Individual Animal Management in Commercial Sheep Production

Using objective measurement, through EID, to optimise productivity in line with end product specifications

A report for:

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Executive Summary

- The need to combine on-farm productivity gains with specifications of the end product is more important than ever as the demand for consistently safe, high quality and ethically-grown food increases. Productivity gains on farm are a mainstream way to increase profit under a largely commodity-driven pricing structure. However, in the absence of adequate and accurate product feedback, productivity gains alone could limit the ability to produce product to market specification. Linking feedback on the products being produced in the sheep industry (lamb, wool and sheep meat) back to production and reproduction is very important. Current technology such as electronic identification (EID) can facilitate such linkages in a simple, practical and cost effective way.

- A focus on the full range of animal performance data - rather than the average - through Individual Animal Management (IAM) allows for more accurate identification of superior and inferior stock. This information can be used to make precise decisions around genetics and nutrition. For example, the top 25% of ewes can be more than twice as efficient as the bottom 25% of ewes, under identical management. Therefore, having the ability to identify the animals that fall below the average on an economic measure allows for greater gains through more precise selection pressure.

- Matching a ewe to her progeny, using EID, will enable a weaned litter weight to be correlated to her. Currently Pedigree Match Maker (PMM) is the most efficient commercially available tool for matching ewe and lamb. Work is being done on creating a sensor tag which will remotely link ewe and lamb through near field technology. This will be an area that will continue to evolve.

- A ewe efficiency index can be calculated if the liveweight of the ewe and weaning weight of the lamb(s) is collected. This is a key profit driver, which can be optimised, and enables greater selection pressure by producing surplus replacement ewes. It also supports selection of favourable component traits including fertility, number of lambs born, lamb survival, lactation and lamb growth rate.

- Individual Animal Management in a commercial setting requires a resource commitment and must be practical. Data collection should be integrated as part of the annual management calendar to ensure greatest efficiency in time. Typical measurements that align with annual animal husbandry are pregnancy scanning, liveweight and condition score, sex of the lamb, age of the dam, lamb marking weight and weaning weight, wool cut, sire group (and their genetics) and matching ewe and lamb.

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Foreword

My first exposure to the impact Individual Animal Management (IAM) can have in the sheep industry was when I was feed-lotting lambs. The ability to draft lambs on weight gain per day meant the less productive lambs could be regrouped away from (and managed differently to) the more productive lambs. This is when I discovered the power that objective measurement has, particularly when it relates to traits not visible to the eye. My interest in using IAM has evolved as a way of identifying the most profitable ewes from the least profitable ewes. The variation in lambs at weaning, and a sense of frustration at the inability to do anything about it without objective measurement, stimulated interest into studying this topic further.

With a large variation in wool cut per head, as well as kilograms weaned per head, there is clearly a range in profitability and efficiency from the top performing ewe to the bottom performing ewe. It Is not possible to identify these differences using visual assessment only. The immediate appearance of an individual ewe can have little relevance to how productive she is under commercial conditions. This raises the question of whether sheep judged on having the best credentials in a show-ring are aligned with the best credentials to a commercial producer on an economic level.

I grew up on a farm near Benalla and now manage a property at Greta in North East Victoria. I studied Rural Science at the University of New England completing an honours (first class) project on factors affecting lot-fed sheep. I worked in the dairy and pig industries for two years before beginning my career in farm management nine years ago.

Being a commercial producer, practicality is at the forefront of my vision for IAM to work successfully. A concept that is perceived as very complicated needs to be very simple in execution. I believe that when the profit drivers of the business are recognised, a very simple system can evolve. Recording data against an animal's Electronic Identification (EID) tag, means animals become individuals by default, despite running under a mob-based management structure.

When EID technology first became available for commercial applications in the sheep industry, there was a focus on the product and what it could do rather than understanding 'why' we

may need it. We have since realised that simply having the equipment or collecting the data will not in themselves increase profit - only the action taken upon the interpreted information can increase profitability if it is aligned to the profit drivers of the business. To first understand 'why', we can work out the 'how' and select the appropriate 'what' to align ourselves with the best chances to make IAM an economically viable option. With this sequence in mind, the focus of my study is on the benefits IAM can have in commercial production systems using EID technology as the tool, rather than looking at the technology itself. Using this approach means the voluntary use of EID tags will be validated on economic reasons, leaving traceability for biosecurity to be the bonus to a commercially-driven decision.

To explore this topic further I visited a range of industries in New Zealand, South Africa, Kenya, Eastern Europe, UK, Ireland and Denmark. Understanding how production, reproduction and product can all be maximised is a focus of this Nuffield report.

Acknowledgments

I feel immense gratitude to have had the opportunity to undertake this scholarship. I would sincerely like to thank everyone for sharing their knowledge and having me to their businesses and homes over the past year.

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Abbreviations

ASBV – Australian Sheep Breeding Value

AWI – Australian Wool Innovation

BWT – Birthweight

CS – Condition Score

CWT – Carcass Weight

EBV – Estimated Breeding Value

EID – Electronic Identification

HWT – Hogget Weight

IAM – Individual Animal Management

ILRI – International Livestock Research Institute

KPI – Key Performance Indicator

LWT – Liveweight

MLA – Meat and Livestock Australia

NLW – Number Lambs Weaned

NZ – New Zealand

PMM – Pedigree Match Maker

PWWT – Post Weaning Weight

RFID – Radio Frequency Identification

SIL – Sheep Improvement Limited (NZ)

SRS – Soft Rolling Skin

WPP – Wool Production Potential

WWT – Weaning Weight

YEMD – Yearling Eye Muscle Depth

YFAT – Yearling Fat

Objectives

The objectives were:

- To optimise the profitability of commercial sheep production through measuring the productivity on individual animals and making objective selection decisions.
- To investigate methods used in other industries to follow production through to product
- To further understand the role that the maternal traits play on production, and to investigate ways commercial farmers can practically optimise ewe efficiency.

Chapter 1: Introduction

The Sheep Industry Background

The Australian sheep industry is a proud one with a long history. Since the early 1800s, Merino wool has been a major part of the Australian economy as it was both needed and Australia had a suitable climate. The wool boom in the early 1950s contributed to the success of the Merino in Australia and is where the saying "*riding on the sheep's back*" came from. This boom came about as a result of demand from the American army during the Korean War (ABS, 2003). Shortly after this spike, sheep numbers rose dramatically from 96 million to 113 million during 1956 to 1960.

Sheep numbers peaked in Australia at around 170 million in the 1990s receding to a current level of around 68 million including breeding and non-breeding animals. The current ewe flock is around 38 million head. The interesting trend to note is that the Merino ewe portion of this trend is declining at around two million per year to be now around 65% of the national ewe flock (Trompf, 2014) (Figure 1).

Australian Merino Ewe Population Decline

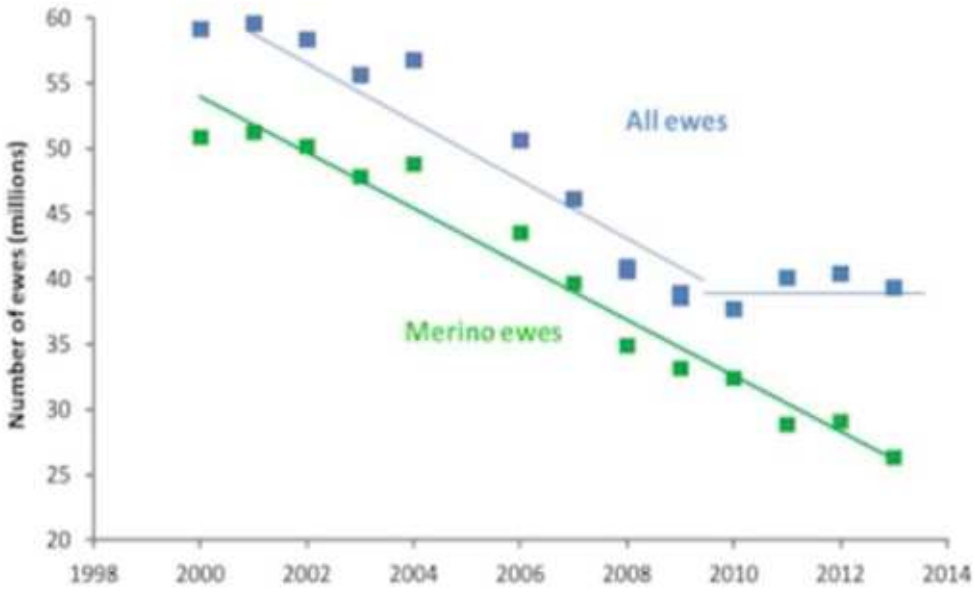


Figure 1: The decline of Merino ewes as a proportion of all ewes from 2000 to 2013. (Source: Jason Trompf, 2014).

