

Improving Sheep Efficiency through Weaning Nutrition

Weaning Protocols for better feed conversion



A report for



by James Robertson

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Executive Summary

The aim of this study was to determine whether the introduction of starch into the diet of lambs as an integral part of the weaning process would provide benefits to the rumen function of the lamb in order to improve feed conversion efficiency.

Several different methodologies of introducing starch as part of the weaning process were studied;

- Pen weaning using a high starch concentrate diet.
- Small paddock weaning using a pellet based high starch diet with grazing available.
- Transition from a milk replacement diet in calves to a starch supplement in grazing paddocks in a high rainfall environment.
- Creep feeding lambs from two weeks of age and then removing the dam, allowing the lamb to remain in familiar surrounds.
- Natural weaning in a semi arid mountain environment where the lambs remained with the dam permanently.

Apart from the natural weaning process in Wyoming, United States of America (USA), various forms of early weaning were observed. The aim of this was to reduce the required feed, the lamb and the dam requiring less feed running separately than if they were run together.

All systems employed the use of a high starch diet, whether a direct management tool aimed at improving rumen function or simply as a supplement that ‘worked’, without a broad understanding of the physiology of what was occurring in the rumen. Each property or business, in trying to maximise returns to get the best feed conversion efficiency (FCE), this being a key profit driver.

The key findings of this study are;

- Starch is a key driver for early and enhanced rumen function and where possible should be integrated into a weaning protocol. While rumen function may not be permanently improved, when starch is present better feed conversion occurs.
- Improved rumen function leads to earlier and more rapid weight gains in weaners allowing for improved use of high value pasture and potentially less methane emissions.

- Rangeland grazing systems are at a disadvantage to those with improved pasture so there is a need to adopt weaning strategies that provide for better performance. Lambs which perform well during and after weaning will be more likely to perform better during their lifetimes.
- Pen weaning using a high starch diet can be useful providing the risks and costs have been identified.
- Creep feeding in a weaning system is the most cost effective way to introduce starch to the lamb.
- Weaning early, at 10-12 weeks, provides more opportunity for the ewe to be more productive the following year. Weaning early also reduces the dry matter intake and can therefore lead to higher stocking rates.

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Foreword

My property, Chowilla, is located on the New South Wales – South Australia border immediately north of the Murray River in a semi-arid rangeland zone. Rainfall average is 212 millimetres (mm) annually and spread throughout the year with only a small increase in the cooler months. Pastures are native and contain native grasses, medics and chenopods. The land comprises flood plain, open grassland, sandy mallee rises and swales (low flats among the mallee sand dunes) as well as scotia country. Scotia country consists of heavy calcareous clay/marl soils covered with Black Oak and chenopods. No improved pastures, fertiliser or irrigation is utilised.

We view our primary business as wool production, although in the last year meat income has become the larger of the two incomes. We also harvest feral goats annually, do a small amount of share cropping (relative to the area) and finally a small amount of machinery contracting.

The focus on my property is to enhance the feed conversion efficiency of the breeding ewes in particular, so that for a given amount of natural pasture they will produce more wool, more meat and also be more productive (% lambs) than they otherwise might have been. It was for this reason that I chose to apply for a Nuffield Scholarship, so that I may view first-hand how producers in different geographical and climatic areas wean and introduce starch into the diets of their animals.

During my personal study I travelled to New Zealand, the United Kingdom and the USA. Also during the Global Focus Program I travelled to India, Bahrain, Turkey, Ukraine, France and the USA.

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Finally to my referees, Michael Harrington and Mark Stoeckel, thank you.

