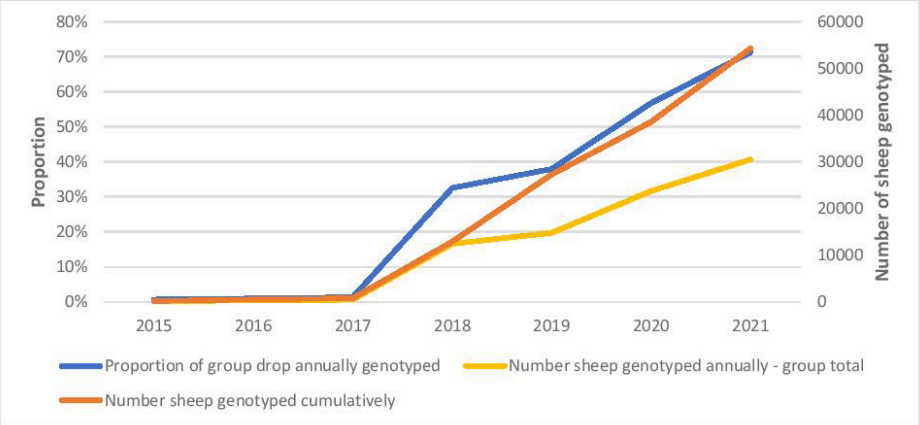


Figure 3: Number of sheep low-density genomic tested leading up to and then through life of the project

New traits – welfare

As a group, the ram breeders decided that mulesing would become a forced welfare issue. Many breeders within the group took it upon themselves to start measuring and selecting for flystrike indicator traits. Traits included early breech wrinkle, body wrinkle, breech cover and dag score. Figure 4 demonstrates that at the beginning of the project (2000-2018) the group had only collectively measured 28,649 early breech wrinkle records. In the three years after the group collectively increased their total number 84,551 records, or almost 200% increase. The group now have contributed 37% of the early breech wrinkle records to the Merino Select database. With extra measurements being made across a wider genetic base, coupled with selection meant that the spread of genetic merit (horizontal axis of Figure 4) was much larger than 2019. This allows faster genetic progress to be made for this particular trait. Similar trends were observed in the other traits mentioned in this section.

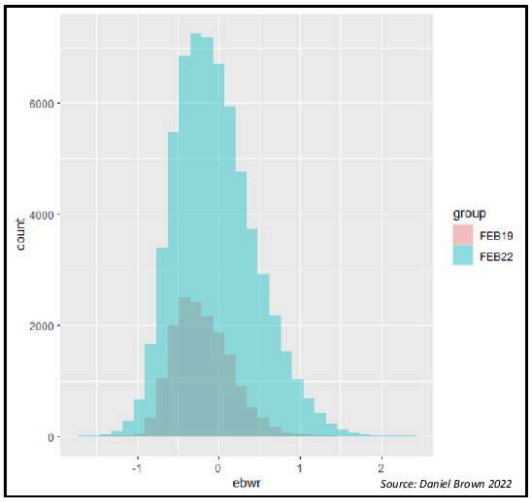


Figure 4: Histogram of spread of early breech wrinkle ASBVs within the ram breeder group in 2019 (pink) and by the end of the project (blue)

Project conclusions

Rates of genetic gain were measured in two five-year periods. From 2012-2017 was counted prior to the project starting while drops 2018-2021 were included in the project period. Overall, in this period the ram breeders as a collective group increased genetic gain by 134% (Figure 5).