The reasoning behind Figure 1 is interesting; why are people getting out of Merinos into cross bred sheep? When comparing the last 44 years of benchmark data from the Livestock Farm Monitors Project, wool production per hectare and wool price in real terms has not increased. However, price received per head for lamb has increased 56%. Evidence suggests that selecting for wool alone impacts negatively towards reproduction. It is also evident that selecting for reproduction can result in decreased wool cut per head. In reality, both can be maximised simultaneously by using objective measurement and is an opportunity that lies within the Merino industry. While increases in lamb income has clearly outstripped increases in wool income in recent years, resistance within the merino industry to focus breeding objectives towards producing more lambs, while maintaining wool value per head, is very concerning. It represents a big opportunity for the Merino industry in the coming years.

Individual Animal Management

Identifying the animals with low fertility is impossible using subjective methods alone. Individual identification with electronic tags gives sheep producers the ability to measure actual production and make objective decisions based on this information. Aligning objective measurement with identified Key Performance Indicators (KPI) gives farmers the ability to maximise profit.

In addition to improving on-farm production, increasing this without end-product quality measures could be detrimental to the sheep industry in the long term. On a world scale, lamb and wool are products that do not have a high per capita consumption. Therefore, it would be wrong to have an unbalanced focus on on-farm production at the expense of product quality and still expect good prices derived from a strong demand. This, coupled with the increasing pressure from consumers for safe and ethically grown products, means we have to get smarter about the way we farm sheep.

Getting the balance between reproduction, production and product right is important. Product feedback can be used by farmers in an objective way to ensure product quality and productivity gains can symbiotically improve together. Understanding the product we are producing and how this can be altered through on-farm, productivity driven decisions is where Radio Frequency Identification (RFID) could be very useful in allowing the flow of information throughout the value chain.

Identifying which animals are under-performing is the focus of Individual Animal Management (IAM) and can allow selection decisions to be made. Ensuring selection decisions are based on identified KPIs will make sure the data collected is accurate and useful. Historically (and currently), selection decisions have been made by subjective means only, assessing confirmation and desirable wool traits by eye. This paper explores the limitations of this type of classing system when used as the sole tool to select replacement stock for breeding.

When assessing whether IAM should be commercially viable on Australian sheep farms, there are a few elements that need to be considered. Fundamentally, profit is only enhanced where the added value derived from the data is greater than the cost of collecting and processing it. Identifying what the KPIs are and aligning current production levels to these is most important in ensuring optimum measurements are taking place to achieve the biggest gains. It is also important to ensure that the cost of culling is less expensive than the cost of keeping unproductive stock (C. Nakielny, Pers. Comm. October 2014). This is the case where ewes bought in are the main source of ewe replacements. Buying the same underperformers each year could negate the effort to identify these ewes on a yearly basis.

The KPIs of most frequent concern included kilograms of liveweight (LWT) produced, kg of wool produced, lambing % and lamb survival. These KPIs correlated with work done here in Australia that identified these areas with the most potential to improve. Industry research indicates the biggest returns for Australian gross profit is twin lamb survival worth $515 million, with the second highest return being improved reproduction from ewe lambs with a pay-off of $332 million. Other areas of significance are improving survival of single born lambs ($285M), improving percentage of lambs conceived ($235M) and improving reproduction from two year old ewes ($221M) (Young, Trompf, & Thompson, 2014).

Establishing an information flow between on-farm production, reproduction and product quality will ensure on-farm improvements occur without compromising product quality.

Chapter 2: Production – Wool

According to Cameron McMaster (Pers. Comm., September 2014) in South Africa, 30% of income should be from wool; 70% should be from meat in the form of lamb and surplus ewe sales. In the 1970s, the demand for meat in South Africa increased and as a result became a focus of the breeding objectives for that country. Coupled with the embargo of Australian sheep into South Africa, this meant that German meat Merinos were the major source of new genetics. This move complemented the breeding objectives of the country, which were for a plainer bodied Merino that was highly fertile. Around this time, the Dohne Merino was developed (C. McMaster, Pers. Comm. 2014).

One of the underlying theories behind the breeding of Dohne sheep is what Cameron McMaster (Pers. Comm. September 2014) defined as the Wool Production Potential (WPP). This is a measure of the ratio of wool to liveweight. He has identified that a WPP of 7% (the ratio of wool produced to an animal's liveweight at 12 months of age), is ideal to maximise lambing percentage. Over 7% WPP and fertility is compromised.

Relationships between wool production, reproduction, body weight and energy balance are complex (Woolaston, 2013). It is understood that wool and reproduction both compete for energy sources. Over a number of generations, this can manifest into a negative correlation but at a genetic level they are not intrinsically antagonistic and both traits can be simultaneously improved. With this in mind, selection for both genetic muscle (YEMD) and genetic fat (YFAT) are extremely important from both an efficiency and a product quality point of view.

As the skin is the biggest organ in the body, the requirement of energy to maintain it is also considerable. In the very early days of Merino breeding, wrinkle was added to the sheep as a method of increasing wool cut per head. The wool boom in the 1940's and 50's exacerbated the desire to produce more wool; however, there is a balance now required between wool production and lamb and surplus ewe sales (reproduction) to take advantage of today's market. High Clean Fleece Weight (CFW) sheep have been shown to have reduced energy reserves and this is especially evident during periods of inadequate nutrition (Thompson, Ferguson, Gordon, Kearney, Oldham, & Paganoni, 2011). However, skin type can play a large role in energy distribution and was a fundamental reason behind the development of the Soft

Rolling Skin (SRS) skin types which are more energy efficient (J. Watts, Pers. Comm. March 2015). Some of the latest research has now indicated by decreasing wrinkle score by one score (as measured on the one to five scale) lambing percentage can increase by 16% (M. Ferguson, Pers. Comm. December 2014).

Combining visual classing with objective measurement is the best way to select the most profitable animals (J. Rive, Pers. Comm. May 2014; B. Steers, Pers. Comm. March 2015). South Australian wool classer Brian Jeffries demonstrated this when he had access to objective measurements on a group of ewes on a commercial property. Each ewe was mid-side sampled and tested for yield and micron. The ewes had a fleece weight taken at shearing and each fleece was given a dollar value. The group of ewes were then visually assessed by a group of farmers. Of the 20 ewes, the second most profitable ewe under objective measurement was classed out on visual assessment by all farmers. The use of economic data where sheep were measured individually indicated the need to combine visual with measured data. These objective measurements showed that the profitability of the top sheep was double that of the bottom sheep (K. Solly, Pers. Comm. 2014).

Following on from this, taking objective measurements and selecting breeding animals on one production measure alone could be worse than taking none at all. A ewe that raises two 30kg lambs for example, could cut less than average kilograms of wool per head. If wool per head is the only selection criteria, this ewe may be identified as underperforming (M. Ferguson, C. Taylor, M. Murphy, A. Bouffler, Pers. Comm. 2014). Furthermore, lambs born as a twin are more likely to cut less and have a higher micron than single lambs (Thompson et al., 2011). Selection of heavy cutting, lower micron ewe replacements has essentially meant we are selecting for single bearing ewes. In other words, we have been indirectly selecting against reproductive efficiency for many years (R. Apps, Pers. Comm. 2015). Similarly, with lamb production, emphasis should be put on the yield of compliant (within market specifications) meat per ha rather than just meat per ha (M. Inglis, Pers. Comm. 2014) as this will also ensure selection of the right animals.

Although the industry average is heading toward a 50:50 split between wool and meat as a proportion of overall income, wool income on some Merino farms is as low as 30% of total

income with no reduction in total kilograms produced. High lambing percentage and surplus ewe sales make up the other 70% of income.

John and Charles Douglas-Clifford in NZ have combined wool weights with weaning weight per ewe to give a better overall understanding of the profitability of individuals. On a commercial scale, pairing ewes and lambs is the area least developed but with the most potential to have a positive impact on IAM (Douglas-Clifford, Pers. Comm. May 2014). Technology using proximity sensors is currently being worked on by La Trobe University in Bundoora the University of New England in Armidale, Australian Wool Innovation (AWI) as well as in NZ. This will add significant value to commercial farmers by giving vital parentage and maternal ability data.

