Hybu Cig Cymru/Meat Promotion Wales
Livestock Scholarship Report 2014

Genetic selection for lamb meat yield and quality in New Zealand and Australia

Written by: Eleri Margaret Price

Executive Summary
This is a report to Hybu Cig Cymru/Meat Promotion Wales after the completion of a Livestock Scholarship 8th January – 20th February 2015 by Eleri Price.

Sheep meat is a priority source of income for the Welsh agricultural sector (especially with the decline in the wool industry). With Australia and New Zealand as global leaders in sheep meat production, it was deemed essential that further investigation was needed in the area of genetic selection of lamb meat yield and quality traits. The objectives of this scholarship include how is meat yield and quality measured and how are they adopted within industry.

Key findings

- New Zealand and Australian abattoir/processors had different grading structures based upon the range of technology being used to measure meat yield including X-Ray, and video image analysis. With the standard meat yield measurement being carcase weight and GR fat score (ruler measured fat depth 10cm down from 12th rib).
- Meat quality was measured more frequently in beef than lamb.
- In New Zealand, BeefEQ was a processor based programme that rewards farmers on meat quality based upon when meat quality trait thresholds are obtained.
- Meat Standards Australia (MSA) was an Australian based beef supply chain programme that aims to optimise meat quality by grading individual carcase cuts. Research was underway to extend this programme into the lamb meat industry.
- It was found a balance was needed when breeding for meat yield and meat quality. As breeding for carcases with higher lean has reduced fat content which impacts upon meat quality.
- Progeny testing allows for a wide range of traits to be measured that represent the whole industry and provides processor/consumer information feedback to the farmer/breeder (plate to paddock).
- Genomic research was being researched and applied in combination with estimated breeding values in the New Zealand and Australian sheep industries.

Future development opportunities for the Welsh meat industry include:

- Research and/or adoption of modern processing technology (X-ray, VIA).
- Increase data flow throughout the supply chain.
- Measures and incentives to produce better meat quality.
- Genetic based projects linking to lamb meat yield and quality (including phenotypic recording, progeny testing and genomic techniques).

The New Zealand and Australian sheep industries, although different, have similar goals. A future target of the Welsh sheep industry, should be to measure meat yield and quality accurately. Meat quality is a whole industry responsibility and as such measurement and developments for improvement need to occur throughout the whole supply chain.

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1.0 Background

My name is Eleri Price and at the time of the scholarship I was undertaking a PhD at the Institute of Biological, Environmental and Rural Science (IBERS), Aberystwyth University. I divide my time between Aberystwyth and my home which is Beiligwern Farm. Beiligwern is a dairy and sheep enterprise situated in Crai (Sennybridge) which lies within the Brecon Beacons National Park. Alongside farming, my father and brother also run a sheep shearing, contracting business. I am also an enthusiastic member of Sennybridge Young Farmers Club (Figure 1).

I have always had a keen interest in the food and agricultural industry. I studied an Animal Science degree in Aberystwyth University. After this I worked for Innovis Ltd (a sheep genetics company) for 2 years as a Livestock Technician, helping with the day to day management of the nucleus flocks.

At the time of the scholarship I was undertaking my PhD in collaboration with Innovis, which is based upon the title: Incorporating carcase, eating and nutritional quality parameters of lamb into a genetic programme. This is funded by an EU grant called the Knowledge Economy Skills Scholarships (KESS). This project has led to a new breeding line of sheep which is bred for tenderness.

The aim of my scholarship was to experience first-hand, other world leading lamb meat industries (New Zealand and Australia). I wanted to observe the developing focus on lamb meat quality and to gauge what lessons can be learnt by the Welsh sheep meat industry.

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Figure 1. (left) Competing in a shearing competition at Brecknock Young Farmers rally. (right) Beiligwern Farm

2.0 Report

2.1 Introduction

The UK produces nutritious red meat from sustainable grassland production and can provide high meat quality. The UK produces the highest amount of sheep meat within the EU at 34% (324,000 tonnes in 2008; Hybu Cig Cymru, HCC, 2009). There is a need to understand how our international competitors are targeting lamb sales in the global market. Additionally how do other countries measure and ensure high meat quality standards of lamb.

The two biggest lamb exporting countries in the world are Australia and New Zealand. In comparison, the UK is a smaller country with a larger population. The UK produces a high amount of lamb and mutton meat for the size of its national flock (Table 1.1). Australia is a large continent with variable climate (the UK is 3% the land mass of Australia). New Zealand although a similar land mass, differs to the UK as it has an extremely high lamb export trade.

Table 1.1 *Comparison figures of agricultural challenges for the UK, Australia and New Zealand industry*

	UK	**Australia**	**New Zealand**
Land mass (km^2)	243,610	7,692,024	268,021
Area of farming land (million hectares)	17.2	405	14.3
Population 2013 (million)	64.1	23.1	4.5
Sheep (million)	14.8	72.7	30.9
Lamb & mutton (tonnes)	300,447	640,154	488,400
Exporting	40%	51%	95%
Meat export/global trade	9.2%	33.5%	35.1%

DEFRA (2015), Meatstats (2015), MLA (2015), Beef and Lamb New Zealand (2015)

Previous genetic selection for increased lamb growth and meat yield has been successful in the lamb industries. Breeding for meat yield and quality is a current goal.