Abbreviations

AWI	Australian Wool Innovation
AWPFC	Australian Wool Production Forecasting Committee
BJD	Bovine Johnes Disease
ELMS	Elders Livestock Management Solutions
DSE	Dry Sheep Equivalent
DM/ha	Dry matter per hectare
FCE	feed conversion efficiency
FCR	feed conversion ratio
GHG	Green house emissions
Ha	Hectares
VFA	Volatile fatty Acids
PA	Propionic Acid
pH	A figure expressing alkalinity or acidity
%	Percentage
Kg	Kilogram
BA	Butyric Acid
MLA	Meat and Livestock Australia
mm	millimeters
USA	United States of America

Objectives

The objectives of this study were:

- To maximise the health of the rangeland, particularly in dry times, and to promote soil stability, thus reducing erosion.
- To achieve the most from genetic improvement. Investment in quality genetics can only be fully expressed if an efficient digestive system is in place that will allow best utilisation of poor native pastures present on rangeland properties.
- To compare different weaning systems that utilise starch in the diet.
- To increase the fertility of ewes.
- To increase the wool cut per animal.
- To reduce the carbon footprint of our wool growing enterprise.

Introduction

The Australian sheep industry has seen a decline in number since the late 1990's when sheep numbers peaked at 190 million head. According to the Australian Wool Production Forecasting Committee (AWPFC) current numbers are 72.5 million head and have declined each year since 2008, with the exception of 2010 to 2011 (AWPFC, 2013). Lambs marked have conversely increased to 34.7 million head. AWPFC forecasts the greasy wool production to be 350 million tonnes in 2012/13 selling year.

Since the wool price crash of the early 1990's pastoral producers have been faced with some price slumps, adverse seasonal conditions and a declining market for their key commodity. During this period many producers left the industry, either leaving the land completely or changing the focus of their enterprise. Some in the pastoral zones have chosen sheep which shed their wool, such as the Dorper, and focus purely on meat; others have changed to domestic goats. Both enterprises have been attractive as meat prices have been high for some time.

Fortunately a large number of producers have remained wool producers and keep a foot in both markets. Merino sheep may not be as hardy as a Dorper, or have the carcass weight, but a well run Merino enterprise can not only produce a high quality apparel fibre, but also a credible meat product for both domestic and international markets.

This report will contain some ideas, based around weaning for producers who want to improve the productivity of their sheep. Sheep are ruminants and the rumen is a key part of the digestive tract of a sheep that allows the animal to convert raw feed materials into usable energy. Ruminants differ from other animals in that they 'chew their cud' and much of their food is broken down by the process of fermentation by microbes in the rumen.

The stomach of a sheep is divided into four chambers – the rumen, reticulum, omasum and the abomasum. At birth the rumen is completely undeveloped, small and not functioning. As solid food is introduced the rumen gradually becomes more developed. This occurs as solid foods are fermented to produce volatile fatty acids (VFA), mainly acetic, propionic and butyric acids, and methane and ammonia are produced as by-products. Ammonia is utilised by the microbes within the rumen as a food source.

Cereal grains are composed mainly of starch which produces a large amount of VFA's. Microbes within the rumen that ferment starch secrete enzymes which promote rumen function; this is to say that the rumen wall thickens, blood flow is increased and papillae growth is enhanced. This is the key driver for an improved Feed Conversion Ratio (FCR).

The bacteria that ferment starch are different to those which ferment cellulose. Cellulose fermenters are sensitive to an increase in acidity, whereas the bacteria which ferment starch are acid-tolerant. They can survive in pHs ranging from 5.5 to 7.0. This is the reason why ruminants need to be introduced slowly to grain. Rapid introduction causes a loss of microbes leading to a rapid drop in pH (due to a build up of lactic acid in the rumen).

The ability to manipulate the efficiency of rumen function using starch has been well documented, particularly in the dairy cattle industry. This report demonstrates that it is possible to cheaply and effectively manipulate the rumen to provide for better feed conversion efficiency through weaning in conjunction with a high starch diet.

A major innovation on Chowilla was to build a confined feeding area for weaning; this consists of fourteen pens, with water in each yard and feed troughs as well as self feeders. This allows us to wean lambs, hold feral goats on feed prior to transport to abattoirs, as well as feedlot lambs and sheep prior to sale. It is anticipated that as we learn more about intensively feeding sheep we will use the facility to pen join 'maiden ewes' and in dry times to provide a maintenance ration in order to reduce our dependence on the native pastures.