Figure 2: Bar codes on a board in the Douglas-Clifford's shearing shed in NZ allowing for simple identification of desirable or undesirable wool traits at the end of the day. These animals can then be drafted off after shearing or at the next convenient time. (Source: Douglas-Clifford, J., December 2014)

Chapter 3: Production - Meat

Putting an economic basis to IAM is critical. There has been some work done which shows that the value of an extra lamb was very sensitive to a 20% change in price of the meat, but was less sensitive to a 20% change in the value of the wool (Young, Trompf, & Thompson, 2014). It was also shown that the input cost per ewe to achieve an extra 10% scanning was $0.50 in a Merino to $2.20 in a meat breed ewe. However, if lamb survival rates are below 50%, there is very little value in increasing scanning rates. The value that could profitably be spent per ewe for an extra lamb at weaning (lamb survival) is from $7.50 and $11.20 for a single and twin Merino ewe respectively and $7.30 for a single and $14.60 for a twin meat breed ewe, when the price point is $4/kg carcass weight (CWT) (Young *et al*, 2014). Large productive variation within a flock highlights the opportunity that lies within IAM (N. Scott, Pers. Comm. December 2014).

From a management point of view, identifying an animal by birth rank, mob (social status) and weight gain per day, has helped maximise intensive feeding groups and feed efficiency (Douglas-Clifford, Pers. Comm. December 2014). Twins are more competitive than single lambs under intensive feeding programs. Drafting on weight gain per day in a feedlot situation separated the less competitive from the more competitive. As a result, the lambs growing under 200 grams per day jumped to over 400 grams per day when separated from the competitive lambs. Visual assessment cannot identify the slower growing lambs; objective measurement is the simplest and easiest way and drafting on weight gain per day and is very easy to set up on the scales monitor.

Through the New Zealand Farm IQ system, Sam and Hannah Morrah (Pers. Comm., May 2014) discovered half of their lamb kill was over-fat. The use of EID tags in their lambs highlighted that the ewe lambs were largely the over-fat lambs. As a result, ewe lambs are now finished on plantain and wether lambs are finished on clover. Without the use of eID, feedback would have indicated half the lambs were over-fat but would not have shown which lambs these were. Sam and Hannah record paddock of birth, paddock of growth, as well as sire genetics, growth rates and birth status (single, twin or triplet). Paddock records are very important to Sam and Hannah to help identify underperforming paddocks.

Scottish cattle farmer and 2013 Nuffield Scholar Robert Niele separates cows on the sex of their calves. The steers wean at heavier weights and heifers go to fat earlier. He has also identified his good fields produce up to double the amount of feed when compared to his poor fields (R. Niele, Pers. Comm., September 2014). This is also something identified by NZ farmers John Douglas-Clifford and Julie Crawford who now measure growth rates of pasture using a C-dax pasture meter. Linking pasture production and utilisation with weight gain and CS change allows for targeted improvements on objectively measured information.

Work in the US is correlating weight gain with the amount of food consumed by measuring daily intake. The range in feed efficiency is also an area of opportunity to improve in this sector (Figure 3).

Figure 3: EID reader on feed bunks to measure daily intake is linked to weight gain to achieve a feed efficiency value (Source: Nebraska State University, April, 2014).

Chapter 4: Reproduction

By definition, 're' in a meaningful word, describes the action 'to do it again'. So, in terms of 'production' of wool and meat, to increase outputs of these KPIs – 're-production' must play an important part. The main KPI for reproductive efficiency, as identified in the CSIRO publishing (Young *et al*, 2014), is lamb survival. This is the main factor affecting lamb marking percentage on farm.

"If we want to get serious about lamb survival, we must get serious about selecting the right ewes" (M. Ferguson, Pers. Comm., June 2014). As the highest priority in reproductive performance in the Australian sheep industry, attention must be paid to optimising genetics, nutrition and management. The introduction of Estimated Breeding Values (EBVs) needs to be widespread best practice, as they add an enormous benefit to visual selection alone. Selection of genetics without EBVs could result in traits being introduced that are not in line with the objectives of the business.

An increased lambing percentage is needed to ensure an adequate number of replacement ewes come into the system so that appropriate selection pressure can be put on the flock. Fertility is the most important KPI measures in a beef herd in Kenya as selection pressure on good fertility is essential (G. Powys, Pers. Comm., April 2014). Litter weight weaned is recommended as a principal trait for selection to increase overall reproduction and ewe productivity (Snowder & Fogarty, 2009). This is also the method Duncan and Tina MacKintosh (Pers. Comm., June 2014) use when selecting their ewe replacements in North Canterbury, NZ.

The ultimate aim of Focus Genetics in New Zealand is to breed ewes that conceive, deliver and raise two good lambs (B. Wilson, Pers. Comm., May 2014). Objective measurement of genetic potential has been the underlying reason this aim is constantly met by NZ sheep producers. Merino sheep classer and farmer, Jayne Rive of NZ, suggests taking out dry (barren) ewes at lamb marking is the single biggest thing that can be done to identify which ewes raised a lamb (J. Rive, Pers. Comm., May 2014). Jayne suggests this will invariably impact on genetic gain of carcass traits such as muscle and fat, due to the positive correlation these traits have on reproduction.

Selecting too heavily on one trait, or silo selection, will lead to an unbalanced animal (A. Charteris, Pers. Comm., May 2014). Too much selection pressure for production in one area can have negative effects on fertility, as has been seen in other species (Ferguson, Adams, & Robertson, 2007). Andrew Bouffler explained in his Nuffield Paper in 2007 that a negative 0.35 correlation between a push for production of milk, led to major fitness problems in Holland's dairy industry. This occurred because a higher than optimal proportion of energy was going into milk at the expense of getting back in calf. Upon recognizing this, they were able to turn fertility around without compromising production (Figure 4).

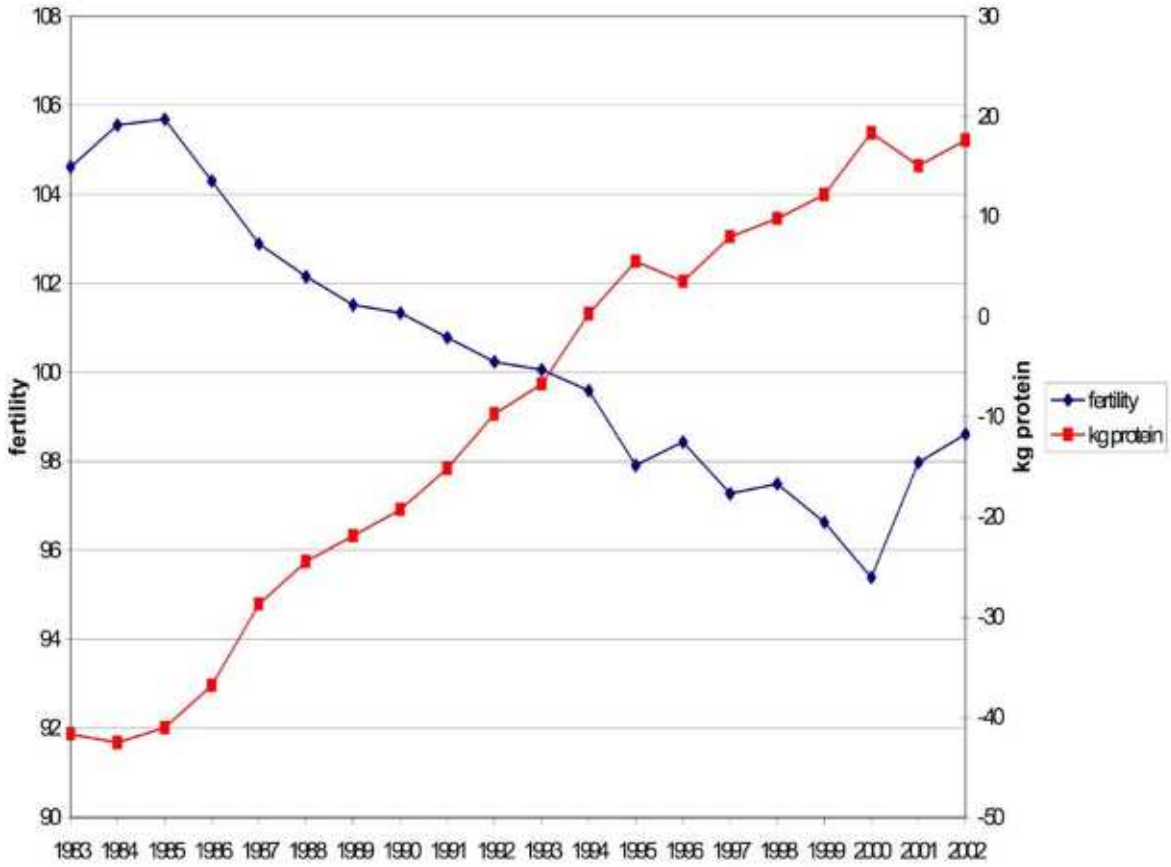


Figure 4: Relationship between fertility and production of milk protein (kg protein) in Holland's dairy herd from 1983 to 2002. (Source: Andrew Bouffler, 2007 Nuffield Scholar)

Animal fitness, under Charles Darwin's definition, is the ability of the animal to reproduce. Fitness remains a major breeding goal for sheep breeders in South Africa (C. McMaster, pers. comm., September 2014). Having the best producers unable to reproduce makes them ultimately unproductive.