2.2 Aims

1) Investigate the range of meat yield and quality parameters actively measured within the sheep industry.
2) Investigate how meat yield and quality information is applied in New Zealand and Australia industries.
3) Examine the relationship between the sheep industry, meat production companies and research initiatives.

2.3a Industry background of New Zealand sheep genetics

Figure 2. Mount Linton Station, maternal composite.

Beef and Lamb New Zealand (B&LNZ) is the meat levy board of New Zealand and plays an active role within the industry. Sheep Improvement Limited (SIL) is the national genetic recording company that provides estimated breeding values (EBV) for terminal and dual purpose breeds. New Zealand has a national flock of approximately 30 million sheep. Dr Mark Young (B&LNZ/SIL) estimated that 30,000 sheep would be SIL recorded. Data is confidential to the owner who can give permission to release the data. However the Sheep Improvement Limited Advanced Central Evaluation (SIL-ACE) provides data for farmers that want to compare rams in an all-breed comparison, which allows the best ram to rank first regardless of its breed. Both maternal and terminal sheep types record live weights, ultrasonic measured traits, worm faecal egg count and dag score. Additionally there are weighted growth and meat value indexes which are expressed in NZ dollars.

Figure 3. Focus Genetics, Texel ewes (Waikite Station).

New Zealand maternal breeds include the Romney, Coopworth, Border Leicester Perendale and Highlander. It is thought that the national flock could consist of up to 90% maternal composites, with terminal breeds consisting of 60% purebreds and 40% composites (Figure 2). With the majority of purebred terminals being Texel, Poll Dorset, Suffolk and South Down and composites such as the Primera, Lamb Supreme or Suffolk based crosses (Figure 3). There is low use of artificial insemination in the sheep industry in New Zealand. The majority of farmers visited were not loyal to a particular breed and were open to using composites/other breeds to improve their flocks.

There are large sheep breeding companies in New Zealand (e.g. Focus Genetics) but there are also commercial producers who have created their own terminal sire breeding flocks in addition to their main commercial flock (e.g. Mount Linton Station). Larger companies have increased resources enabling them to use advanced technologies to increase genetic gain. These include elite breeding rams being computer tomography (CT) scanned for breeding programmes, as CT estimated breeding value's (EBV) provide accurate predictions of body composition and so quicker genetic gain can be made (Figure 4). Also sheep are DNA tested for genetic markers related to production traits (e.g. LoinMAX™ and MyoMAX™). These markers have been researched and developed for commercial use at AgResearch, New Zealand. Further genotyping and DNA research is being carried out including relating SNP data with meat yield and quality data (Figure 4).

Figure 4. (left) CT scanner, (above) a blood DNA sample before being processed at AgResearch Invermay.

Large sheep breeding companies often have their own recording programmes and weighted indices, to enable them to target specific animal trait goals. Focus Genetics have developed their own (within company) indices, which correlate well with the SIL industry indices as explained by Dr Geoff Nicoll (Focus Genetics).

In New Zealand many farmers choose rams on looks/phenotype, with about roughly 30% choosing on recorded EBV's. Most rams are sold off farm, rather than in sales or auctions. Dr. Mark Young explained that an aim of SIL is to get more commercial producers using figures for ram selection and so they have produced a "Flock finder app", a tool to assist farmers in selecting rams, based upon EBV's and geographical location (Figure 5).

