How to Fully Utilise and Rapidly Improve the Australian Maternal Ewe Flock (including Merinos) to Ensure Continuity of Supply Into Our Valuable Meat and Wool Markets

A report for

by Andrew Bouffler
2007 Scholar

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SPONSORED BY:

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Foreword

The Australian sheep industry is facing a crisis due to the continuing downward trend of our national flock numbers. Current estimates place the national flock at around 92 million head, (source: ABS yearbook) which is the lowest level since 1925 and a decline of 46% from the most recent peak of 170 million in 1990. The crisis will stem from continuity of supply issues for both wool and sheep meats as both industries compete for an aging and decreasing ewe base.

The incredible export growth of the lamb industry has been one of Australian agriculture's great success stories over the past decade. Due to a sustained period of depressed wool prices Merino breeders who traditionally would have been using Merino rams have increasingly used Terminal rams to generate cash flow. The problem is that this production system isn't a sustainable situation as not enough replacement ewes are being bred to even maintain the low National flock numbers let alone re-build it. An improvement in wool prices as witnessed over the past 12 months has resulted in a swing back to Merino over Merino joining, leaving the lamb industry with serious supply issues looking forward. The future viability of the Australian sheep industry is dependant on a more productive maternal focused ewe that can produce wool, meat and surviving offspring within the constraints of limited nutrition. This has been highlighted recently by the run of droughts which have emphasised nutritional constraints especially with grain prices at high levels which make supplementary feeding economically unviable.

My initial goals when applying for a Nuffield Scholarship were to search the world for new genetics or breeds, which could be introduced to help solve this problem. I quickly decided that this outcome would be very unlikely as the sheep genetics available already in Australia and the performance testing systems in place via Sheep Genetics (SG) are already the best in the world. In other words this work has already been done by Australian breeders, initially with the first arrival of Merino's from Spain, followed by a constant stream of imports of new genetics and breeds culminating in the last ten years with the big influx of new exotics including the Dohne, SAMM, Dorper and Texel.

As a result my study focus changed to gaining a better understanding on the genetic possibilities and constraints facing the breeding of this superior multi -purpose “super ewe”. In my opinion the breeding of this superior maternal ewe that produces quality product for both our wool and sheep meat markets is essential if Australia is to have a thriving sheep industry going forward.
This report aims to stimulate debate, challenge traditional thinking and breeding objectives while identifying scientifically sound solutions to address the associated problems of a declining national sheep flock.

Acknowledgments

To acknowledge all the individuals, companies and organisations involved in making my Nuffield Scholarship experience so incredible would require a full report on its own. There are, however some people whose help and generosity need to be highlighted. For those that are not mentioned individually I am very grateful for your role in contributing to the whole process.

For my South African visit I would like to thank Cameron McMaster and Henry Londt for the detailed and very full programme they put together. My time with Cameron more than any other defined the path that my Scholarship would follow. For Chile I would like to thank Doug Martin, Falkland Islands – Neil Judd and Critta Lee, Argentina – Jim Sama, and Holland – Chris Schrooten.

I would especially like to thank Nuffield Australia in conjunction with my major sponsor Australian Wool Innovation (AWI). Without the extraordinary organisation and planning skills of Jim Geltch and Janette Lees and the financial backing of AWI the opportunity offered to me would not be possible. This thank you extends to all the previous scholars along with the past and present Nuffield Boards as they have all contributed to the building of the Nuffield brand, which opens so many doors. I would also like to thank Nuffield Canada and in particular Marilyn Sharp and Rod Bradshaw for organising such a wonderful week in Calgary for the 2006 Scholar International conference.

On a more personal note I would like to thank the rest of the 2006 scholars. Being able to share this whole experience with such a diverse, intelligent and probing group of people certainly made it a lot more interesting.

The great thing with Nuffield is that although our year is over we are not at the end but just at the beginning of the Nuffield experience and friendships.

Most importantly I would like to dedicate this report to the people who stayed at home. To my wonderful wife Mandi and children Jamieson, Henry and Ruby, thank you for being so supportive and loving. Mandi's increased and ongoing involvement in our business has been one of the great outcomes of the process. To my extended family, in particular my brother Philip, who bore the main brunt of an increased workload and responsibility during my time away I will be forever grateful.

Abbreviations

AWI - Australian Wool Innovation

MLA - Meat and Livestock Australia

SG - Sheep Genetics

BLUP - Best Linear Unbiased Prediction

EBV - Estimated Breeding Value

SAMM - South African Meat Merino

WPP - Wool Production Potential

FAO – Food and Agricultural Organisation

GFP – Global Focus Program

NLW – Number of Lambs Weaned

CFW – Clean Fleece Weight

BW – Body Weight

ABS – Australian Bureau of Statistics

AAABG – Association for the Advancement of Animal Breeding & Genetics

Executive Summary

Introduction

If you had picked up any rural paper over the past 12 months, more often than not you would have found a headline along the lines of " Merino flock stumbles - Australia is running out of sheep" (The Weekly Times Aug.29, 2007) or " Ewe chase – In search of the Merinos our recovering markets need" (The Land Dec. 6, 2007)

The reality is that Australia's national sheep flock is estimated at less than 92 million, which represents an 80 year low. The breakdown of this figure is more frightening with the MLA conducted June national survey finding that the Merino to Merino matings for winter last year to autumn this year was 61%, across a total ewe flock of 41.3 million. According to CSIRO modelling, 65% is the critical rate for flock rebuilding. These figures illustrate that the downward trend is set to continue, which suggests increased pressure on the Merino to fulfil the role of a dual purpose meat and wool animal (Richard and Atkins 2004).

With the success of the Australian lamb industry the reversal of this dramatic trend is very difficult as Merino producers continue to cash in by joining a portion of Merino ewes to Terminal rams. This greatly reduces the young replacements coming into the system and has resulted in wool production in Australia declining by 57% to 470million kg since 1990.

Any change in the profitability between the two enterprises as witnessed by the recent improvement in wool prices will result in a higher percentage of Merino ram matings, placing considerable continuity of supply issues on the lamb industry.

There are only two solutions to this massive problem. The first is to reverse the trend and build flock numbers, which is proving very difficult especially given the current economic conditions, coupled with a severe run of droughts. The second is to greatly improve the genetic base of the ewes we do have in the system so that they and their progeny can supply more product into both markets. This report investigates how the second of these two options can be achieved.

Report Objectives

To highlight, a genetically superior ewe base can be achieved by producers' better understanding of:

- Their business and where their income is derived
- How traits correlate and work with and against each other
- The value of objective performance testing to ensure genetic progress is obtained
- There is no magic wand or breed but only superior individual animals
- The concept of diminishing returns with regards to sheep breeding
- The greater the genetic variation of a trait within a sheep population the larger the potential gains that can be obtained.
- The bulk of new breeding techniques such as BLUP are well established, proven over decades within the sheep and many other animal breeding related industries.

Conclusions

All sheep producers involved in breeding with breeds such as Merino, Dohne, SAMM, Bond, Corriedale, Cormo and Comebacks are already involved in dual-purpose maternal breeding programs.

There is a relatively low negative correlation between fleece weight and other traits associated with fitness such as fertility and growth. This probably goes a long way in explaining the Australian Merino's relatively low weaning rates.