In Australian conditions, season contributes to variation within a flock. Reproduction under harsh conditions breeds for resistence to stress. Selecting for Condition Score (CS) should be done under poor feeding conditions (G. Erasmus, , Pers. Comm., September 2014). Under stress, or when ewes are under condition score three (CS3), an extra one mm of genetic FAT can lift lamb survival by 25% (Ferguson M. , 2011). Measuring CS in commercial sheep production can reflect the amount of genetic fat (YFAT) a ewe carries at certain times of the year and therefore her resilience to stress, and hence her ability to reproduce.

South African farmer Wynand du Toit's (Pers. Comm., September 2014) flock had a low lambing percentage which was costing him hundreds of thousands of dollars every year. For the same price as a "130 horse power John Deer tractor", Wynand paid for his lambing shed in two years due to increasing lamb survival (Figure 5). Wynand lambs 3,200 commercial Dohne ewes in a shed, 600 at a time, within a week of going in. Mothering ability of each ewe is recorded each year and any ewes with poor mothering ability are culled and her lamb is not kept as a replacement. Wynand has increased his lambing percentage from 138% to 171% by lambing his twin bearing ewes in the shed. He has also decreased his assisted lambing from 12% to 1% through selection and culling on objective measurement and has increased his weaning weight by 9kg at the same time. This is a great example of where production and fertility can be simultaneously improved through objective selection.

Figure 5: Wynand du Toit and two other staff members lamb 600 twin ewes at a time, measuring mothering ability and assisted lambing for each ewe (Source: Wynand du Toit's property, September, 2016).

Chapter 5: Maternal Ability

While attention has been paid to wool and meat traits for many years, little attention has been given to the implications of these strategies on maternal performance. Maternal performance encompasses a range of fitness-related traits including fertility, fecundity, milk production, lamb survival and growth (Ferguson, Adams, & Robertson, 2007). Growth rate and Number of Lambs Weaned (NLW) EBVs are the most profitable traits to select for maximising maternal objectives (M. Young, Pers. Comm., June 2014). Ignoring maternal genetic effects in genetic evaluation will lead to sub-optimal economic gains. Conversely, including maternal genetic effects in genetic evaluation when there is inadequate data to estimate them properly, can lead to erroneous conclusions. (Woolaston, 2013). Accuracy of the data collected is paramount to successful selection decisions (R. Apps, Pers. Comm., 2015).

It is important to understand the correlations that exist between production traits and maternal (reproductive) performance (Ferguson, Adams, & Robertson, 2007). Selecting traits based on the maternal benefit is much more important than selecting traits based on the terminal sire production in a self-replacing flock (A. Charteris, Pers. Comm., May 2014). John Vipond in Scotland (Pers. Comm. October 2014), suggests this benefit could be six times more important in terms of profitability. Heritability is low in these reproductive traits. Selecting for multiple births is only 5% heritable (Douglas-Clifford Pers. Comm., May 2014, Mackintosh Pers. Comm., May 2014). However, if a ewe is scanned as twin bearing and loses both lambs, there is a 70% reduction in lambing percentage the following year (of that ewe) (Amer, Sise, Jopson, & Bray, 2009).

Despite this low heritability, a trial done in South Africa demonstrated that selection for or against multiple rearing ability led to significant divergence in reproduction without unfavourable genetic changes in wool and liveweight (Figure 6) (S. Cleote, Pers. Comm., September 2014). Ewe, permanent environment, heritability estimates for reproduction in the present study were 7% for number of lambs born, 11% for number of lambs weaned and 11% for weight of lamb weaned. Figure 6 demonstrates that selection for reproductive traits on an individual level can have significant impact on overall economic success when meat production contributes markedly to the income of a sheep enterprise (Cloete, Gilour, Olivier, & van Wyk, 2004).

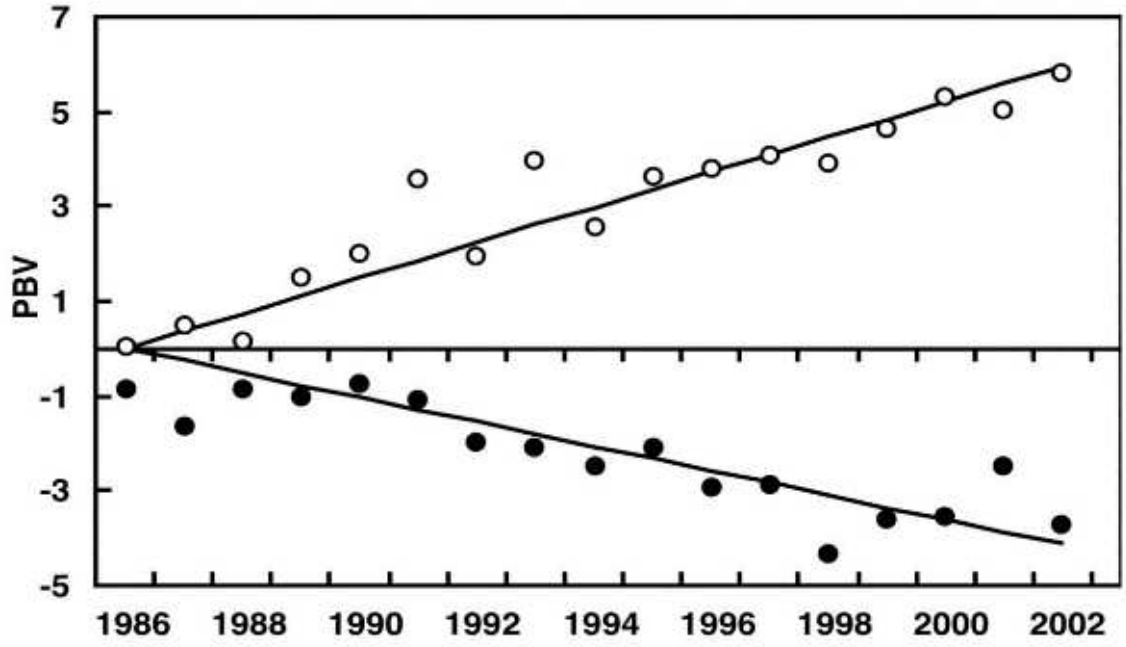


Figure 6: Genetic trends depicting averaged predicted breeding values (PBV) representing the High (O) and Low (●) reproduction lines corrected for weaning weight. Source: (Cloete, Gilour, Olivier, & van Wyk, 2004)

Mothering influence on their progeny will be highest in the first eight weeks of life. After this, nutritionally, lambs will gain more from the grass than their mother. Milk composition may dictate some of the variation in maternal ability but this is not something that has been quantified as yet (A. Charteris, NZ, Pers. Comm., May 2014, S. Beatie, Pers. Comm., March 2015).

A South African Dormer breeder (Dorset/SAMM), said that in some heritage breeds (namely the Dorper), visual selection based on desirable carcass quality and show ring attributes, has led to a decrease in reproduction rates (J. Swart, Pers. Comm., September 2014). He believes the heritage breeds were built for walking long distances and so had a phenotype that suited this. Fitness traits, such as fertility, have been compromised for the benefit of visual assessment. How something looks is only important when related to how appearance impacts its function.

Chapter 6: Ewe Efficiency

Knowing weaning weight per ewe will reflect on both production and reproduction. Pedigree Match Maker (PMM) is a system developed by the Sheep Cooperative Research Centre (CRC) to match ewe to lamb using the number of repeat measurements past a radio frequency compatible scanning gate. Every time the lamb(s) tag follow the ewe tag, it is recorded. It is a method used throughout Australian and NZ flocks both in studs and commercially. A range of accuracy has been identified from 65-95% accuracy depending on a range of environmental influences (Sutherland, Bush, Steers, & Brown, 2014). However, if ewes and lambs match 10 or more times throughout the matching process, which is usually three weeks, there is a 95% accuracy (N. Scott, Pers. Comm., July 2014)**.** Mismothering at birth will not be detected by PMM; it can only be detected by DNA testing. However, this method is currently too costly for commercial use. Seventy percent of a dairy herd is mismothered at calving but the researchers at LIC in New Zealand developed GeneMark technology can give a 99.99% accuracy of parentage (G. Udy, Pers. Comm. May 2014). There will always be some error, but having some error is better than no accuracy when making selection decisions (N. Scott, Pers. Comm., July 2014).