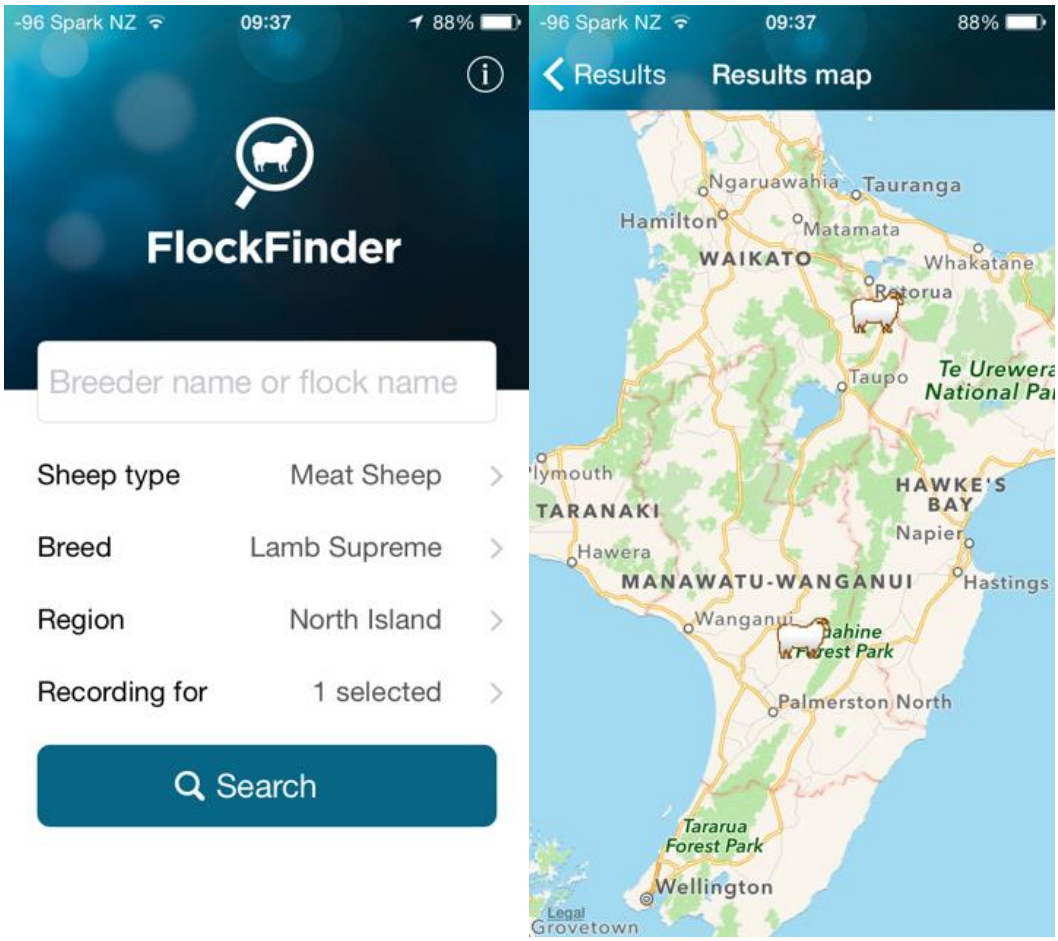

Figure 5. Flockfinder mobile phone and tablet app (images provided by Dr. Mark Young).

2.3b New Zealand carcase grading

New Zealand lamb producers are paid on carcase weight (target carcase weight of 16-21kg) and subcutaneous fat depth at the 12th rib (the "GR" measurement, target <15mm). Lamb carcases with excessive fat depths are penalised.

Interestingly each processor visited had a different payment structure. New Zealand's larger and innovative processors are testing/using more objective carcase yield measuring technology for accurate grading and increased efficiency. These measures can aid the processor payment structure. For example, Silver Fern Farms meat processor has aided the development of Scott's Technology, where CT scanning technology is used to assess the lamb carcase prior to cutting. Video Image Analysis (VIA) is used to assess meat yield in some New Zealand processors also (Alliance). Improvements could be made to Wales/UK based carcase grading systems by upgrading plants to use objective technology.

The New Zealand lamb industry seemed very adaptable, especially with clear market signals. Significant changes have occurred in the lamb market, where once the European chilled lamb was one of the biggest global lamb importers, now other market opportunities are available such as the Asian/China frozen lamb market. It was observed that many plants target a wide range of export markets and so processing and storage facilities have been adapted to facilitate this change (e.g. blast chillers and frozen storage of lamb within plants).

There were also new initiatives where abattoirs/processors were creating stable (strong) relationships with producers and producer groups, with educational open days. ANZCO a

meat processor, own a ram stud which breeds terminal sire rams for farmers that are part of their high-performing supplier group. This facility allows ANZCO to manage the supply base of lambs more effectively; thereby improving carcase quality and producing a stable volume of lamb.

2.3c New Zealand breeding for meat quality

As measurement of meat quality traits are destructive and therefore difficult to measure, progeny testing is needed. The Central Progeny Test based in New Zealand was set up in 2002 (as the Alliance Central Progeny Test) to assist with:

- Identifying high performing rams within the sheep industry,
- Build connectivity of ram groups,
- Develop genetic parameters (including new traits),
- Provide a genetic resource for additional projects and industry bodies.

Progeny are produced from rams across the whole of the country, with approximately 20 new rams tested every year. Farmers can then access breeding values in published lists of the best 25 rams for each production traits. Breeding values measured in the progeny test include live weight, ultrasonic traits, carcase weight, dressing percentage, pH, meat colour and fat colour. A recent development of the Central Progeny Test is the addition of two hill farms to help assess environmental challenges on the tested animal genetics. Currently in the UK a progeny testing project called Ramcompare is being developed, which could be a great asset for the Welsh/UK sheep industry.

Processors are also adapting to provide increased information for their farmers. The company FarmIQ assists in data sharing across industry bodies. FarmIQ works with Silver Fern Farms, who measure beef meat quality traits - pH, meat colour, fat colour, marbling score, ossification, rib fat depth and eye muscle area. In collaboration they provide a "Beef EQ performance report" for farmers. The report given to producers, identifies individual carcase meat quality and shows if the carcase met certain meat quality thresholds to gain premium payment. This assists farmers in making informed breeding decisions as they can identify stock of superior carcase quality (Figure 6). It is hoped that this system might be developed for the lamb meat industry to aid key market decisions on carcases and cuts.