The divide between producers adopting modern breeding techniques like performance testing using BLUP, DNA markers as they come on line, artificial insemination and embryo programs while widen exponentially with traditional breeders who rely solely on subjective evaluation.

"As long as you maintain a large varied population size to select from in any population there are no physiological limits to genetic progress". (Professor W Hill Edinburgh University)

Introduction

I manage a family farm in partnership with my brother (Philip) and wife (Mandi) at Lockhart in the Southern Riverina in NSW. Our operation consists of 2850 Hectares of which approximately 1250 Hectares is winter cropped annually. Crops are grown with a minimum till focus and include wheat, barley, canola and faba beans. I am the principal of the Trigger Vale Bond and White Suffolk Stud and it is within this role that my focus and agricultural interests lie.

The basic objective of our breeding programs is to provide both commercial and stud clients with Sheep Genetics, (SG) (performance tested genetics) that will impact directly on the profitability of their sheep flocks. The fact that I need to add that the performance-tested figures are used in conjunction with visual assessment in all selection decisions illustrates a major problem in the Australian sheep industry, which will be addressed later in this report.

SG was launched in October 2006 and is jointly funded by AWI, MLA and the current users of the service. I am currently a sitting member of the SG Advisory Board and my travels highlighted that the SG database size, intellectual property and world leading geneticists are the envy of the rest of the world.

The Bond breed of sheep is a dual purpose maternal developed in the Lockhart region during the 1940's by sheep breeder Thomas Bond and classer Jim Daley. Our family have had an association with the breed since 1952 when we formed our stud. When the Bond breed broke away from the Corriedale Association in 1983 my father Jim was the inaugural president of the Australian Bond Sheep Breeders Association. My interest and breeding in the concept of a dual-purpose sheep started at a very early age and along with this came the realisation of how difficult this actually can be. This was highlighted when we formed our terminal White Suffolk stud in 1998 as we were able to make quicker genetic progress in this breed as the breeding objectives are focused just on meat. I have watched with great interest and some concern over the past decade as the Australian sheep industry has been flooded with new foreign breeds and local bloodlines claiming to be the one and only true dual or multi - purpose sheep, as they all represent to myself both competition and a potential new genetic source.

The first thing that I learnt in South Africa was that to a degree they are all correct in their claims as the reality is there is no such thing as a single purpose sheep. Even the wool shedding meat focussed Dorper has maternal traits or an ultra fine Merino wether has some mutton value at the end of its wool producing life. When stripped bare with the emotional and subjective appraisal removed from the equation, it's the amount and relative proportion of farm income derived from different traits that highlights the actual genetic variance between breeds or individually within breeds and flocks.

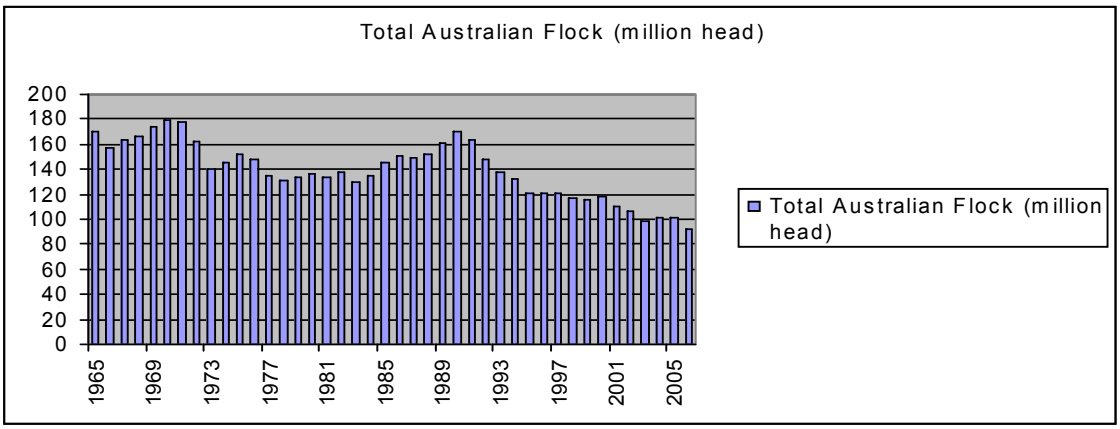
The real challenge facing the Australian sheep industry is for breeders to objectively, through performance testing, get a clear picture of what each of these different and even individual animals within a breed bring to the whole Australian genetic table. If this can be achieved we will then have the information required to realistically breed a true dual purpose maternal ewe that will allow continuity of supply and future growth of our wool and sheep meat industries. It is only now with the developed and proven tools like BLUP generated EBVs and Genomics about to come online that this outcome is realistically achievable. It is an exciting time to be involved in the Australian sheep industry.

Tigger Vale Bond hogget sale rams - dual purpose Maternals

Chapter 1: The Current picture

I feel that a brief overview of the current supply and demand picture is necessary to illustrate the seriousness of the current crisis facing the Australian sheep industry. Figure 1.1 highlights the steady decline of the Australian flock since the 1980's.

Figure 1.1 (Source ABS Yearbook & State Statistical Summaries)



There can be no denying the steady downward trend. The most worrying aspect is that there is no sign that the trend is slowing or even starting to flatten out. The interesting thing I learnt during my visits to many of the world's main sheep producing countries is this decrease in sheep numbers is a worldwide phenomenon. China is the only large sheep producer in the world, which has a national flock increasing. Australia, New Zealand, South Africa, Argentina, Chile, USA, and Uruguay all have flocks on the decline. Even though China's flock is increasing it still fails to satisfy domestic demand so its growth has little impact on tradable world supply of wool or sheep meats. With wool being one of the major products of Australian sheep and predominantly exported it is not surprising to see that the declining flock has corresponded with both a decline in total wool production and volume exported (refer Figure 1.2 and 1.3).

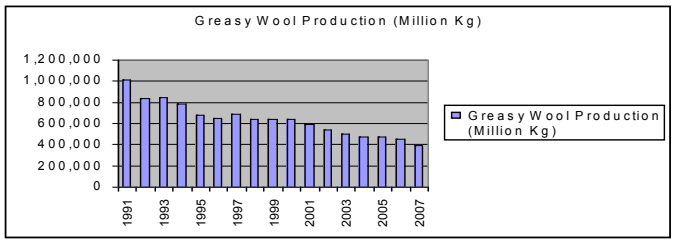


Figure 1.2 (Source: Foreign trade Statistics, the Woolmark Company)

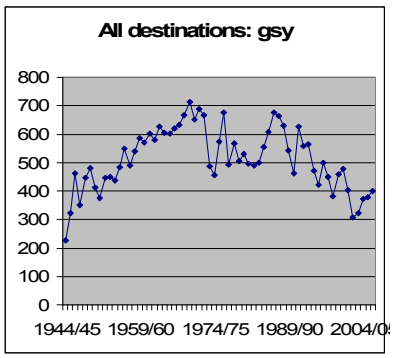


Figure 1.3 Aust. Total wool exports (Source: as per Fig. 1.2)

What is interesting; however is that this trend has not flowed through to the lamb industry with Figure 1.4 showing the dramatic increase in lamb exports over the past two decades. This export growth has also coincided with the domestic per capita lamb consumption also increasing.