Figure 7: Transportable PMM system between two paddocks in NZ on Julie Crawford's property (December 2014)

Figure 8: Australian PMM system using four, used, pellets, water and feed as attractants (December 2014)

Matching a ewe to her progeny will give a litter weight weaned figure. This can result in a balanced biological composite trait with favourable responses in component traits including fertility, number of lambs born, lamb survival, lactation and lamb growth rate (Snowder & Fogarty, 2009). When 400 ewes were matched to 670 lambs, the results showed a variation

in ewe efficiency. Liveweight of lamb weaned per kg ewe liveweight, was from 175% down to 32% with the top 25% showing an average of more than double the bottom 25% (Figure 9). Identifying the bottom 25% of ewes on a profit/year scale highlights the importance of a lambing percentage that will provide the replacements needed when selection pressure is applied. Low lambing percentages limit the selection pressure that can be put on flocks from visual and objective assessment.

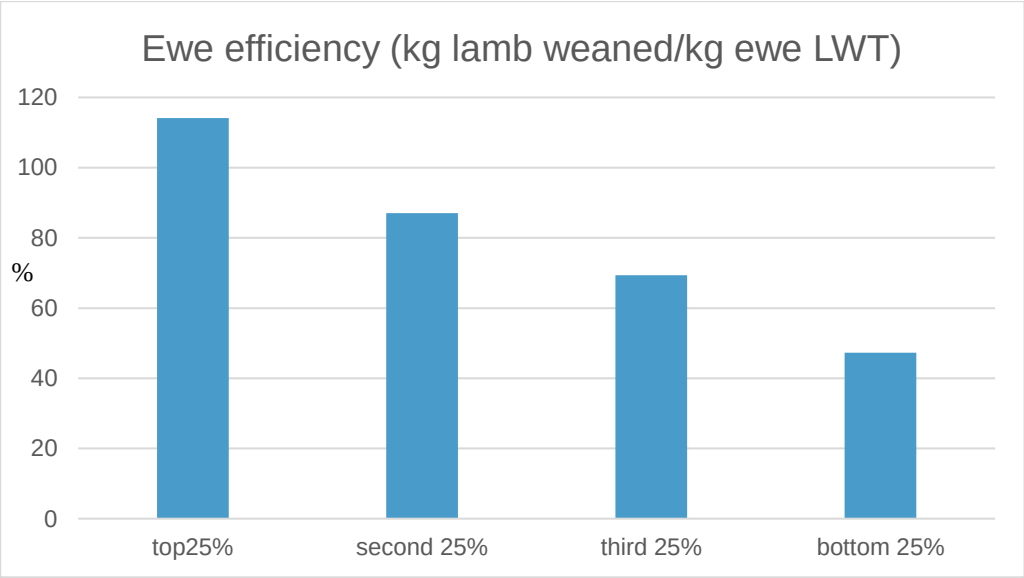


Figure 9: Comparing ewe efficiency in terms of kg of lamb weaned per kg of ewe, the top 25% of ewes is more than twice as efficient as the bottom 25% of ewes. (Source: Own data, October 2014).

With condition score also measured, it is easy to see the range in production levels when ewes of the same age are run on the same pasture (Figure 10).

Figure 10: Kilograms of lamb weaned per ewe liveweight at different condition score at weaning. (Source: Nathan Scott October 2014).

Figure 11: Photo of the ewes represented in Figure 10 demonstrates it is hard to identify which ewe is the most profitable through visual methods only (November 2014).

Lambs from this mob were sold for $2.88/kg in 2014. The poorer ewes produced $60.50 worth of lamb and the best performing ewes produced $227.50 worth of lamb (this excludes the isolated case in Figure 10 which weaned $311 worth of lamb). A difference of $167 per ewe in one year suggests that there is room for improvement in many animals. Matching progeny on a commercial scale, using methods which were cost effective and could take out environmental noise, would deliver huge benefits (M. Ferguson, Pers. Comm., June 2014). This variation in efficiency between ewes is impossible to identify using visual selection only. Figure 11 gives an image of the same ewes represented by dots in Figure 10.

Chapter 7: Selecting Ewe Replacements

This was identified as the second most important area of national focus as it relates to economic return for the industry (Young, Trompf, & Thompson, 2014). Selecting for early maturing, fertile ewe replacements can mean joining at eight months of age is a reality. High Weaning Weight (WWT) EBV in association with YFAT and YEMD are a good combination for producing early maturing, fertile ewe lamb replacements. One of the Dohne Merino philosophies is selecting replacement animals on economically important traits with the most important criterion being measured as the relative production of marketable produce (C. McMaster, Pers. Comm., September 2014). Linking ewe lamb selection back to the main objectives of the business will ensure profitability is being optimised through genetic gain.

There is a significant difference between lambs born from different aged ewes and this needs to be considered when differentiating between genetics and environmental expression. Lambs weaned from maidens are lighter than lambs weaned from older ewes (Woolaston, 2013). Twin-born lambs raised as a twin will have a lower fleece weight and higher fibre diameter throughout their lifetime than lambs raised as a single lamb. Genetic gain is much faster if you can shorten the generation interval by selecting replacement ewes from younger stock (D & T Mackintosh, Pers. Comm., June 2014). IAM gives the Mackintosh family the ability to identify this lifetime data to ensure they do not class out productive stock.

Selection of ewe lamb replacements in Duncan and Tina Mackintosh's self- replacing Landmark flock is based on three measurements and is prioritised in order of importance. Firstly, weaning weight; secondly, ewe lambs born from younger ewes; and thirdly, whether it was a twin or single (D & T Mackintosh, Pers. Comm., June 2014). Understanding that lambs weaned from maidens are lighter than lambs weaned from mature ewes, they allow for a 1.5kg lighter lamb to ensure genetic gain is maximized while still allowing time for these lighter lambs to reach joining weight. Such selection has resulted in their ewe lambs born from two-year old ewes scanning up to 20% more for the same weight as ewe lambs born from older ewes. Similarly, ewe lambs born from two-year old ewes can be 2kg lighter and scan the same percentage as the ewe lambs born from older ewes (Figure 12). A combination of joining the youngest and genetically superior rams, with the ewe lambs has given Duncan and Tina the ability to select the most productive animals coupled with a lower generation interval.

Figure 12: Scanning percentage of Hoggets (ewe lambs) in their corresponding weight ranges, born from two tooth dams (top line) and mature ewes of two different breeds (green and red lines). Relevant data collection demonstrates the significant gains that can be made. (Source: Duncan and Tina Mackintosh, June 2014).

Merino breeder George de Kock from South Africa has a simple method of selecting his replacement Merino ewes. Fertility is the most important profit driver for George so he joins his Merinos to a Merino for the first cycle of three weeks, then replaces these with terminal rams for the second cycle (George de Kock, Pers. Comm., September 2014). This automatically selects early cycling ewes as the source of replacements.

Joining maiden ewes to a terminal meat sire is a way which Anne, Sandy and Tom Welsh (Pers. Comm., October 2014) suggest as identifying the best maternal breed ewes as the source of replacements. The following year, the top producers are bred back to the maternal line with the rest going to a terminal sire.

Chapter 8: Genetic Selection

Genetic selection has to be accurate to be useful (M. Ferguson, Pers. Comm., June 2014). On self-replacing commercial sheep properties, rams are the main way new genetics will be brought into the property. Often being a couple of generations of performance selection ahead and having greater influence over more lambs than individual ewes, rams will also have the biggest impact at the mob level (R. Apps, Pers. Comm., April 2015). Relating back to the KPIs, it is important Australian Sheep Breeding Values (ASBVs) corresponding to the lowest current production levels are given highest priority when selecting rams. Although used widely in prime lamb production, only 18% of Merino studs use ASBVs which limits progress by limiting the accuracy of selection (Woolaston, 2013).

Desirable traits that cannot be visually identified, such as genetic fat (YFAT), genetic muscle (YEMD), and Number of Lambs Weaned (NLW), can all be selected for, using ASBVs. Heritability is only part of the story with the remaining expression of phenotype coming from many other non-heritable factors. Heritability of traits needs to be recognised when making selection decisions. Birth weight (BWT) is highly correlated with weaning weight (WWT) and post weaning weight (PWWT) (Ferguson, Adams, & Robertson, 2007). However, with correct selection, growth rate can be maximised while BWT stays low and WWT can be high while PWWT remains low which will reflect early maturity. Growth rate is also positively correlated with Eye Muscle Depth (EMD) (M. Young, Pers. Comm., June 2014) and this leads to higher Lean Meat Yield (LMY). LMY is negatively correlated with eating quality, which highlights the need for product feedback so that product quality can be maintained, whilst there is a focus on on-farm productivity gains (A. Ball, Pers. Comm., May 2014). The limitation is the estimation of eating quality, as this can only be done by genomic testing at this stage (R. Apps, Pers. Comm., 2015).