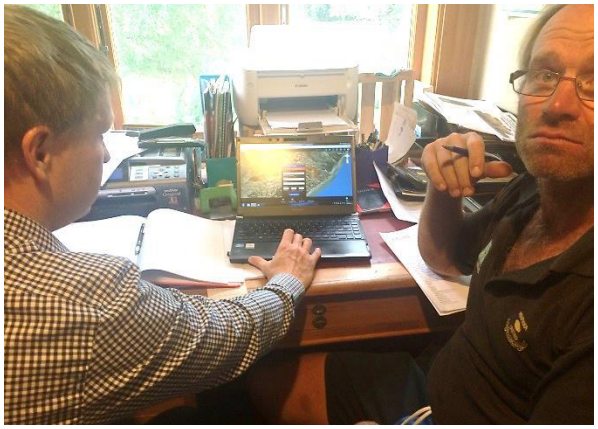

Figure 6. A FarmIQ demonstration by Garth Nielsen-Vold with beef and sheep farmer Phil Barnett.

2.4a Industry background of Australia sheep genetics

The Merino is the main sheep breed in Australia. The Australian sheep industry with a national flock of 70 million ewes, of these, 40 million are estimated to be Merino (with approximately 135,000 Merino's recorded). The Merino ewe has adapted to the harsh Australian environment and been selected for wool production (although some breeders that were met indicated that they were changing focus to yearling size). Merino's are either purebred (mainly for wool production), crossed with a Border Leicester (as a mule type cross) or crossed with a terminal sire (for the meat industry).

Figure 7. Katanning Regional Sheep Saleyards (largest undercover sheep selling complex in the southern hemisphere with 22,000 sheep (mainly Merinos).

The Australian lamb industry is the second largest lamb volume exporter (Figure 7). The industry is responding to an export market signal that the consumer wants lambs with larger carcase weights, larger eye muscle area and with less fatty meat. The main terminal sires used in Australia were the Poll Dorset and the White Suffolk breeds (Figures 8a, 8b and 8c). There were low numbers of Texel (<2000 recorded) and Charollais (<1000 recorded) sheep in Australia. There was also a visit to Murnong Farming who were breeding New Zealand composite breeds, the Highlander and Primera rams in Melbourne. In Australia there were 1.7 million sheep recorded, with about 37,000 DNA recorded including 14,000 sheep DNA recorded (by using the 50k, 700k and also the low density 12k chip).

Figure 8a. Poll Dorset - Arthur Gates (Pollambi steedstock stud) and Sam Lisle (Old Woombi stud).

Meat & Livestock Australia Limited (MLA) is the meat levy board, funded by industry. The MLA aims to deliver marketing, research and development services for Australia's cattle, sheep and goat producers. The Cooperative Research Centre for Sheep Industry Innovation (Sheep CRC) is an industry led research initiative. In 2007, the first Sheep CRC had an Information Nucleus Flock (INF) which is an example of a large scale progeny test. This MLA 5 year funded project chose 100 industry sires (based on their genetic diversity) and mated them to 5,000 ewes each year across 8 sites in Australia to collect phenotypic and genetic data. In the five years, 20,000 animals were recorded for more than 150 traits. This project was recently granted another 7 year investment to look at three major projects

including sheep wellbeing and productivity; sheep meat quality and faster affordable genetic gain. The Nucleus flock has been reduced in scale and is based at the two sites, and is now known as the MLA Resource Flock (based in Armidale, New South Wales and Katanning, Perth).

Figure 8b. White Suffolk yearling rams, Martin Oppenheimer (Petali stud)

The national genetic evaluation programme called Sheep Genetics, implements research, collates data and provides Australian breeding values (ASBV) for Terminal, Merino and maternal breeds (traits in Table 1.2). Animal Genetics and Breeding Unit (AGBU) runs the genetic analysis. The Resource Flock acts as a reference population that demonstrates genetic variation across the Australian industry and aids estimation of trait EBV for Sheep Genetics. Traits that are researched include difficult to measure traits such as carcase, meat quality (intramuscular fat, shear force sensory), fertility and resistance to disease/parasites.