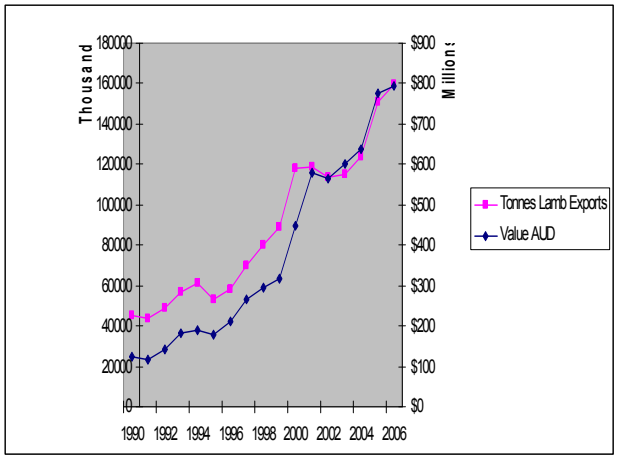


Figure 1.4 (Source: ABS Yearbook, 2006)

Closer analysis of the figures show that since 1990 there has been a 57% decrease in total wool production compared with only a 46% decrease in total sheep numbers. This illustrates that due to the relative profitability there has been a swing to lamb production within sheep enterprises. This coupled with dramatic productivity gains in the lamb industry has allowed the growth of this industry during a period of falling sheep numbers. As a result this leaves the lamb industry exposed to any readjustment to the relative profitability of the two industries. The first indications of this has been seen in the past 12 months with a improvement in international wool prices resulting in strong Merino spring ram sales at the expense of some terminal sales.

The recent increase in the wool price received by producers is a result of tightening supply and increasing world demand and is even more impressive when viewed in light of the strong Australian dollar. During the global focus part of my Nuffield experience we were reminded time and time again about changing consumer buying patterns and what drives their purchasing decisions. Particularly in developed countries consumers are becoming increasingly aware of the environmental footprint being left by there purchasing decisions. A natural renewable fibre like wool is ideally suited to benefit from this growing concern.

It seems that the marketing, research and development done by AWI and private companies like Icebreaker in New Zealand with regards to the fantastic natural properties and attributes of wool is starting to pay dividends. This coupled with the easy care characteristics, new blends and "next to skin properties" of woollen products in this environmentally conscious market place suggests very strong future demand.

With regards to lamb the potential increased demand worldwide is virtually only limited by supply constraints. The Food and Agricultural Organisation (FAO) estimates the current world per capita sheepmeat consumption averages 1-2 kg. This compares with 15kg of beef, 20kg of pork and 25kg of poultry meat in developed countries. Developing countries consume about half of these volumes for beef, pork and poultry so sheepmeat is a higher proportion of their diet.

Cooking traditional lamb - Argentina

World meat consumption is projected to increase by 20% over the 10 years to 2016 (FAO-OECD Agricultural Outlook). This will require an additional 108 million tonnes of meat production per annum to satisfy the growing demand (source: Rabobank Global Focus – summer 2007). If lamb simply maintains its current percentage of meat consumption this represents approximately a 5 million ton increase. It is likely that due to the breakdown of the lamb carcase into high and low value cuts and the targeting of well established niche markets such as the US for the higher value cuts (racks, legs and loins) that lamb's percentage of world meat consumption will increase.

The developing markets as they switch their diets from rice to meat protein are currently important customers for the lower priced cuts and offal's. As disposable incomes in these developing countries increases further they are likely to create extra demand on the higher value cuts. This bright future is further enhanced by the fact that sheepmeat in developing nations are already proportionally a higher part of their total meat consumption patterns. For example, in India sheepmeat comprises about 15% of total meat consumption.

Marketing work does not have to be implemented to improve market share, as it is already high. To benefit from India's potential the Australian Government needs to apply pressure on India's stringent import and market access restrictions to open the market up for Australian exporters.

As I travelled around the world during the Global Focus Program (GFP) a recurring theme was summed up during our meeting with Chuck Dias during our visit to California who stated that, "in modern agriculture consumers perceptions have become reality". While Chuck was referring about urban based consumers that quote remained fixed in my head as it seemed to sum up a long time concern I have had for the Australian sheep industry.

In Australian Agriculture and possibly the wider community the general perception is that the sheep and particularly the wool portion of the industry has lost its importance and relevance. The endless reporting often by the rural press of negative news stories about drought, low wool prices, johnes disease and the shift away from sheep enterprises to other so call perceived glamorous enterprises such as cattle, cropping and viticulture has fed this perception over the past decade. This perception has been fuelled further by many consultants, agronomists and multi-national reps (including fertilizer, chemical and machinery companies) bombarding farmers with short term enterprise benchmarking and the promise of the big cropping windfall year that in many cases has failed to materialize.

The reality is that even with the difficult conditions over the past decade and the low flock numbers the wool industry in 2006 was Australia's second most valuable farm export industry with a total value of $3.07 billion (Australian Bureau of Statistics 2006). Given one of the goals of this report is to identify that the wool and sheep meat industries are linked and reliant on each other its interesting to note that when the wool figure is combined with sheep-meat exports of $1.57 billion (Australia Bureau of Statistics and Livecorp 2006.) the combined total challenges beef position at number one as Australia's top export earner.

In conclusion, while it is obvious that Australia's economy no longer rides on the sheep back the significant contribution the sheep industry makes as a proportion of Agricultural and total exports highlights the importance of both the wool and lamb industry and in turn why the declining national flock and continuity of supply problems need to be addressed. This is a major objective of this report.

The tightening world supply situation along with the likelihood of increasing demand for both wool and lamb suggests that Australian sheep farmers face great opportunities going forward. From what I saw first hand during my Nuffield travels, the consumers are not only demanding more of our sheep products but are willing to pay for it. The continuing strengthening of the Australian dollar could compromise the full benefit of this situation.

Exported Australian Merino rams at Estancia Tecka - Argentina

Chapter 2: South Africa and Falkland Islands

The single best decision I made while organising my Nuffield program was to spend a month in South Africa first up. Two issues that where brought to my attention and redefined my final topic and future direction of my studies.

They were the concept of the "meat to wool income ratio" and the negative correlation between wool production and fitness traits and the implications of both these things for sheep breeding programs.

2.1 The meat to wool income ratio

During my visit to South Africa I observed that every sheep producer I had a meeting with knew exactly what proportion of total income was being derived from the meat and wool sections of their business. They referred to it as their "meat to wool ratio" and they always spoke about it as a percentage of total income. For example if someone had a meat to wool ratio of 70:30 then meat made up 70% of total income and wool 30%. Without fail when I asked the question, "what is your meat to wool ratio?" apart from getting the answer, I also got invaluable insight into their breeding direction and objectives. This was because they were making breeding decisions based on the relevant importance of each product on total income.

While always careful in making broad generalisations and acknowledging that there was considerable variations from these averages, as a rough guide the ratios of the different breeds I saw were as follows.

- South African Merino 60:40
- Dohne Merino 70:30
- Afrino 80:20
- South African Meat Merino (SAMM) 90:10

High fertility SAMM flock near Stellenbosch, South Africa

While the ratio varied both between breeds and between individual flocks of the same breed the fact that the meat was always the major income stream remained constant. This is due to the very high level of domestic demand constantly placing upward pressure on prices in South Africa. It is interesting to note that even though South Africa has the eighth largest sheep flock in the world they are net importers of sheep meats.