Rapid gain in performance is very achievable through genetic selection, however care must be taken to ensure maternal fitness traits are not adversely affected (Ferguson, Adams, & Robertson, 2007). EMD and Hogget Weight (HWT) have a positive correlation to fecundity. Hogget weight is 90% correlated to mature weight. To target early maturity and hence join ewe lambs successfully, South African breeder Wynand du Toit (Pers. Comm., 2014) recognised the need to combine WWT with HWT.

As well as the importance of EMD for reproductive efficiency, the importance of genetic FAT is also paramount to the optimisation of reproduction, particularly under times of nutritional stress. The highly variable Australian climate lends itself to having times of abundant nutrition and limited nutrition in the one year. With a negative correlation between clean fleece weight (CFW) and FAT, wool selection must be done in conjunction with these important carcass traits to optimise profitability. Furthermore, fat content in lamb carcasses is very important for their marketability and eating quality and therefore carcass fatness has an intermediate optimum (Ferguson M. , 2011).

Attention to Detail

Assigning data to an animal gives it individuality. Mob-based management does not need to change and hence it can be a very simple system. Taking a weaning weight only could indicate a significant difference in growth rate due to a 5-6 week joining. If early joining success was being targeted, this bias could be a desirable outcome. Taking a lamb weight at tailing (lamb marking) takes out any difference in weaning weight due to birth date (D & T MacKintosh, Pers. Comm., May 2014). Variation in a flock that has had no selection pressure can be enormous. The variation in 30 unselected bought-in ewes was greater than the variation in 600 ewes that had been measured for 10 years (A & T Welsh, Pers. Comm. October 2014). It is important that ram selection comes from studs that have consistency throughout the drop rather than studs that have a few high performers but a greater range throughout the drop. An exception to this is when the average performance of the whole flock is at an elite level and the outliers are exceptional.

A system can be complex, but this does not mean it has to be complicated. A complex system made up of simple parts leads to greater uptake and a more practical approach to adoption. Having a defined 'purpose' will also lend itself to adopting a simple system; when we do not know why we are doing something, there is little point finding out how to do it.

To measure some traits but not others could lead to selecting the wrong animals. Given the relationship between production and reproduction, both need to be considered to avoid biased selection. It is imperative that measurements are done in alignment with KPIs, as this

will keep IAM simple while maximising reward from effort. The law of diminishing returns applies to data collection; there is an optimum to achieve the best results, while too much data recording is costly and unproductive.

Chapter 9: Traceability

Transparency in supply chains and industry cohesion are essential to get the most out of a good traceability system (A & T Welsh, Pers. Comm., October 2014). When abattoirs buy livestock, they not only own the product, they also own all the information. Most provide some degree of product feedback as they understand it is in the best interest of all involved. Without accurate feedback, objective decisions cannot be made and product specifications are hard to meet. The chance of meeting product specifications on a grid system can be as low as 6% in some flocks (M. Inglis, Pers. Comm., March 2015).

Product safety and traceability are seen by the consumer as part of the service and something they should not have to pay extra for. (D. Hughes, Pers. Comm., July, 2014). China's middle class is expected to grow from 0.5 billion in 2009 to 3.2 billion in 2030 (DEPI, 2014). Five percent of Chinese people will pay extra for product traceability and guaranteed quality and safety. This equates to 70 million people. This sector of the Chinese economy does not just want to know the farm; they want to know the sheep (A. Plummer, Pers. Comm., February 2015).

Seven million cartons of apples are sorted and marketed out of Fruitways Apples in South Africa each year. Apples that enter the packing shed are measured for size, colour and any impurities. The 72 different lines that each variety is split into, gives manager Chris Moodie (Pers. Comm., September 2014), the ability to trace each batch back to the tree area. He can then make changes on water, fertiliser and other inputs, depending on what the market is doing. Although apples are very different to livestock, it was a fantastic example of what a transparent supply chain can look like. The ability to make paddock decisions based on product and market feedback could happen in the lamb industry if EID tags are used. Again, industry collaboration is important if this is to emulate.

Chapter 10: Product Quality

Meat

To concentrate on on-farm benefits at the expense of product quality would be limiting the long-term ability to achieve market specifications. Lamb is positioned in the market place as a premium product – or is it? Farmers identify their lamb as a premium product, but they sell it as a commodity (A. Charteris, Pers. Comm., May 2014). Given the average annual world consumption of sheepmeat (including mutton) is just 1.9kg/head, lamb is not a product that is needed, but rather wanted. If we lose customer desire for lamb, we will significantly limit the ability to sell our product. Consumers will pay for quality product that is consistent and has a good story. The story is important 95% of the time and science 5% of the time. However, if/when it is needed, science will matter 95% of the time and story 5%. It is therefore important to have the science (genetics, feeding, objective measurement) supporting the story, when selling product at a premium (A. Charteris, Pers. Comm., May 2014).

Figure 13 gives the estimated consumption of world meat from now until 2030 and when looked at in conjunction with Figure 14, it is evident that a lot of this meat is driven by developing countries rather than developed countries. With developed countries largely being the major market for lamb, quality will now, more than ever, be a factor sustaining premium prices. European countries have a subjectively based EUROP grid which indicates premiums and deductions from the base contracted rate, based on weight and fat cover. Lack of quality and market differentiation could lead to a depressed outlook for lamb, which will be forced to be priced competitively with the other protein sources. The high Cost of Production (COP) of lamb will make it unprofitable to produce without this premium for quality, so for this reason we cannot afford quality to wane (R. Apps, Pers. Comm., 2015). Lack of eating quality in the future will have a much bigger negative impact in the future than a bit of excess fat ever will (S. Chapman, Pers. Comm., March 2015).

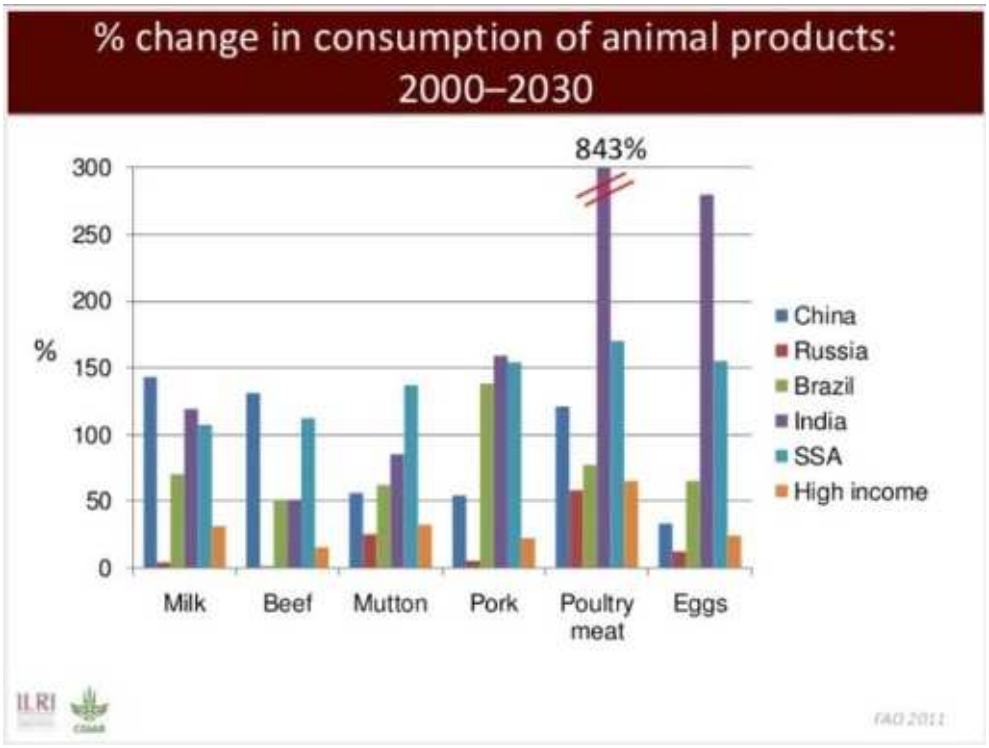


Figure 13: Estimated consumption of meat from 2000-2030 (Source: ILRI, Kenya, April 2014)