Table 1.2 *Summary of traits for each group of sheep. Y' indicates trait EBV's are available (taken from Results for Genomics Pilot Project II)*

Trait	Name	Unit	Merino	Terminals	Maternals
BWT	Birth weight	Kg	Y	Y	Y
WWT	Weaning weight	Kg	Y	Y	Y
PWT	Post Weaning weight	Kg	Y	Y	Y
PEMD	Post Weaning eye muscle depth	mm	Y	Y	Y
PFAT	Post Weaning GR fat depth	mm	Y	Y	Y
GFW	Greasy fleece weight	%	Y		
FD	Fibre diameter	µ	Y		
DCV	Fibre diameter CV%	%	Y		
SL	Staple length	mm	Y		
SS	Staple strength	N/ktex	Y		
EBWR	Early breech wrinkle	score	Y		
FEC	Worm egg count	%	Y	Y	Y
HCWT	Hot carcase weight	kg	Y	Y	Y
CEMD	Carcase eye muscle depth	mm	Y	Y	Y
CCFAT	Carcase fat depth	mm	Y	Y	Y
LMY	Lean meat yield	%	Y	Y	Y
IMF	Intra muscular fat	mm	Y	Y	Y
SHEARF5	Shear force at 5 days	kg	Y	Y	Y
DRESSPERC	Dressing Percentage	%	Y	Y	Y
Poll/Horn	Poll horn	PP, PH or HH	Y		

2.4b Australia carcase grading

The Australian carcase grading was similar to New Zealand. It too was based on carcase weight (average 21.5kg) and GR fat depth (range 5-15mm). The carcase weight range was larger varying from a carcase weight of 18kg to 32kg, which aims to target different markets (which includes the United States). Like New Zealand, Australian lamb was processed as chilled or frozen.

Further research is under development in the meat industry to increase objective technology within the abattoirs/processors including CT (Scott's Technology) and other intramuscular fat predicting technology. This research is partly funded by the MLA acting as a donor company for the use of this technology to benefit the whole industry, rather than just the processors that are developing it. JBS are also aiming to provide feedback directly to farmer groups, such as their own producer group the Great Southern with the progress of Livestock Data Link.

Figure 8c. (left) White Suffolk ewes, Dr Kelly Pearce, Bullaring. (right) White Suffolk ewe lambs Guy Bowen, Mount Ronan

2.4c Australia - breeding for meat quality

The Sheep Genetics terminal sire breeding programme (LAMBPLAN), has previously focussed on increased growth, increased muscle and decreased fat. It has been found that selection for increase lean can lead to decreased fat content. Therefore in 2007, it was decided that fat was important to maintain (for meat quality purposes) and so new indices were formed. Currently, eating quality and yield traits are included in the breeder EBV information (by a combination of pedigree and genomic information). Meat quality measures include intramuscular fat and shear force. Intramuscular fat content enhances many sensory traits (tenderness, juiciness, flavour and overall liking) and is a type of invisible marbling in lamb. Researchers recommend Australian lamb intramuscular fat content to be between 4 and 6%. Shear force is a measure of force needed to cut through meat. Currently there is research underway to combine these traits to form a new meat quality index to make it easier to select for animals that produce progeny with better meat quality. Sheep breeders are actively using these meat quality breeding values, with the suggestion that soon there will be a meat quality based payment system similar to the one being developed by the Australian beef industry.

2.4d Meat Standards Australia

Beef meat quality is easier to measure as the carcases are larger and there are fewer carcases for a large amount of meat yield, and therefore beef are more cost efficient than lamb carcases, which need more resources. Beef meat quality traits have been researched by the Australian beef industry, which created the Meat Standards Australia (MSA) program. MSA is an eating quality program which has been designed to take the guesswork out of buying and cooking Australian red meat. MSA involves all sectors of the supply chain from paddock to plate. It aims to improve production influences that can create poor grading of meat quality and can serve as a benchmark of meat quality across years, states, processors and producers. This is especially useful to gauge and improve genetic progress on eating quality.

MSA research was carried out to aid prediction of eating quality, on a wide range of cattle and sheep management practices, processing systems, cuts, ageing periods and cooking methods. Measures of carcase and meat quality are combined into an MSA Index using 140 different predictions (formed by previous algorithm research) to enable meat quality to be predicted. Direct animal measurements include:- carcase weight, sex, breed type (hump height for *Bos indicus*), hanging method, hormonal growth promoters, age/maturity (ossification) marbling, pH and temperature and meat colour (Figure 9). Fat colour and eye muscle area can be measured upon request. The MSA Beef Index is a weighted score, based upon differences in inputted values and using algorithms made from consumer meat eating quality research (to produce a score range between 30 and 80).

Figure 9. (above) MSA marbling score cards and (left) meat/fat colour sticks.

MSA grading is increasing in the Australian beef industry, as between the years 2000 – 2002 there were 3000-4000 MSA graded cattle, whilst in 2014 there were 3,175,000 MSA graded cattle. The MSA Index allows the industry to move towards payment systems developed on carcase and meat quality, and underpins many of the new marketing aims of the processing industry. It allows processors to reliably quantify specifications for end users and consistently deliver products tailored to suit various markets. Grading can allow segregation of good quality carcases and market the product as a premium/value added. Premium cuts can be removed and placed into appropriate markets at the processors and so increase efficiency. The MSA Index is still being researched for its

use within the lamb industry. This type of system provides clear market signals/incentives for breeders. These meat quality measures are integrally linked to the consumer (who ultimately create the demand for lamb).