For the last two years the Chowilla Pastoral Company has weaned lambs early (12-14 weeks) into a confined feeding area and fed them on a high starch diet with the support of the Elders Livestock Management Solutions (ELMS) system. The idea is that this will improve rumen development, which improves the ability of the animal to convert feed into energy. This will provide some extra sensitivity in drier times for the business as well as creating more product from the same amount of livestock and may allow the slight increase in numbers if it can show a definitive reduction in the amount of feed from the paddock.

Investment in quality genetics is a key driver for improving rumen efficiency on Chowilla as too often poor seasons can have a negative impact on the ability of the animal to fully express their genetic potential. Hence the oft quoted statement,

'Ninety percent of genetics is what goes down its throat' (unknown).

Rarely does a stud sale occur without this being said. It conveys a common belief that in order for an animal to express its genetic potential it must get the best possible start in life.

It is abundantly clear in the pastoral zone that innovation and change are two things that have not happened as rapidly as other agricultural areas. In the pastoral zone most properties are leasehold of some form, often with statutory limitations to what can occur on the property. This means no improved pasture, no cropping, fertiliser or irrigation. Also the maximum number of stock that can be run on the property is pre-determined by the relevant agency administering the leases. In South Australia, pastoral leases are administered under the Pastoral and Land Management Act by the Pastoral Board.

Opportunities to increase productivity are therefore limited. The main opportunities to improve productivity are;

1. Genetic – improve through genetics the quality of the product and therefore increase the price or the amount of the product that is produced.
2. Change enterprise to one that is more profitable, something that has been done by many producers.
3. Improve the productivity of existing animals through better management.

Weaning

Weaning is the removal of a milk based diet, either provided by the ewe or milk replacement in a hand rearing system, onto a forage or grain based diet. As with any management practice where there is a change of diet or significant social change for the animal, the period may be stressful and careful management is essential.

In the pastoral zone weaning generally occurs after 14 weeks of age (MLA, 2007). Leaving lambs on their dams until after this point ensures that lambs have achieved target weights that will allow the lamb to survive. Small increases in weight make a significant difference to weaner survival. For example, a 14 kg weaner has a 34% lower mortality risk than a 12 kg weaner, and a 20 kg weaner has 22% lower mortality risk than an 18 kg weaner; also small increases of monthly weight gain (0.25 – 0.5 kg per month) can reduce mortality by 74% (MLA 2007).

The joining period in the pastoral zone can occur anywhere from six weeks to 14 weeks; usually the operation of removing the rams coincides with a muster for another operation. For example, on Chowilla, rams are introduced in January to ensure the ewes have a better chance of green feed prior to and during lambing. Rams are then removed at the next major muster, which is at crutching in late March. Therefore, the age of lambs at weaning can vary a great deal, as can the weight which greatly impacts on the ability for the lambs chances of survival. MLA (2007) recommends weaning at 14 weeks after the first lambs are born.

Benefits of Early Weaning

MLA (2007) states that weaning lambs at an early age has many benefits for both the lamb and its dam, such as:

- Heavier live weight (in lambs) that can be more easily maintained until first joining.
- Higher conception rates for ewes at next joining.
- More lambs weaned from the following years joining.
- Breeding ewes grow more wool.

These benefits are supported by Rick White of Livestock Central who, in conjunction with Elders Ltd., offers select advice regarding weaning through the Elders Livestock Management Solutions service. White (2009) states that;

- Removing lambs early and exposing them to starches rather than milk contributes to higher levels of rumen development.
- Early weaning offers the potential for a significant step forward in stocking rate potential, lifetime feed efficiency and reproductive efficiency in any breeding enterprise.
- Removing progeny early improves reproductive cycling (in the dam that has its lamb removed early).
- It takes less feed (30-40%) to maintain dam and progeny separately than it does to leave them together.

In particular, White (2009) states that successful weaning requires the progeny to have attained good levels of rumen development at weaning. This development plays an important role in the lifetime feed efficiency of the animal.