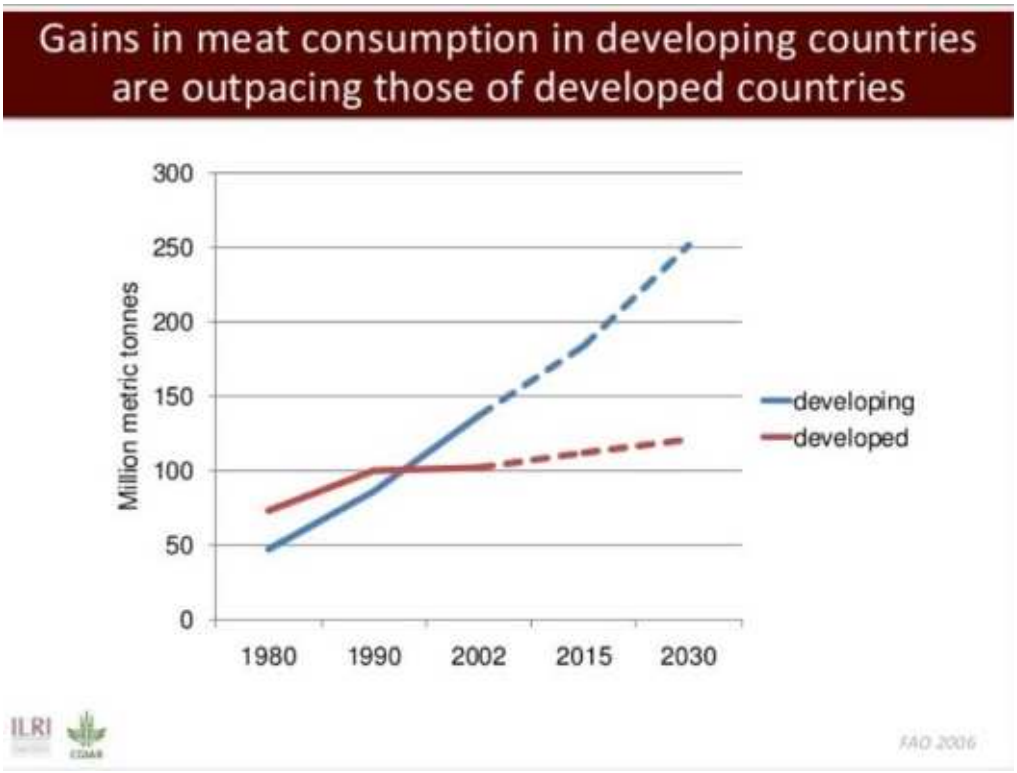


Figure 14: Growth of meat consumption from developed and developing nations (Source: ILRI, Kenya, April 2014)

Growth rate and LMY are key profit drivers on a prime lamb property (A. Ball, Pers, Comm. August 2014). In the absence of product feedback, these can have negative effects on product

quality, in the form of sheer force and intramuscular fat (IMF), and hence consumer satisfaction.

Henrik Anderson and the team at Carometec in Denmark are working on what is called a Fat-o-meter in conjunction with the Sheep CRC and Murdoch University in Western Australia (Pers. Comm., October 2014) (Figure 15). This is being designed to be used in line in abattoirs to give accurate measures of IMF as this has direct correlations to a positive eating experience. There is a lot that can influence IMF from genetics, nutrition and management pre- and post-farm gate. Without measurement and feedback, the ability to make accurate changes to optimise eating quality is compromised.

Figure 15: Fatometer under development at Carometec, Denmark. This will measure IMF through electrical conductivity and is being designed to be used in line during processing (Source: Carometec, October 2014).

Payment on yield is happening in the German pig industry where they not only pay on LMY and eating quality, they also pay on relevant portions of shoulder, loin and rump under different payment grids (H. Anderson, Pers. Comm. October 2014). On-farm decision making as a result of objective product information is a reality with information flow using RFID technology. Due to the negative correlations between LMY and eating quality, yield payments

will emphasise the need for eating quality measurements in the future (R. Apps, Pers. Comm., March 2015).

Wool

Compared with other textiles, wool fits into a niche area with use per capita ranging from a high of 0.7kg in the UK to 0.02kg in India (Poimena, 2009). It is interesting to note that consumption of wool clothing is more sensitive to changes in income than changes in wool prices (Figure 16). As provenance increases, the unique 'wool story' of being a natural, sustainably grown fibre, in pristine environments, carries more weight. Alongside this is the desire for animal welfare to be at the forefront of production. Welfare issues are concerning to consumers and should be addressed to secure marketing a premium product to the affluent consumer. Adding breach and wrinkle score to the overall classing criteria of individual animals gives the ability to select animals best suited to breed replacements, leaving the remaining animals for terminal joining or selling.

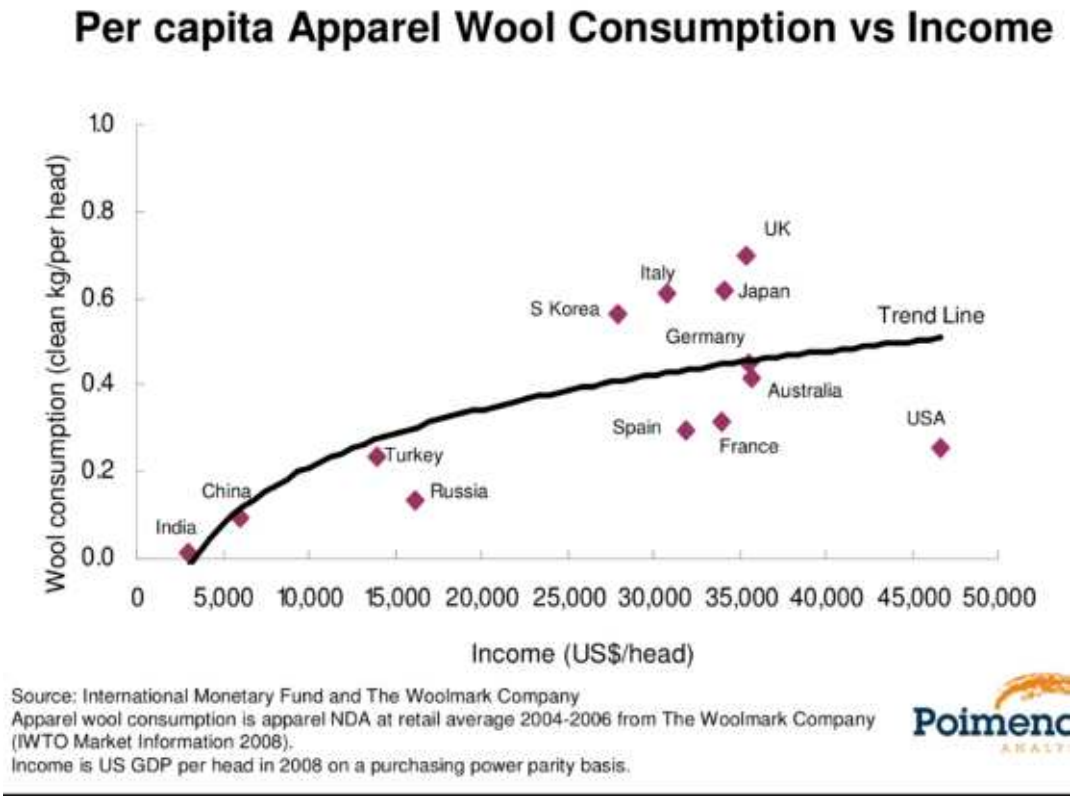


Figure 16: The trend of wool consumption per capita with increased wages. (Source: Australian Wool Innovation, April 2015)

Sheepmeat, lamb and wool are among the products least consumed in the protein and textiles market respectively, leaving little room to drop quality of these luxury products and maintain high demand.

Chapter 11 - Technology

Although the reasons Individual Animal Management could deliver better results to the commercial farmer is the focus of this study, the author also visited a number of technology providers who have the equipment to deliver detailed IAM data. Ear tags are the most widely used device for electronically recording information in a passive manner. All these methods use Radio Frequency technology to transfer the passive ID number to a computer. Additional information about the animal is then added against the ID number within some form of database system.

Presently, only 13 characters in the ear tags are unlocked (R. Webber, Pers. Comm., October 2014) which limits storage on the tag to be the ID number only. Unlocking more characters is something which is being looked at now to allow for further storage on the tag. A hand-held scanner developed by Shearwell is widely used throughout the UK. It is easy to use, allows entry of active information, drafts on multiple criteria, allows comments and will Bluetooth to phone and scales. Hand held devices are also available through Tru-test, Gallagher and Aleis among others, including most tag companies.