South African sheep producers recognised the importance of this strong domestic market and hence high prices on total farm income nearly 40 years ago. By using the meat to wool ratio they identified the economic drivers, listened to customers and directed their breeding towards animals that would drive increased profit in their businesses. With these forces at play it isn't hard to understand why dual-purpose breeds such as SAMM's, Dohne's, Alfrino's and very plain-bodied Merino's have developed.

For the Australian industry I believe the introduction of the "meat to wool ratio" as a standard business practise would be of great benefit. Historically, the Australian wool industry has played a major role in the shaping of our nation. I think as a result the wool industry still may have a slight "hangover" from these heady days with the historical view of Australia riding on the sheep's back hard to move away from. While there are always exceptions when asked, Australian sheep producers still tend to answer that they are specialist wool or lamb producers. In reality in most cases they are either directly or indirectly both and the introduction of the "meat to wool ratio" would be very beneficial in illustrating this. For example, once a wool producer identifies that he actually derives 25% of his income from joining his cull young ewes or Cast for age ewes (CFA) to a terminal ram or selling them to an irrigation farmer for lamb production he should start to view his business and the decisions on his breeding program differently.

It has only been over the past decade the Australian sheep industry has faced the same sort of economic realities that South Africa have had for over 40 years. The increases in both export and domestic demand for lamb in Australia over this period and hence prices received have dramatically changed the relative profitability of lamb compared to wool. While acknowledging that the larger proportion of farm income in wool focused flocks is still derived from the wool cheque the increased importance of income coming either directly or indirectly from the lamb industry should be taken into account when making future breeding decisions. This brings me to my theory of diminishing returns in sheep breeding which is discussed in chapter 6.

2.2 The negative correlation between wool production and fitness traits

One of the highlights of my Nuffield experience was a morning I spent in the company of Cameron McMaster and Wynand du Toit. Cameron is the immediate past Director of the South African Dohne Association and Wynand owns a very impressive mixed farm operation near Bredasdorp and is the stud principle of one of South Africa's leading Dohne studs.

Cameron inspecting Wynand's hogget sale rams

While doing a farm inspection of Wynand's operation I asked him the question that if he had a magic wand and could improve any facet of his sheep enterprise by 10% what would it be. This was my standard question, which I asked at all farms to identify what they perceived to be the major weakness of their operation. The standard answers were generally along the lines of lift lambing percentage, increase wool cut, decrease micron or improve growth rates, which is what you would generally expect.

In Wynand's case his answer was to improve lamb survival or decrease lambing loses which was quiet different to the standard answers. When questioned further he stated " that he was very happy with the performance of his sheep in general including fertility and conception rates however was constantly frustrated by the losses incurred between pregnancy testing and weaning". While I found that answer very interesting it was Cameron McMasters comment from the back of the car, which proved to be the defining moment of my studies.

That being "**your ewes must have too much wool cut per head which is compromising their overall fitness".** This conversation and a future meeting with Cameron where we explored his views in more detail directly lead to the rest of my studies investigating the compromise between selecting for production and the fitness attributes of your flock. With fitness being defined by the Oxford dictionary as – the ability to survive, grow and reproduce in a particular environment.

Cameron McMaster during his role as the Director of the South African Dohne Merino Breed Society was responsible for investigating and setting the breeds selection objectives for the dual-purpose breed. During a 4 hour meeting with Cameron, the single point which he stressed over and over again, was that "maintaining an optimum relationship between clean fleece weight and body weight forms the single most important part of the breeding goals for dual purpose sheep". This relationship is termed Wool Production Potential (WPP%) and is calculated by expressing the average clean fleece weight of a flock as a percentage of average body weight.

WPP = Clean Fleece weight X 100 / Body weight

Cameron went on to say that, "a WPP of 7% is the figure which the Dohne breed uses as the maximum desirable for optimum profits. If clean fleece weight increases or body weight decreases pushing the WPP higher than 7% the negative effects on fitness, reproduction traits, hardiness and adaptability will result in falling total flock income.

What this formula tells us is that if a wool cut per head increases due to selection pressure relative to body weight then a ewes ability to do other things well like conceive, carry a pregnancy to full term and lactate will be compromised.

These observations by Cameron were based on studies conducted by Herselman *et al* 1998 and Wentzel *et al* which both built on decades of research which suggested a negative relationship between fibre production potential and fitness or hardiness. Figure 2.1 illustrates clearly why Herselman *et al* concluded that, "**any selection program with the net result of increased WPP will have a detrimental effect on ewe productivity irrespective of breed and environment"**.

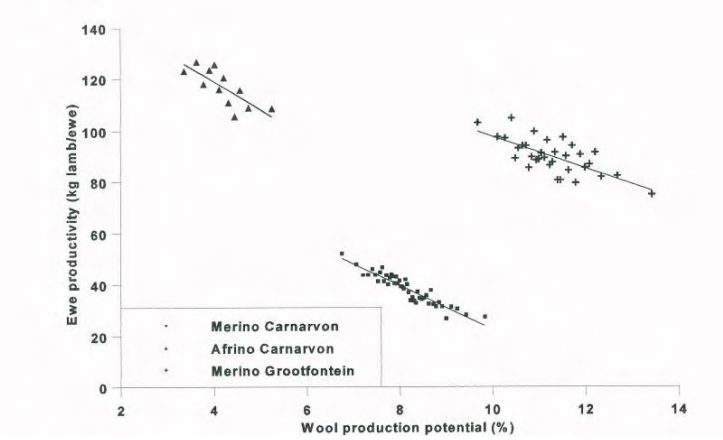


Figure 2.1 (Source: Herselman *et al*)

Relationship between wool production potential (%) and ewe productivity over three lambing opportunities (kg lamb weaned/ewe) in the Carnarvon Merino and Afrino flocks and in the Grootfontein Merino stud

The third factor involved in this relationship between production and fitness is the environment. The more hostile or sub-optimal the environment the more severe the increase of WPP will be on the ewes fitness. This is just common sense as any ewe has been genetically programmed to produce a certain amount of wool. Her genetic make up has a maximum potential for clean wool production, which she can only express if both the quality and quantity of her food is sufficient.

For example, if you have two ewes both running in optimal feed conditions until hogget age then they will express the full potential of their genetic make-up for wool production. If they both weigh 55 kg's when weighed and shorn and ewe 1 cuts 4 kg's and ewe 2 cuts 6 kg's of wool then their WWP will be 7% and 11% respectfully. If these two ewes are now placed in an environment where both feed intake and quality is greatly reduced the heavy cutting ewe (ewe 2) will still try and produce 6 kg's of wool. If due to her environment she only produces 5.5 kg's then clearly her diet was insufficient for her to express her potential. The fact that ewe 2 produces 5.5kg's on this diet indicates that ewe 1 who is programmed to produce 4 kg's should have little trouble in expressing her full genetic potential on the same diet. If she has been selected for reproduction, maternal (milking) and high growth traits there should be surplus in her diet to allow the expression of these. If ewe 2 has also been bred for these other traits common sense tells us that she will defiantly struggle to express them.

It is the prevailing economic conditions at the time that will dictate which of these two ewes are the more profitable to be running in this environment. Even if the wool price is extremely high then the 1.5kg's of extra wool may not be enough to compensate for the possibility that ewe 2 won't raise a lamb.