2.5 New Zealand and Australian sheep industry challenges

- Commercial carcases are not linked to sire. The problem lies with the identification between sire/dam and lambs being slaughtered. Parentage information linked to progeny phenotype is extremely valuable and can act as a progeny test. Further research in this area includes cheaper parentage testing, integration of databases and pedigree matchmaker.
- Meat yield and meat quality are negatively correlated and so selection for one results in a decrease of the other. Additionally if a trait is not measured, then variation is unknown and selection for it cannot occur. Objective measures are needed for meat yield and quality that can be measured on the slaughter line, so that market decisions can be made early and efficiently. The accuracy of these measurements is also an issue for processors.
- Welfare of animals is also becoming an issue for producers and processors. As Australia is a large country, transportation can be an issue and can affect meat quality. In New Zealand and Australia, it was commented that welfare standards are regarded as being very high in the UK and as an industry it is suggested that it is something that is promoted.
- Meat quality is important to the processor, retailer and consumer but farmers are generally not paid on meat quality. Some traits that are best for the industry are not selected upon by farmers as there are few financial rewards/premiums available. Thus, meat quality measurements and markets have to be developed. Especially measures that could be measured on farm, at the slaughter line or at processing, which could be most beneficial/cost effective.
- In both New Zealand and Australia there was an urgent need to increase the size of the national cattle herd and sheep flock. In New Zealand, over the past few years there has been a lower supply of lamb due to the rapid rise of the New Zealand dairy industry, coupled with environmental factors such as droughts. The increase in dairy production has offset the beef and lamb supply. As such the beef industry is highly influenced by dairy genetics. Many farmers are diversifying due to the perceived higher profitability, with many hectares being improved for dairy production by using irrigation for intensive crop production. The change in land use and the demand on water resources are substantial. There are strict guidelines on irrigation and use of fertilisers and natural urea.

Figure 10. Rainfall being measured on an Australian farm.

- Climate changes are having a major impact on Australia. Cattle numbers have lowered with 20 million cattle being lost from the industry, mainly due to large droughts. As such farmers often measure rainfall on selected areas on their farms to aid productivity (Figure 10). Cattle herd

numbers in Australia are at their lowest in 20 years. Companies are worried about the global beef and lamb supply. The Australian beef industry wants to target the grass-fed beef market. The decreasing cattle numbers mean less levy payment for MLA research.

- There are fewer young people wanting to stay within the industry. To combat this B&LNZ and MLA are funding producer led groups to create further networks and aid future development of farm based knowledge by holding workshops etc.

2.6 Conclusion

To summarise, this scholarship found that Australia and New Zealand have similar genetic objectives, which are mainly meat yield based but with a new focus on meat quality. Meat quality is multifactorial and as such future development within Wales should be based upon a whole supply chain approach.

There are development opportunities that may be exploited by the Wales sheep meat industry which include:

- Research/Adopt modern processing technology (X-ray, VIA).
- Increase data flow within the supply chain (currently ongoing with electronic identification EID projects).
- Methods/Incentives to measure meat quality.
- Genetic based projects linking lamb meat yield and quality.

In this scholarship four key tools have been identified to aid genetic selection for better meat yield and quality:

1. Data flow
   Including identification of carcases throughout the supply chain
   Using modern processor based technology e.g. electronic identification EID, X-ray and VIA.
2. Progeny testing.
3. Meat quality assessment
   Including provision of clear market signals for breeders, which are consumer driven.
4. Genetic assessment (including phenotypic recording, progeny testing and genomic techniques).

Adding new market targets, such as meat quality could be beneficial for the lamb industry, but may provide challenges which require considerable research and implementation across the supply chain. It was found that meat quality is a whole industry responsibility and as such, it requires the collaboration of many bodies integrally linked to the supply chain.

2.7 Scholarship Benefits

It has been a privilege to be awarded the Hybu Cig Cymru Livestock Scholarship 2014. At home, we have been buying a mixture of recorded (Innovis bred) and non-recorded rams, and thanks to the EID voucher provided by HCC, we have begun EID tagging and recording lambs from birth. Thanks to the scholarship, we are aiming to compare 2015 born progeny from recorded and non-recorded rams, to see if there are differences in carcase traits (weight and EUROP grid). This will enable our own mini progeny test as well as aiding data linking sires to progeny. I wish to share the wealth of knowledge I have gained as a result of this scholarship, not only by implementing some changes at home but also providing influence on others to reflect on their own farming systems and the ways they can improve it.

During the scholarship, I have met a variety of amazing and generous people, which without them this report would not have been possible. The scholarship has also aided the development of my PhD studies. Getting the chance to visit New Zealand and Australia gave me the opportunity to gain first-hand knowledge direct from farmers and breeders to advance my understanding about their sheep genetics and production systems. Meeting with and viewing a range of abattoirs and processors has also helped build my meat industry background and knowledge in measuring meat yield and quality. Whilst in Armidale, I attended a genomics course which was highly valued, not only for the scientific knowledge but also for the great networking opportunity.