Pen Weaning at Chowilla

Chowilla is a 130,000 ha station in the semi arid rangelands, running 11,000 grown sheep plus lambs. It produces 75,000 kg of wool per year and has sales of 6,000 sheep per annum. Chowilla has a dry sheep equivalent (DSE) rating of 15,150. The property consists of river floodplain, open grass land, open chenopod country, light timber and heavy timber. The pastures are poor quality native, unimproved pastures.

When looking at weaning strategies for this property it was clear that the bulk of advice available was directed towards higher rainfall more intensive systems, not towards large extensive properties that rely on native pastures in arid environments. When advice indicates that 1,200 - 1,500 kg green dry matter per hectare (DM/ha) is required it does not provide many answers (MLA, 2009). Properties like Chowilla run 1 sheep to 6 – 10 ha, DM/ha is simply not measureable and what is there is not in any way improved.

Because of the poor quality pastures it is important to manage both the land and the livestock carefully in order to achieve the best result. The proprietors had been concerned with ill-thrift

in weaners on the property for some time. Following weaning the lambs would not gain weight. Losses were unacceptably high (5%) and it was suspected that fertility may be impacted later in life, because the ewes did not meet target weights at joining. It should be noted that this was not an every year occurrence but happened when conditions were either dry, or when green feed during spring was in short supply.

The proprietors engaged ELMS to develop a strategy to achieve better results with its weaners. As a result, a weaning system was developed on Chowilla to allow early weaning and introduce a high starch diet to improve rumen function. A confined feed area consisting of 14 pens was constructed to allow up to 4,200 lambs to be pen-weaned at a time. This means that in most years all of the ewe lambs on Chowilla can be weaned in this system.

In 2009, 4,200 lambs were weaned in the pen weaning system on a high starch diet. The diet consisted of:

- 75% barley
- 20% lupins
- 5% ELMS early weaning pellets
- Ad-lib barley straw

A minimum of 150 gms per day/hd of the high starch concentrate (barley) is required to achieve a positive influence on rumen function (White, 2009).

The strategy involved weaning at 10-12 weeks of age, inducting the lambs onto the concentrate diet (high in starch) leaving the lambs on this diet for three weeks with the aim of permanently improving rumen function. The benefits of this would be that the lamb would have a more developed rumen when reintroduced to the natural pasture paddock leading to an increased FCR. This was expected to result in higher and more rapid weight gains, more wool production and higher fertility.

The system worked relatively well despite the lambs having not been introduced to grain previously. Adaption was helped by placing lucerne hay in the concentrate feed troughs and pouring measured rations over the hay. This worked extremely well and by day two most lambs were feeding. By day 10 lambs were at the full ration and for the most part feeding well. However, problems started to express themselves such as;

1. Acidosis
2. Shy feeders

3. Sudden death

Acidosis occurred because some sheep were able to dominantly feed on the measured ration, and there was not enough buffer in the mix to deal with over-eating (White, 2009).

Shy feeding was an issue, mainly due to failing to imprint lambs prior to induction into the pen weaning system. This occurred because sheep had not been supplementary fed on Chowilla before. Feed was purchased to do this but unusually high rainfall events precluded this from being done during lambing.

Losses during this process were 1.6%, much higher than anticipated and weight gain during the three weeks was minimal. The following year improvements were made to the feed protocol to ensure sufficient feed was provided to the lambs. Not only was rumen function enhanced but there was enough ration to gain weight as well. As a result the following improvements in livestock performance were observed:

- Following release into the paddock the lambs immediately gained weight on very poor pasture and within three weeks were performing extremely well.
- Growth rates of 'treated' lambs post weaning were not monitored closely, however, at joining the maiden ewes were 5kg heavier.
- Wool cut on average in the 'treated' mobs increased by 0.4 kg.
- Lambing percentage increased from 83% in 2009 to 97% in 2010, and has remained at or above this level since.

It can be argued that these results could be season dependant, but these results are consistently above the district average.