2.3 The Falkland Islands

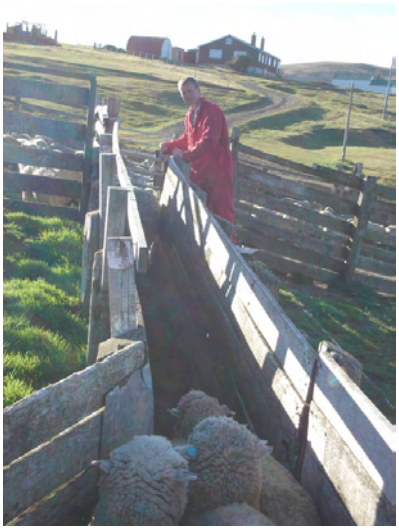
My visit to the Falkland Islands in April highlighted possibly like no other place on earth the impact of environment on sheep production systems. Without a doubt the conditions here were the most hostile I had ever seen for running sheep. The natural vegetation such as a plant called diddly dee had very low nutritional value and digestibility. The climate and soil types made the establishment of large areas of improved pastures impossible. The annual rainfall while not extremely high (400-700 mls) was spread over a lot of rainy days and the low temperatures, infrequent snowfalls and high winds for a large portion of the year all combined to create a very challenging landscape for running sheep.

Falkland Islands grazing land

Local residents quickly informed me that sheep were by far the main agricultural enterprise as the climate and soil types were such that very few other agricultural activities could be carried out here.

The program for most sheep enterprises on the Falkland Island was dictated by the season with a mid to late spring lambing the only option if any lambs were going to survive here at all. The properties were very extensive and rugged making supplement feeding over the severe winter months virtually impossible so a mid to late spring lambing was necessary so that the ewes could put on some of the condition lost over the winter prior to lambing and lactation. A lambing percentage of 70% was exceptional with the average more likely to be around 55-60% for the farms I visited.

I spent two nights with Critta and Beccy Lee on Port Howard farm during my visit to the Falkland Islands and it was here during a general conversation with Critta that the importance of body fat in this whole production versus fitness trade off came to prominence. Critta made the comment that they really only have a small window of 3-4 months where they have favourable feed and weather conditions. During this period from late spring into summer his ewes must raise a lamb, wean it and then put on enough condition (body fat) to be able to fall pregnant again and have the reserves put away to survive the autumn and winter. He went on to say that if he can't get enough condition on his ewes over this period then her chance of raising another lamb the following year is low. As a consequence of the above lambs must be weaned quiet young and small and they must then put on enough body weight and fat reserves before autumn to survive the winter. The ones that don't will more than likely die from exposure and weaner losses are quiet high.



Critta Lee drafting sheep in Falkland Islands

This conversation and seeing the Falkland Island conditions first hand really highlighted and reminded me that the storing of body fat in the good times is natures way of storing little hay stack reserves for the tough times and logically must tie into the whole production versus fitness story.

Due to supply chain wastage, costs and consumer diet concerns the Australian sheep industry and particularly the terminal breeds has moved to selecting animals in general with less fat. While this may be very beneficial to the profit margins of processors, wholesalers and retailers down the supply chain, in some production systems if the selection for less fat is pushed to far it could be quiet detrimental to the overall profitability of their sheep enterprises.

In the case of lamb feedlotters or finishers on irrigation or highly productive improved pastures this would not be the case and selecting for animals with lower fat would be desirable as the goal is to convert as much high value feed to saleable meat as possible. The current economic conditions however with high grain prices, very expensive water for irrigators and a run of droughts has resulted in a shift back to grass, stubble and failed crop finishing systems and the industry push for leanness could cause problems for both the finishers and breeders of these lambs.

If the goal of my study is to outline the possibilities and constraints in producing a superior maternal ewe (including Merino's) that can supply more wool, lamb and progeny then the role fat plays in achieving this outcome can not be understated and is investigated in more detail chapter 4.

Wynand du Toit's 5000 head labour efficient lamb feedlot – South Africa

Chapter 3: Examples from other species

3.1 Dairy

As part of my research I spent some time in Holland to investigate what insight could be gained from other species and production systems on the inverse relationship between breeding for production and fitness. I met with Chris Schrooten who worked in Research and Development for New Holland Genetics. New Holland Genetics is recognised as one of the major genetic herd improvement schemes for Dairy in the world. They have been using performance testing and BLUP for decades to maximise the rate of genetic gain in traits that drive profitability such as increased milk production and milk protein and butter fat content. Figure 3.1 shows clearly the spectacular production gains achieved. What is of great interest was the corresponding decrease in fertility over the same period

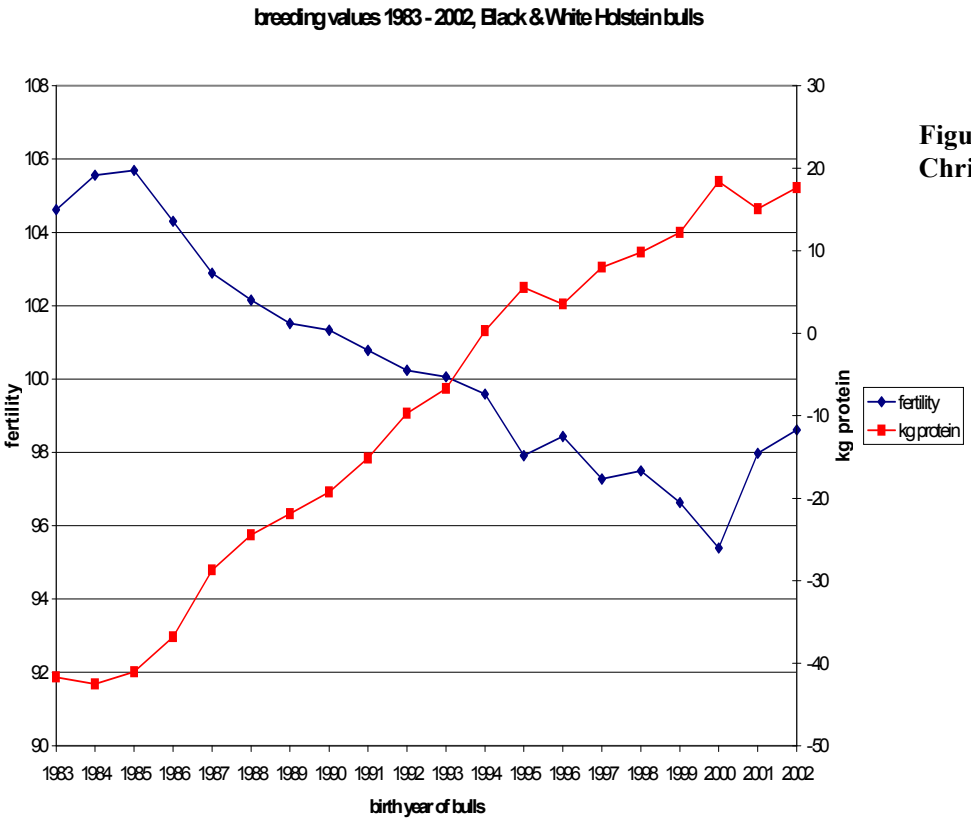


Figure 3.1 (Source: Chris Schrooten)

Chris stated that the near perfect inverse relationship shown above was reflected in Holland Genetics EBV's for fertility dropping dramatically in their database over this period. This along with the anecdotal evidence that their customers were having serious problems trying to get heifers pregnant illustrated without doubt that a negative correlation between production and fitness was present.