I have made some great, long-term contacts while visiting these two countries, with some of the companies and organisations I visited giving me an invite to visit and/or work with them in the future. Likewise, some of the contacts I met out there are keen to visit Wales and my home farm (Beiligwern). This scholarship has been an amazing experience, and I'm very thankful to Hybu Cig Cymru for giving me the opportunity, along with BSAS and Innovis who gave me additional funding support. I look forward to sharing my experience and the knowledge I've gained due to this scholarship, and hope I've made some life-long friends along the way.

3.0 Brief description of visits

3.1 New Zealand

For three weeks in January 2015, many New Zealand organisations were visited including farms, breeding companies, processors, meat research companies and universities (Figure 11).

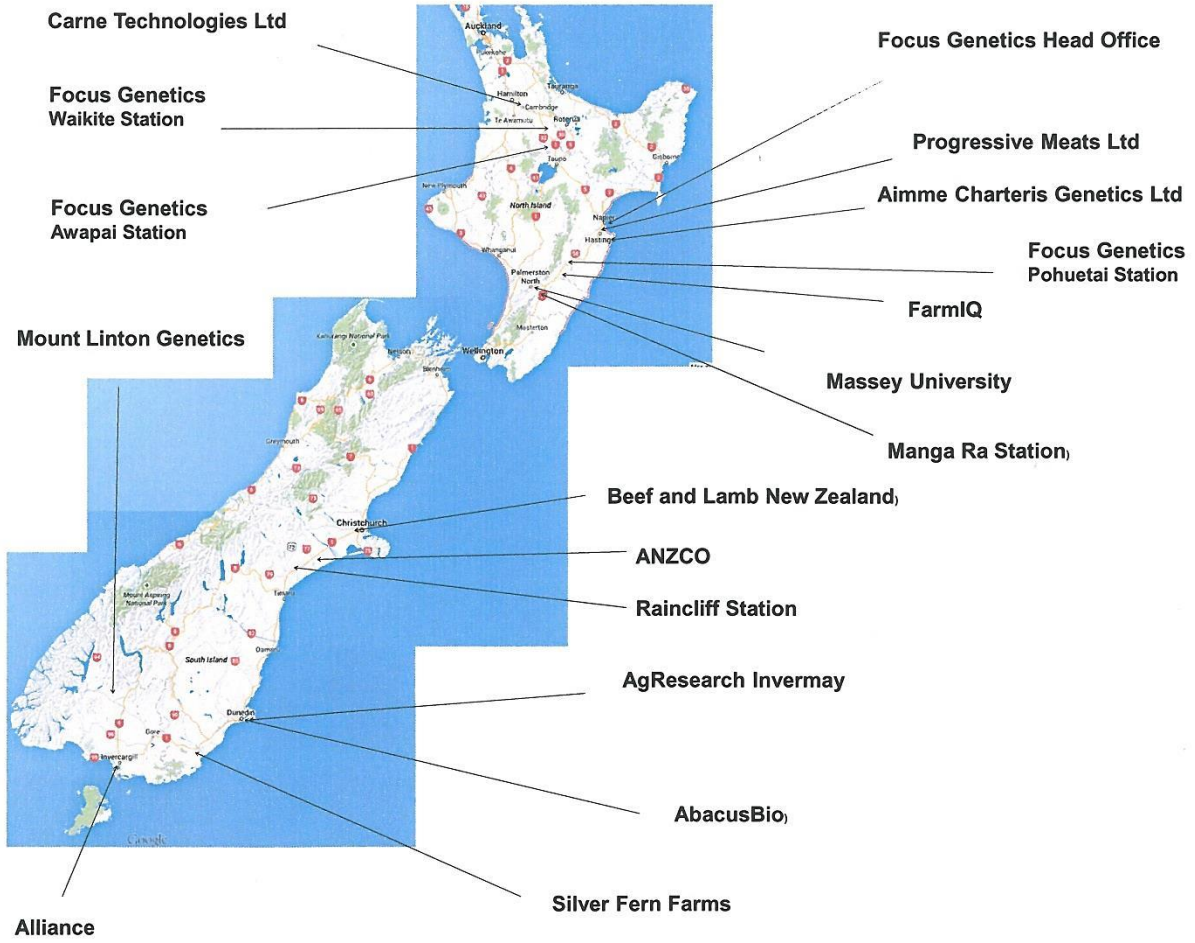

Figure 11. Names and geographical location of organisations visited in New Zealand.

Dr. Richard Lee from Focus Genetics (a sheep and beef breeding company) was very accommodating and arranged visits to three large Focus Genetics terminal sire breeding stations Waikite, Awapai and Pouheutai (Figure 12).

Figure 12 (left) Awapai ewe lambs and (right) John Heald from Pouheutai station.

Farm visits also included William Morrison and Erica van Reenen around their beef and sheep station - Manga Ra (Figure 13); Raincliff Station, a Red deer farm (Figure 14), and Mount Linton Station; a large sheep and beef enterprise with their own terminal sire breeding unit (Figure on front cover).

Meetings were also held with individuals working in the sheep genetics industry including: Dr. Geoff Nicoll, Dr. Natalie Pickering and Dr. Aimme Charteris. FarmIQ was visited where they demonstrated their agricultural recording system.