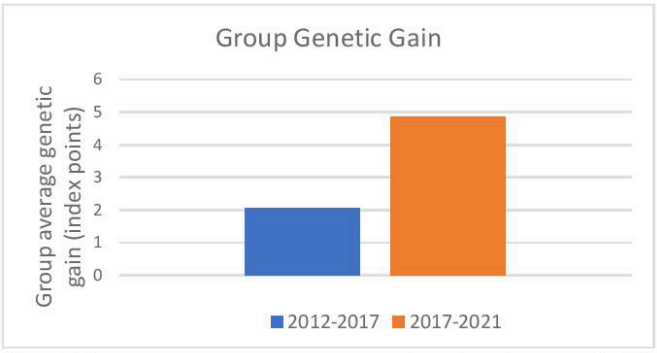


Figure 5: Ram breeder group average annual genetic gain pre-project (2012-2017) compared to genetic gain during project (2017-2021)

Peta Bradley, Sheep Genetics – *"One of the highlights of the project is that it has not been a one way street, it is two way communication. The workshops have been fantastic to hear the practical on farm considerations that producers are having to consider when making selection decisions or decisions on what traits to record and then being able to have input from a technical perspective, so it has been two way communication which has been a real strength – not only breeders but also service providers and other consultants working with the industry, it has been an awesome project to be able to capture so many different facets and work together as a whole."*

Sally Martin, SheepMetriX – *"There is a great future in the Merino industry with the capacity that we have now. With the data quality improvements and genomics, the group are now contributing close to 40% of the current genomic tests that are being done over the past 5 to 10 years, which is a significant contribution."*

e. Project agreements

MerinoLink & UNE DNA Project Agreement _Commercial Breeder

First Name: _____

Surname: _____

Property Name: _____

Address: _____

Town: _____

State: _____ Post Code: _____

Postal Address: (only if different to above) _____

_____

Phone: _____ Mobile: _____

Email: _____

Agreement to participate in the MerinoLink & UNE DNA Stimulation Project

I agree to participate in the MerinoLink & UNE DNA Stimulation Project, contributing 50% of the project funding that relates to my component of the project. I understand that the project is a 50:50 funding arrangement with the Meat & Livestock Australia Donor Company.

I agree to collect DNA samples from a random selection of the 2017 and 2021 ewe progeny and submit it to the Sheep Innovation Company, formally the Sheep CRC via MerinoLink Limited. I agree to participate in the projects breeder workshops and to actively engage with the project program to endeavour to achieve the aim of the project, to double genetic gain by 2022.

I agree to allow Sally Martin (MerinoLink) and Tom Granleese (University of New England) access to my Genomic Flock Profile results and production data provided as part of the DNA Stimulation Project whilst maintaining my confidentiality.

Name (print): _____

Signature: _____

Witness Signature: _____

Witness Name: _____

Date: _____

MerinoLink & UNE DNA Stimulation Project Agreement _Ram Breeder

First Name: _____

Surname: _____

Property Name: _____

Address: _____

Town: _____

State: _____ Post Code: _____

Postal Address: (only if different to above) _____

_____

Phone: _____ Mobile: _____

Email: _____

Service Provider: _____Mobile: _____

Agreement to participate in the MerinoLink & UNE DNA Stimulation Project

I agree to participate in the MerinoLink & UNE DNA Stimulation Project, contributing 50% of the project funding that relates to my component of the project. I understand that the project is a 50:50 funding arrangement with the Meat & Livestock Australia Donor Company.

I agree to collect DNA samples to be used strategically for DNA Parent; Horn/Poll and Genomic 15k testing and to be open to utilising the current tools the DNA Stimulation Project is suggesting. I agree to participate in the projects breeder workshops and to actively engage with the project program to endeavour to achieve the aim of the project, to double genetic gain by 2022.

I agree to allow Sally Martin and Dr Tom Granleese access to my flock information via Sheep Genetics to generate RAMPing Up Genetic Gain Reports (including but not exclusive to - database counts; genetic trends; sire summaries; individual listings; exclusion listings; linkage report; percentage recorded; selection efficiency; generation interval; reproduction summary; pedigree queries and issues; genetic diagnostic reports) and production data provided as part of the DNA Stimulation Project. All data, information and reports will be kept confidential and will only be used for the purpose of the DNA Stimulation Project.

Name (print): _____

Signature: _____

Witness Signature: _____

Witness Name: _____

Date: _____