This has greater implications for sheep producers as he stated that the genetics had reached such a high level of production that little energy or protein remained in the system for reproduction and body maintenance. It's interesting to note in Fig 3.1 that production is represented as kg's of protein. Protein is the main building block for wool production, which makes this comparison between the dairy and sheep industries even more interesting.

In 2000 due to the fertility problems New Holland genetics changed their selection index from 70% production: 30 % functional traits to 40% production: 60 % functional traits. Functional traits included fertility, longevity, disease and conformation. The dramatic improvement in fertility since the weighting of the index changed without sacrificing any of the previous production gains is a great outcome. If you take the comparison right through to the Australian Merino industry it is not unreasonable to surmise that it is possible to improve fitness traits such as fertility and hardiness without compromising current wool production levels.

3.2 Angora Goats

When looking at all fibre producing animals in the world the Angora goat is regarded as the extreme with regards to efficiency of fibre production when expressed as the amount of fibre produced per unit body mass. i.e. (It has a very high WPP %). Dr D Wentzel's paper titled "Fibre production potential versus fitness in fibre producing animals" states that "the Angora goat with its unsurpassed efficiency of fibre production is, however, also well known for its characteristics reproduction problems. Beside poor conception rates, the incidence of disastrously high abortion rates, afflicting up to 80% of the breeding animals in some flocks, has presented for many years a serious problem for the Angora industry. Furthermore, the frequent losses of varying numbers of animals during cold spells and the poor growth rates of young animals, coupled to an exceptionally high mortality rate add to these serious constraints."

Broadly speaking the paper found that trials on the Angora goats found that when placed under various kinds of nutritional or other kinds of stress the demand for energy increased. This was reflected by a decrease in blood glucose concentration leading to the cause of most abortions. (Wentzel, 1990)

To me this highlights once again the important role body fat must play in smoothing out these periods of higher energy demand in animals selected for production as fat is the body's short term energy reserve.

The paper goes on to state that, "the energy cost of fibre production has been estimated to be approximately four times higher than the requirements for body growth". If this observation is true it explains why the low fibre producing Dorper can obtain such high growth rates compared to the Merino in our low feed value pastoral country.

3.3 Belgium Blue Cattle

These are another good example of pushing production without keeping a focus on the overall fitness of the animal. For decades the breeders of these beef cattle have been selecting for higher and higher growth rates as clearly quicker growth and hence turnoff is a driver for profit. The problem is that there is a well documented, and proven positive correlation between growth rates and birth weights. The final result of this single focused breeding objective of growth at all costs has resulted in calf birth sizes, which can-not in the majority of cases be born naturally. The result is calves are born by caesarean section performed by vets and the cow generally is limited to 3-4 calves in a lifetime. This is another good example of nature's way of keeping things in balance. Other industries such as meat chickens, layer hens and intensive pig production have similar stories to tell when production has been pushed at a faster rate than associated fitness traits.

While many cynics and knockers of performance testing and BLUP will advocate that the above examples are a good reason for not adopting the technologies I take the opposite view. The fact that by using BLUP and selecting for these production traits you can get such extreme outcomes is the ultimate proof that the science works. The sheep industry generally has been relatively slow in adopting these techniques, and we now, as a result, have the advantage of learning from the mistakes of other industries. We must put selection indexes in place, that ensure, that as we put increased selection pressure on traits that drive production, we also put weighting on other traits that ensure fitness, and hence overall profitability continues to increase.

Chapter 4: The Australian Story

4.1 Sheep Genetics

Due to my current role on the Sheep Genetics Advisory Committee one of my aims during my travels was to investigate whether any other sheep producing countries had a performance-testing database in place, which was superior in any way to Sheep Genetics. While picking up some small reporting and presentation ideas I quickly learnt that Sheep Genetics is by far the largest and most accurate sheep database in the world. Due to the investment of grower funds via their meat and wool levies into Sheep Genetics we have at our disposal a world-class database with over a million animal records in Merino Select alone. Due to the huge sample size the accuracy of heritability and correlations of traits is extremely high.

The Sheep Genetics database shows clean fleece weight (CFW) is moderately negatively correlated to Number of lambs Weaned (NLW) at -0.1. The NLW EBV is a very good indicator of fitness as it reflects the animal's ability to reproduce itself. This result falls neatly within the range of results complied by Safari and Fogarty in their Technical Bulletin titled "Genetic Parameters for sheep Production Traits – Estimates from the Literature".

This moderate negative correlation between CFW and NLW probably goes along way in explaining the Merino's relative low lambing percentages. While the correlation is relatively small the cumulative effect of over 200 years of selection for increased wool cut per head must have indirectly impacted on the Merino's fertility levels.

During a visit to Sheep Genetics office in Armidale I had a series of meetings with various genetic experts and researchers to discuss their views on the negative relationship between wool cut per head and fitness (fertility). One of the meetings was with Rob Banks who brought up the subject that in most cases in literature the correlation figures between CFW and NLW are not adjusted to weight. This was a very interesting observation and tied in with what Cameron McMaster was talking about during my visit to South Africa with regards to WPP% or the relationship between CFW and body weight.

4.2 The most up to date research

There have been a number of papers presented in the past two years from Australian researchers, which further emphasises the impact on fitness traits when selecting for production, and puts more light on the complexities of the subject.

A research paper by Hatcher and Atkins titled "The impact of phenotypic selection for clean fleece weight on reproduction" was recently presented at the AAABG conference in Armidale NSW. The paper stated that, "establishing which component trait of Merino reproduction is most sensitive to selection for increased CFW is the first step in developing potential genetic or management solutions to ensure continued improvement of the Merino breed into the future".

Figure 4.1 once again highlights that high CFW ewes had lower weaning percentages than lower CFW ewes, which is consistent with what I had already covered in this report.

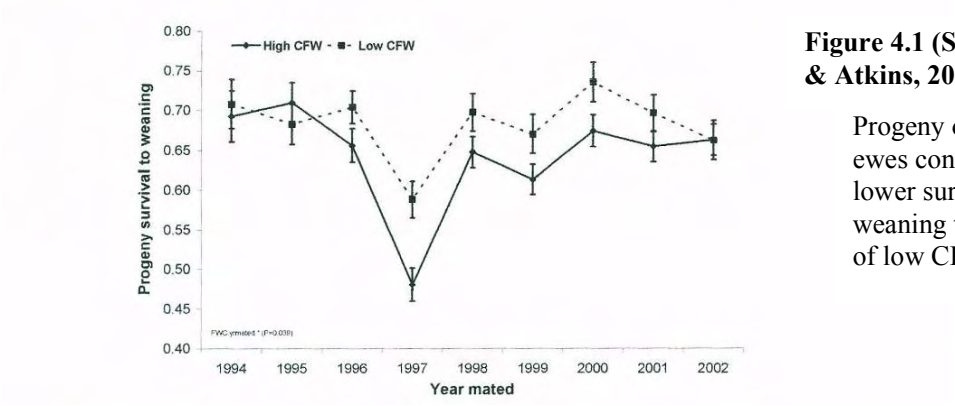


Figure 4.1 (Source: Hatcher & Atkins, 2006)

Progeny of high CFW ewes consistently had lower survival to weaning than progeny of low CFW ewes

What is very interesting is that research found that CFW had no impact on the ability of a ewe to conceive, the proportion of ewes lambing, litter size or the number of lambs born. Where the losses occurred for the high CFW ewes was the rate of survival of the lambs from birth to weaning. This result was confirmed in research by Refshauge et al. (2006) who found that, although there was no significant difference between the birth weights of high and low CFW ewes, the high CFW ewes weaned fewer lambs. From this research it is reasonable to assume that where the problem lies for high CFW ewes is in the lamb's ability to survive until their first drink and then the ongoing milk production of the ewe.