Following completion of pen weaning in 2009, one lamb was euthanized to observe papillae length on the rumen wall. The following photograph, (Figure 1), demonstrates that on the subject animal there was significant development of rumen papillae. Given that the lambs had been in a pen system for 21-24 days, with no other available feed other than the high starch concentrate diet provided, it would be reasonable to assume that the other lambs would have similar papillae development. It was also noted that the rumen wall was much thicker than might be expected from lambs of a similar age that had not been weaned on a high starch diet, muscular and darker in colour, due to increased blood flow.

Papillae are important for the feed conversion efficiency of the animal as this provides an opportunity to increase the surface area of the rumen wall. Also if the rumen wall is more

muscular this will aid in the physical breakdown of rumen contents. Increased blood flow allows for more rapid take up of nutrients from the rumen.



Figure 1. Rumen wall from Chowilla lamb post weaning on a high starch diet. Note papillae growth. Robertson 2010.

New Zealand – Intensive feeding systems

The proprietor of this business, located near Fielding on the North Island of New Zealand, was very welcoming, but has asked that he not be identified in this report because of the negative connotations that are associated with feed-lot lambs in his country. This business is built around supplying lambs to a processor with the lambs being supplied into the feedlot from numerous farmers. This business aims to supply 150,000 lambs annually into the processor by 2014. It is currently in a pilot phase but has contracts extending out to 2014 to cater for the business projections.

Being in the pilot phase, and being in a country without a history of feed-lotting, the proprietor has relied on advice from Australia and his own trial and error. The success of a

business of this nature relies upon being able to increase the weight of the lamb quickly enough so that the cost of the feed given to the animal is less than the value of meat that is returned from that feed. Therefore, if rumen function can be improved, this will improve the rate at which the animal gains weight in the feedlot; improve the growth rate, and improve the profit.

This operator was working with another farmer who had trialled feeding his lambs a high starch diet in order to improve rumen function, and also with a feedstuffs producer to make prescription pellets for the feedlot and rumen development programs.

It should also be noted that grain is more costly in New Zealand than in Australia. Prices quoted in March 2012 were \$420 per tonne for barley, more than double the prices in Australia (Beamish, 2012). Alternative feeds were being utilised, including palm kernel and cotton seed, to produce the protein and acid buffer pellets (Waugh, 2012). The ration being used was cereal based (barley) with protein and buffer being provided by the pellet.

In March 2011, 800 lambs were present in the feedlot and were in the induction phase, that is, they were being weaned on to the feedlot ration. The owner of the feedlot was engaging with farmers locally to wean their lambs on a high starch diet in order for the lambs entering his feedlot to potentially have a better developed rumen so that they would make better use of the expensive feed.

The reason for visiting this enterprise was to determine whether improvements could be made to induction in the Chowilla pen weaning system; it appeared that a very similar methodology was being implemented to that which was being used at Chowilla. In fact, the same people who were providing advice for the Chowilla system were providing advice to the principal of this feedlot. It was noted that both enterprises were experiencing problems with sub-clinical acidosis during induction.

Paddock weaning with a high starch supplement

“Awapi” – Simon Beamish near Hawkes Bay, NZ.

Simon is the 3rd generation to work the ‘home’ block. The property consists of 1,200 hectares, making it one of the larger mixed farms in the area.

They lamb down 8-10,000 ewes, producing some 12,500 lambs, run a cattle herd of 300 breeders as well as a small area of cropping. When they have surplus feed, male dairy calves are sourced, up to 300 at a time; these are kept for 15 months. At any one time there could be two rotations of dairy weaner cattle on the property, this means that the property ranges from 20-30,000 DSE depending on timing.

As a result of the intensive nature of the stocking, careful planning is conducted using the program 'FARMAX'. This allows for the property budget to sit alongside the pasture budget within the same program. Scenario planning is one of the key strategies that allows for early decision making. Actual figures are placed into the program on a monthly basis, including actual financial results, stock numbers, and results of pasture mass measurements. The program also stores historical data that allows the user to make decisions based on historical markers.