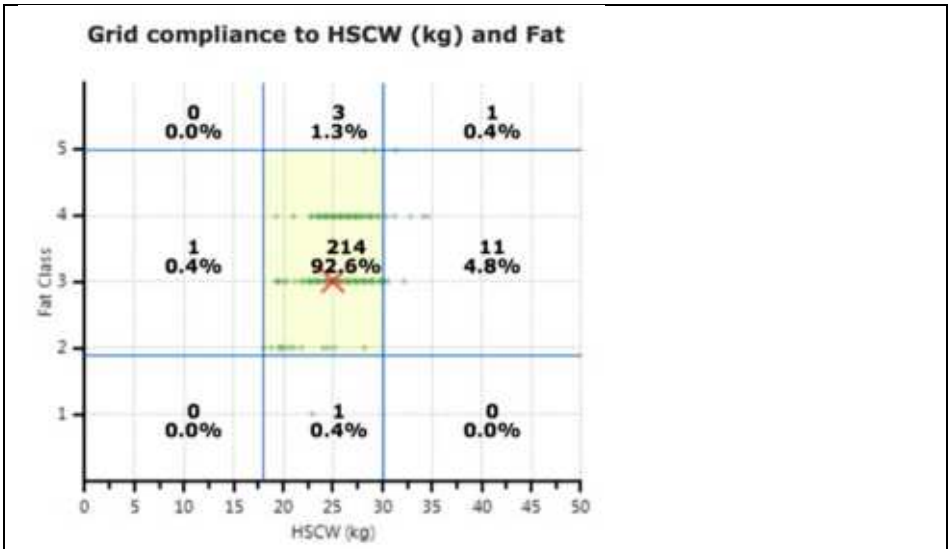
With a lot of sheep and lambs being marketed in Australia through the saleyards, reading each animal is a test of time and accuracy. Shearwell have a double race reader which can read 6,000 animals an hour. Ultra High Frequency (UHF) technology is also under development throughout the world and has the ability to read multiple animals in a pen at one time. However, this technology may limit IAM in yard situations on farm (N. Scott, Pers. Comm., March 2015).

While collecting the data is part of the process, making use of it is where the real benefit lies. There are computer programs that can help make this easier. The two most used in Australia are Practical Systems (Stockbook), and Sapien Technology (Cool Collect). Both these have varying levels of complexity to suit the commercial through to the stud producer. FarmIQ is a farm management program used in NZ which offers a complete record of everything including paddock records, individual animal performance, selection criteria and carcass feedback. A carcass feedback report for the beef sector is shown in Figure 17. Farm IQ is a good program

and gives particular insight into areas which are most limiting the profit margin (D. Mackintosh, Pers. Comm., June 2014).

Figure 17: Sam and Hannah Morrah's Carcass quality feedback sheet for beef from Silver Fern Farms, NZ. This report was for beef only and was produced by Farm IQ software. (Source: Sam and Hannah Morrah, May 2014).

The Australian feedback system, Livestock Data Link, has the ability to give individual feedback from processor to the producer. Figure 18 shows compliance rates of animals under a selected grid with the associated cost of non-compliant animals in the consignment.



Summary of the number head, carcase traits and non-compliance cost	Male	Female	Unknown	All
No. Head			231	231
No. Condemned			0	0
Total HSCW (kg)			5,909.8	5,909.8
Max HSCW (kg)			34.6	34.6
Min HSCW (kg)			18.0	18.0
Avg HSCW (kg)			25.6	25.6
Max Fat Class			5	5
Min Fat Class			1	1
Fat Class mode			3	3
Non-compliance count			17	17
Non-compliance cost			$293.26	$293.26
Non-compliance cost/head			$17.25	$17.25

Figure 18: Feedback from Australia's Livestock Data Link (LDL) on % compliance as well as cost per non-compliant animal. NB: Each non-compliant lamb reduces potential income by $17.25. (Source: ldl.mla.com.au March 2015).

New Zealand farmer Dan Shand recognised the need to have an active computer program to make use of data collected in the yards (Pers Comm., March 2014). His program is designed to be used on a tablet and has been designed for the commercial producer. Whilst still under construction and currently tailored to the NZ industry, this is another program that is designed with IAM as a key output.

In recognising the need to match pedigree on a commercial scale to gain maximum use of IAM, proximity tags are also being researched. This technology will enable communication between tags such as ram to ewe and ewe to lamb. Matching lambs to the mother will help generate an accurate measure of how efficient the ewe is. How much she has eaten and how this corresponds to her own liveweight/condition and the liveweight of her lambs at weaning

is an area of further development. An accelerometer has the ability to identify bites per day and other activities such as time of lambing. Commercial practicality of this technology requires further research.

Conclusion

Linking product feedback with on-farm production and reproduction will help sustain a viable sheep industry. Commercial sheep production can be optimised through understanding the KPIs of the business and aligning data collection of individual animals to these KPIs. Benchmarking on averages is a useful tool in measuring on-farm performance. In addition to this, understanding the full range of animal performance will help highlight the potential of a flock and also a target group. Often, the commercial value of an animal is not recognised under subjective/visual assessment only and needs to be used in conjunction with objective measurement of saleable product: meat and wool.

The role the maternal traits play in the profitability of a self-replacing flock is significant. Maternal efficiency can be optimised by matching ewes to their progeny and taking the liveweight of the lambs and ewes at weaning. The top 25% of ewes can be more than twice as efficient as the bottom 25% of ewes, under identical management. This observed range in ewe efficiency highlights the importance of lambing percentage which allows for selection pressure through surplus replacement ewes. The current method used to link progeny to ewe uses RFID tags and a system called Pedigree Match Maker. Further work is needed in this area to remotely link ewes and lambs and remain commercially viable.

The decline in the Merino ewe number as compared with total ewe number could be a reflection of lower profitability with wool being the sole selection criteria for many years. While wool is a profit driver, benchmark data suggests income from lamb sales has had a higher return rate in recent years. The reality of improving or maintaining income from wool whilst increasing income from meat and surplus ewe sales is an opportunity in the Merino industry. When ewe efficiency data is combined with a wool value per head, ewes can be classed on objective commercial value as well as visual appraisal.

By taking measurements at the same time as animal husbandry procedures are taking place on the annual calendar, time and labour efficiency is maximised. Economic gains only exist if the cost associated with collecting the data is outweighed by gains made with using the information. Successful IAM is the result of relevant data collected against individual sheep and used as a management tool to optimise profitability of commercial sheep production.

Recommendations

Recommendations are made throughout the paper and main points are summarized below.

- Look at the full range in animal performance data as well as the average, and identify animals below average.
- Use a combination of visual and objective assessment to allow underperforming animals on a commercial basis to be identified and culled from the main breeding flock.
- Estimate ewe efficiency by linking ewe and progeny, recording weight of lambs at weaning and correlating this to the ewe liveweight. Further work needs to be done on remotely linking ewes and lambs to identify the most productive ewes.
- Streamline data collection to only include what is needed as defined by the KPIs of the business. Use this information to link product feedback with on-farm production.
- Implement the use of ASBVs when introducing genetics into the flock and target areas most limiting profitability.
- Add carcass traits to the selection criteria in Merino breeding systems to optimise returns from meat and wool.

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Plain English Compendium Summary

Project Title:	**Individual Animal Management in Commercial Sheep Production**
Nuffield Australia Project No.:	1409
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Objectives	• To optimise the profitability of commercial sheep production through measuring the key profit indicators on individual animals and making objective selection decisions. • To investigate methods used in other industries to follow production through to product • To further understand the role of the maternal traits and investigate ways commercial farmers can practically optimise ewe efficiency
Background	The ability to identify the commercially productive animals over the less productive animals is an opportunity if simple and practical methods of objective measurement using EID are understood. There is a lot of variation within commercial flocks which is hard to identify under subjective assessment alone. Objective measurement using electronic tags allows selection of animals on more accurate, economically measured performance. Linking product specifications back to on-farm production and ultimately reproduction is achievable through RFID technology and traceability for biosecurity is therefore the bonus result rather than the only result.
Research	Travelled to South Africa, Kenya, Eastern Europe, Denmark, UK, Ireland and New Zealand and within Australia was undertaken.
Outcomes	• Individual Animal Management allows for a change in focus from the average productivity to the range of productivity within a group. • Targeted selection using visual and measured assessment allows underperforming animals on a commercial basis to be identified. • Feedback on product specifications is imperative to allow linkage to on-farm productivity • Maternal ability is an important aspect of commercial sheep profitability and should be included in the selection criteria of all ram purchases in self replacing systems. • Linking ewe and progeny allows for ewe efficiency measurement to be calculated; however it is also the most difficult to record on large scale. Proximity tags are being researched to make this piece of information easier to measure. . Objectively measuring the performance of commercial sheep can be simple and practical when the main KPIs of the business are aligned to the data collected.
Publications	https://www.youtube.com/watch?v=oOIxAWd_mog