I can't stress the importance of these findings enough for delivering positive outcomes from my Nuffield studies. I have had lengthy discussions with former CSIRO researcher Norm Adams with regards to his work in Western Australia, which adds considerable insight into this whole area. As a result I have inserted the following extract from the Hatcher and Atkins paper as it provides a perfect overview of my current thoughts and sums up what is quite a difficult and complex subject.

> "Recent intensive animal house studies have indicated that energy metabolism is adversely affected by selection for wool growth in that high CFW sheep tend to have a lower metabolic energy status and body fatness than low CFW sheep and an apparent greater feed intake not fully accounted for by their relatively lean mass (Adams et al. 2006). This implies that high CFW sheep may require more supplementation when feed supply is limiting. Preliminary analysis of data from a field study found that ewe fat score was affected negatively among sheep selected for high CFW when feed intake was restricted by higher stocking rates (Refshauge et al. 2006b) has confirmed this implication.
>
> The critical period of the breeding cycle for high CFW ewes appears to be lactation. The management protocol for the QPLU$ project required the sheep within the experiment to be maintained in forward store condition (fat score 3-4) (Taylor and Atkins 1997), even at this level of nutrition the high CFW ewes were less able than low CFW ewes to successfully rear their progeny to weaning. Dove et al (1994) found that, milk production was influenced by the level of body reserves in the ewe at parturition, with corresponding negative impacts on live weight and body composition of their lambs. While ewes are mobilise their body reserves, primarily carcase and internal fat deposits, during pregnancy and early lactation (Lambe et al. 2004) it is likely that high CFW ewes who tend to have lower fat reserves simply can not supply enough energy to support lactation – this is likely to be further exacerbated when feed supply is limiting and high CFW ewes are carrying twins".

Chapter 5: Solutions to the Production Vs Fitness Trade-off

Like most problems the first step in addressing them is to be aware that they exist. There can be little doubt that the mountain of research and scientific evidence as discussed in this report along with anecdotal observations proves that at some point higher levels of production will impact on our animal's fitness. The reality is that as commercial sheep producers we don't really have to have an in depth understanding of the complexities of sheep genetics but we should have a better understanding of our breeding objectives, the limitations of our environment on these objectives and what needs to be done in the way of management if our production objectives are greater than our production systems environmental constraints.

A simple way of summing this up is a saying that I have used regularly while explaining this problem which is "if you put crude oil into a jet fighter you will be very disappointed with the performance". If you want an animal to perform to its genetic potential then you have to make sure it has enough of the right fuel for maximum production without compromising fitness. If you haven't got enough fuel then it would be wise to revise down your production targets. The trick for every sheep producer is to try and find the balance between production and costs (i.e. supplement feed, or expensive high performance rams) that will maximise profits.

To tie all of this in and give this report a practical outcome, I must revisit my discussion with Wynand du Toit and Cameron McMaster when Cameron made the observation that Wynand's lamb losses between pregnancy testing and weaning was a result of "**your ewes must have a too high wool cut per head which is compromising their overall fitness".**

In light of some of the other factors I have highlighted in this report what things could Wynand do to improve this situation.

1. The most obvious is to put breeding objectives in place that will decrease per head wool cut. This would lower the WPP% over time and free up feed resources away from wool production for lambing and lactation. The cost of this option initially is a smaller wool clip. However, in South Africa there is some evidence that while wool cut per head decreases wool cut per hectare will actually increase. The reasons being increased lambing %, faster growth rates, earlier lamb turnoff and more efficient feed conversion results in higher stocking rates per hectare.

2. Decrease stocking rate. This will increase the quantity of feed available per ewe, which can be stored as fat for later use or used as required during the high demand period of lambing and lactation. This will obviously result in a decease in wool cut per hectare

3. The next option is to select genetics that will breed ewes with a larger hogget body weight. This will also lower the WPP% and actually has a similar effect to the second point as the flow on will be lower stocking rates as generally larger animal require more feed to maintain themselves. The exception to this rule is if the larger hogget body weight outcome is achieved by the process discussed in point number 6.

4. Targeted supplement feeding during the high energy. Depending on the value and amount required this is the best outcome for total production. This scenario allows the ewes to express their full genetic potential and maximises production.

5. Actually select for ewes with a higher EBV for fat. Due to the added pressure of being a wool producing maternal the demands on a ewe during this peak demand period of lambing, lactating, while still producing wool is very high. By selecting animals that will store surplus energy during lower periods of demand as fat to be called on when required would be a very cost effective way of addressing these nutritional deficit periods. The downside of breeding for increased fat is the ewe becomes programmed in periods of high nutrition to deposit fat reserve, which means she isn't directing the nutrition towards production.

6. More efficient feed conversion. This holds the key to producing a super dual purpose maternal without incurring increased supplement feed costs or decreases in stocking rates and production. Unfortunately it is a trait, which is very difficult to performance test for, and to date SG hasn't been able to provide an EBV for feed conversion. The only effective way to measure feed conversion to date is a very intensive method using electronic ID, and scales on the food bins so a record of each individual's intake is recorded. By then measuring production by wool and weight gain a feed conversion rate can be worked out. Work carried out by the Victorian Department of Primary Industries at Rutherglen by Nick Linden has shown that feed conversion rates vary immensely between individual sheep. As soon as you have genetic variance in a flock then you can make significant genetic gain on the flock average for that trait by selection pressure.

I am very hopeful that the emerging genomics program with the first gene markers just coming on line will be the answer here. If the efficient converters identified in the Rutherglen work can be incorporated into the Sheep CRC Genomic research and DNA markers identified for this trait then the sky is the limit for our sheep industry and my goal of creating a super maternal dual-purpose ewe.

If this outcome isn't achieved in the short to medium term then SG can still help us identify the more feed efficient sheep in the Australian flock. The fact that all data is analysed in management groups run under the same environmental conditions results by design, that the sheep which perform better are more efficient converters or larger eaters. It's logical to think that the sheep running in sub optimal or poor nutritional circumstances where feed intake is limited which still outperform the average must be more efficient feed converters. By identifying rams or genetics, which perform above average in many different environments, then we are very likely to be selecting for the more efficient feed converters.

To my way of thinking this area holds the most profitable key to Wynand's wish of improving lamb survival (along with most other sheep producer's in the world). It will allow for an improvement in lamb survival and weaning rates without compromising production or requiring higher costs through increased supplement feeding.