Simon Beamish and his manager piloted a project, with the objective of manipulating rumen development using a high starch diet, but conducted using a small weaning pen with available green dry matter. Lambs were weaned at 10 weeks of age, introduced to a high starch concentrate pellet for three days in a confined feeding area with ad-lib hay. They were then turned out into a small weaning paddock where they had ad-lib availability of pasture, cereal hay, and a minimum of 140 grams per head per day of the high starch concentrate pellet. The results of this program were initially very positive, with growth rates 30% higher than the control mob. At the end of the 30 day weaning program lambs were 8 kgs heavier than the control mob.

However, at 'Awapi' it was discovered that when the pellets were removed from the diet at the conclusion of the program, growth rates slowed; in fact at day 100 growth rates between the 'weaned' lambs and the control mob were the same, the difference being the early increased weight gain. This evidence seems to suggest that rather than permanently improving rumen function, the high starch diet either directly improved weight gain, or whilst present facilitated improved rumen function leading to improved feed conversion from the pasture.

Simon Beamish further tracked his lambs, both the control mob and the 'Enhanced' mob through the abattoir in order to examine the rumen internally. It was determined that there was no physiological difference in appearance between the control mob and those that had been weaned on a high starch diet.

Weaning calves in the UK

South Huish Farm – Phil and Sue Darke

Phil and Sue run a 250 cow dairy in Devon, England. The dairy is pasture based relying on shedding and feeding through winter. When feeding occurs grass silage is mainly used.

However like all dairy farmers Phil must early wean and manage his calves in such a way that his cows can come back into production and the ‘opportunity’ of his calves, in particular the heifer calves, is not diminished by a lack of nutrition and stress.

Calves are weaned at day two or three and were being fed on fresh milk (post colostrum). Phil intends to change to milk replacement in order to avoid issues with Bovine Johnes Disease (BJD). After six weeks the calves are introduced to silage and a commercial pellet. The pellet contains 68% starch. When quizzed about the starch content, Phil’s response was that he had no idea what was in the pellet but that he used it because he could see an improvement in performance of the calves. That may be due to a number of reasons but it is also clear that without some form of starch it is difficult to improve rumen function beyond a base level.

‘Without the pellet the calves don’t seem to be able to use the silage efficiently’ (Darke, 2012).

Commercial weaning of dairy calves

Hendham View Farm, Kingsbridge - David Merrin

David is an Irish expatriate who farms with a difference in Devon. David has 200 ha in Devon near Kingsbridge where he turns out 1,000 bulls per year, with plans to increase this to 5,000 bulls for the meat market. David feeds the bulls until 16 months when they are sold in order to avoid ‘taint’. In a symbiotic relationship with dairy farmers, David purchases bull calves from local dairies and puts them through a fattening program using pasture and feed concentrate. In fact, visiting David’s farm was a bit of an epiphany for the author as he was the first farmer visited who deliberately managed starch intake to develop rumen function in order to make the most of his pasture feed. This provided a mechanism for Hendham View Farm to increase productivity from a limited feed resource.

David introduces the purchased bull calves at two weeks of age to a small pen in a shedded environment, when they must be a minimum of 50 kg live weight. They are then fed on milk

replacement and a starter concentrate until they can be turned out onto grass pasture. Providing concentrates is the key driver for rumen development according to Dr Steven Morrison, head of sustainable livestock systems at the Agri-Food and Biosciences Institute (Tricket, 2011).

In the grass pasture they are fed a mixture of corn silage (to provide starch) and a concentrate pellet to provide additional protein and starch. David identified starch as being a key driver for his fattening system as it promoted rumen function and allowed better utilisation of paddock feed, the result of which is increased FCE and growth rates (Merrin, 2012).



Figure 2. David Merrin, Hendham View Farm with young bulls on pasture from 4-10 months, supplementary fed with a high starch ration. Robertson 2012.

When the calves reach 10 months of age and regardless of weight or the time of the year David introduces the bulls to the intensive feedlot (shedded) where he feeds a corn (starch) and concentrate ration to the bulls for five months. The mixture is 50% corn silage and 50% concentrate or 'straights'. The concentrate is composed of citrus pulp, heat distillers, biscuit meal and barley. Trace element minerals are added as well.