Figure 13. The Manga Ra Team.

Presentations were given for Beef and Lamb New Zealand (B&LNZ) and AgResearch/AbacusBio. Processors visited included were Progressive Meats Ltd, ANZCO, Silver Fern Farms and Alliance.

Figure 14. Raincliff Station trophy deer.

3.2 Australia

Three parts of Australia were visited in February (internal flights were arranged to visit the three areas, Figure 15).

Figure 15. The three locations visited whilst in Australia.

3.2.a Armidale

At Armidale, a genomic course organised by Professor Julis Van der Werf was attended at the University of New England. Whilst in Armidale a meeting was held with Hamish Chandler, Manager of Sheep Genetics, who recommended visiting prominent Terminal sire sheep breeders in the area (Figure 16a and 16b).

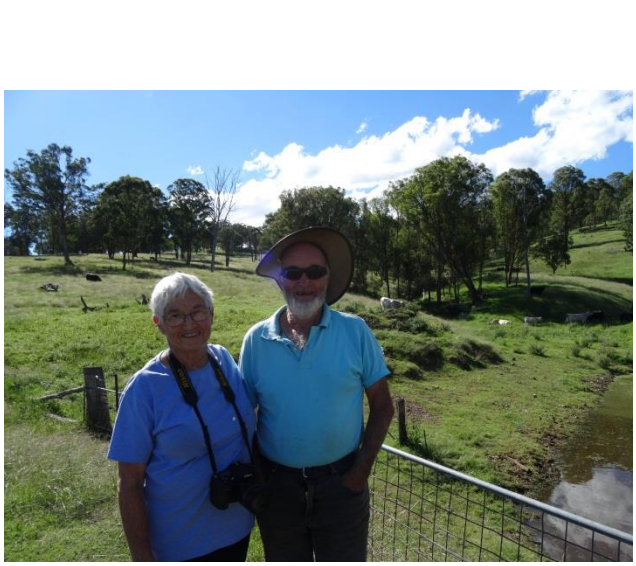

Figure 16a. (left) Arthur Gates, Pollombi seedstock stud (right) George Carter and son James, Linton Poll Dorsets and $uperBorder$.

Figure 16b. (left) Sam Lisle, Old Woombi stud, (right) Martin Oppenheimer, Petali stud.

The genomics course provided an opportunity to meet many people within the industry and to visit the Armidale Resource flock and Dr Alex Ball's commercial property which had Merino flock and an Aberdeen Angus herd. A talk was given at the University of New England. Meetings were arranged with many other sheep/genetics related scientists.

3.2b Melbourne

In Melbourne a tour was arranged with JBS Brooklyn plant, the largest meat processor in the Southern Hemisphere and Murnong Farming who manage a Focus Genetics nucleus flock based in Australia (Figure 17).

Figure 17. (left) Mark Inglis JBS and (right) Murnong Farming and Focus Genetics sales team.

3.2c Perth

The first meeting in Perth was with Dr Graham Gardner, who helped with organising some of the Perth visits. The following day the Midland Cattle Breeders Association open day at Gin Gin was attended (Figure 6). The first farm visit was to Richard Pitchford and Khama Kelman's farm, near Katanning (Figure 18). At Katanning a number of visits took place including: the Katanning Saleyards, the Department of Agriculture and Food, WAMMCO (a meat processor) and Katanning Resource Flock.

Figure 18. (left) Gin Gin Beef producers open day (right) drenching Merino's

Three sheep stud/commercial farms were also visited in the area and include Keith Ladyman's (Dumbldee stud), Guy Bowen (Ronan Genetics) and Alan Manton and Dr Kelly Pearce at Bullaring.

At Murdoch University, meetings were held with meat and sheep scientists and a seminar was given based on the UK sheep industry (Figure 19).

Figure 19. Presenting at Murdoch University.

4.0 Acknowledgements

I would firstly like to thank my scholarship sponsors:

HYBU CIG CYMRU
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5.0 Bibliography

Beef and Lamb New Zealand 2014 - http://www.beeflambnz.com/Documents/Information/Compendium%20of%20New%20Zealand%20farm%20facts.pdf; http://www.beeflambnz.com/news-events/media-releases/2013/november/sheepmeat-and-beef-export-statistics-for-2012-13/ accessed Sept 2015.

Department for Environment, Food & Rural Affairs (DEFRA) 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293717/structure-dec2013-uk-19mar14.pdf accessed Sept 2015.

Meatstats. 2014. http://www.eblex.org.uk/wp/wp-content/uploads/2014/03/Global-trade.pdf accessed Sept 2015.

Meat and Livestock Australia (MLA) 2014. http://www.mla.com.au/Cattle-sheep-and-goat-industries/Industry-overview/Sheep accessed Sept 2015.

Hybu Cig Cymru (HCC) 2009. http://hccmpw.org.uk/index.php/tools/required/files/download?fID=2006 accessed Sept 2015.