Research Station where Dohne Breed was Developed – near Stutterheim South Africa

Chapter 6: Diminishing Returns Concept

The concept of diminishing returns is commonly used in economics. However, while driving one day in Argentina thinking about the wisdom of introducing very high wool cutting Australian genetics into the harsh Patagonia environment it dawned on me that it's just as relevant for sheep breeding. Figure 6.1 illustrates this theory in light of increasing wool cut per head with point "a" representing the optimum wool cut in this particular environment.

Figure 6.1

Example of the Bouffler theory of diminishing returns for sheep breeding

"As long as you maintain a large varied population size to select from in any population there are no physiological limits to genetic progress". (Professor W Hill Edinburgh University). If you put large selection pressure on any trait such as wool cut per head in Figure 6.1 then huge gains can be made on that particular trait BUT an optimal level will be reached before associated fitness issues (i.e. falling lambing percentages) start to drive whole enterprise profitability downwards. This optimal level for any genotype will vary relative to different environmental conditions.

The challenge to individual sheep producers is to understand their breeding objectives, the genetic potential of their sheep, and environmental constraints with the aim being to push production as far as possible along the curve before the point of diminishing returns is reached on total farm income.

Chapter 7: Outcomes and recommendations

7.1 The Introduction of the meat to wool ratio

The Australian sheep industry needs this analysis tool to become common best practice if sheep breeders are going to get a better understanding of their business. The introduction of this simple tool is important to hit home the fact that most breeders in Australia are already running dual-purpose maternal flocks. Merino breeders in particular have to be made aware that the lamb industry either directly or indirectly is contributing a greater portion to total farm income. It's logical to assume that as Merino breeders begin to be made aware that 10-50% of their income is being derived from mutton and/or lamb sales they will start to review their breeding objectives. The repercussions of Merino breeders placing more selection pressure on meat traits are highlighted in the following example. If over the next 5 years the total number of ewes available remains at 41.3 million but rams were selected on a Sheep Genetics index which maintained all current production traits (wool cut, fertility, micron) but placed selection pressure on post weaning weight. An achievable result of this scenario would be an average body weight increase of 2 kg's at 200 days for the progeny born in year 5 without sacrificing the volume of the Australian wool clip. Extrapolating this gain over all lambs at a 75% National lambing percentage and 60 % of ewe lambs retained for replacements would still result in over 21.6 million extra kilograms of dressed lamb available for sale. At $3 per kilo, that would result in an extra $64.8 million dollars in sheep producers pockets.

7.2 Total Weight of lambed weaned EBV introduced

This is used extensively in South Africa and I believe the inclusion of this into the list of Breeding Values offered by Sheep Genetics would be very beneficial. This would be an improvement on the Number Lambed Weaned (NLW) EBV currently being used as, on top of litter size it takes into account maternal traits like milk production, mothering ability, and the genetic growth potential of the lamb. I intend to push for the introduction of this breeding value in my role on the Advisory Board of SG.

7.3 Production per Ha

Over recent years in Australian agriculture a big emphasis has being placed on the results of benchmarking analysis both within and between industries. With regards to the sheep industry the recommendations of benchmarking results has usually been to decrease micron and increase fleece weight and stocking rates. In light of the findings in this report doing each of these things in isolation without fully understanding the possible flow on effects could in fact be quiet detrimental to the profitability of the business.

The single biggest mistake would be to increase the stocking rates per hectare if the flock were already low performance based with poor feed conversion rates or genetically programmed to produce more wool than the environment allows. I would recommend in most cases performance testing and identifying the most productive genetics in each individual flock and increase productivity by running the same number of genetically superior animals rather than running larger numbers of genetically inferior animals. Its imperative that introduced genetics is selected with the aid of SG Merino Select (MS) EBV's.

7.4 Sheep Genetics (SG) generated EBV's

The widespread adoption and usage of EBV's at both the stud and commercial level is vital to the survival and sustained growth of the Australian sheep industry.

7.5 Highlight the positive correlations in genetics

While this report focuses on the negative correlation of CFW and other associated fitness traits such as fertility it's important to stress the correlation is quiet moderate at -0.1 and as a result there are a lot of ewes in the general population which have both positive EBV's for CFW and NLW. It's these ewes that offer the greatest potential going forward for increased profits for sheep producers. By performance testing and identifying the genetics which meet this criteria over different environments, the industry is well on the way to producing genetically superior Maternal dual purpose ewes.

The really good news is that many other traits that have a major impact on productivity are positively correlated with each other. In the context of this report the major one being Body Weight (BW) and NLW (approx +0.3). Some others include (source: New Century tools for merinos):

- Body Weight and CFW (+0.46)
- Body Weight and Staple strength (+0.2)
- Staple Strength and Eye Muscle (+0.2)
- Staple Strength and CFW (+0.3)
- Staple Strength and Fat (+0.16)

Staple strength is a very interesting trait and it is one in which Norm Adams who is recently retired from the CSIRO in Western Australia spent a lot of time researching. In discussions with Norm he made the observation that staple strength is both easy and cheap to measure and could be a very good indicator of an animal's ability to store fat and other body reserves to utilise during higher periods of energy demands (lactation) or lower periods of feed intake. If a staple has a break or section of weakness it's indicating that the animal has had a period where it's available energy metabolism was insufficient to provide for its requirements.

These positive correlations are like a free kick when it comes to breeding. As you improve the trait that you see as desirable these associated traits also improve. If you obtain improved lambing percentages while breeding for faster growth rates in your flock then this is a win win situation.

7.6 Superduals

One of the main outcomes I hope to achieve from my whole Nuffield experience is the formation of a National young sire evaluation group-breeding program. This will be based along similar lines to the Meat Elite or Superwhites genetic evaluation programs already established for terminals. Individual producers involved will nominate young rams which they think have elite dual purpose genetics and staff at Sheep Genetics will independently select a group which has the greatest genetic potential. The selected rams will then be performance tested in randomly selected participant's flocks.

This will mean that the progeny will be born in different environments and compared between each other along with the genetics of the breeder's normal program. The overall result will be better linkages within the Merinoselect database and hence higher accuracies for the EBV's generated.

The program will be open to different breeds and types within a breed and one of the desired outcomes will be to get a better independently assessed picture of what all these different phenotypes bring to the dual-purpose genetic table.

The majority of shearing in South Africa is still done with hand shears

Conclusions

This is an extremely exciting time to be involved in the Australian sheep industry. The worldwide supply and demand equation for both wool and sheep meats is balanced in favour of a dramatic increase in both value and volume of these commodities. The only concern is whether production can be increased to take full advantage of this situation given our historically low flock numbers.

Australian sheep producers have at their disposal the world best sheep performance testing database in Sheep Genetics and a group of dedicated geneticists and researchers ensuring we remain world leaders. Ongoing research such as the sheep CRC and its connected genomics program will ensure producers will have at their disposal the tools to obtain productivity gains (through genetic progress and better on farm management) at rates that have never been achievable before.

While the negative correlation between some production traits and some general fitness traits is undeniable, by gaining a better understanding of the reasons behind the relationship and selecting animals whose genetics don't follow these trends significant genetic gains can still be obtained to drive profits. The key is to have a large genetic variance in the general population, which the Australian sheep flock certainly has.

The Australian sheep industry still contributes significantly to the economic well being of both the rural community and in turn the country as a whole. I look forward to facing the challenges and being actively involved in ensuring that the industry not only remains viable but also enters a period of sustained growth.

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