David's strategy certainly made a lot of sense as he recognised that the feed in the paddock was a resource that is the limiting factor on any farm, therefore, the best way he could see to maximise his output was to increase the efficiency of use of that resource. His means of achieving this was to deliberately introduce starch to the diet.

Maximising genetic potential

Burton Farm – David Rossiter

The importance of nutrition was highlighted at Burton Farm, in Southern Devon near Kingsbridge. Burton Farm is approximately 400 ha and runs about 1000 joined ewes, being predominately Poll Dorset and Suffolk.

David Rossiter has introduced the MyoMAX gene into his Suffolk flock. The gene was introduced to produce a higher muscling animal (Rossiter, 2012). A single copy of the gene was found to increase carcass weight by 0.26 kg in a study conducted by Innovis. When two copies are present it increased carcass weight by 1.09 kg over the control mob (Thomas, 2008). It was also found that presence of the MyoMAX gene while increasing muscle also reduced fat. Thomas suggests that this may allow lambs carrying the MyoMAX gene to be taken to higher carcass weights.



Figure 3. Suffolk Lambs – Burton Farm, on a Chicory based pasture. Robertson 2012.

David provides a creep feed ration to his young sheep, from six weeks, as well as utilising fodder crops such as chicory. At Burton Farm silage maize is also utilised; the maize being used was a high starch variety (Rossiter, 2012). David said that it is critical to provide a high quality diet for the young sheep in order to maximise the potential that the genetic material provides. David has introduced genetic material from Australia and New Zealand to improve the ease of management. David has not targeted a high starch diet, but the creep ration does include some starches in the form of cereal grains. The key message obtained from David is that quality feed is of paramount importance at an early age to make the most of the animal's genetic material.

Creep feeding lambs

Fearn Farm - John Scott

John Scott is in partnership with his parents and operates Fearn Farms on the southern end of the Tarbut Peninsula in Scotland. The Tarbut Peninsula is about 65 km north of Inverness.

The climate is extremely cold during winter and the summer growing season is very short, about 20 weeks (Scott, 2012).

Fearn Farm is about 400 ha and runs stud Beltex and Texel sheep as well as commercial ewes. The commercial ewes have a high amount of Texel blood in them and are crossed with NZ Suffolk and Charolais sires. The commercial ewes number about 1,100, which are in addition to cattle, the stud sheep and arable farming. Fearn Farm has a stocking rate of 13 DSE per ha and 165% lambing (Scott, 2012).

Due to the short summer it is very important to maximise growth rates and make use of the high quality pasture. *‘We need to get the lambs to a marketable weight as quickly as possible while the quality of feed is high, because after about 16 weeks the pasture loses protein, digestibility and metabolisable energy’* (Scott, 2012).

Fearn Farm has implemented a weaning protocol that involves creep feeding. When the lambs are two weeks of age a creep feeder is introduced to the paddock; the lambs are able to access the feeder through a mechanical barrier that does not allow the ewes to enter (Figure 4). John says that due to the inquisitive nature of the lambs they ‘investigate’ the feeder and find the supplementary feed. The feeders remain available to the lambs up until they reach marketable weight.

When the lambs are 12 weeks old the heavy lambs are drafted off and marketed; this is usually 30% of the lambs. They have reached a carcass weight of 18-22 kg by this time. Simultaneously, the balance of the lambs are weaned and returned to the paddock that they came from and the ewes are “dried off” in another paddock in order to put on weight for

joining again.



Figure 4. Creep feeder at Fearn Farm, Robertson 2012.

The lambs that are returned to the paddock ‘comfort feed’ according to John, due to the stress of weaning, although this stress is minimised by returning the lambs to familiar surrounds and the familiar feeder. During the next four weeks the lambs gain weight at a greater rate than at any other time due to the increased rate of consumption of the pellet and the better use of available green dry matter in the paddock. After this four week period another third of the lambs will reach marketable weight. Growth rates are 600-700 grams per day. John attributes the impressive growth rates to efficiently using the available high quality pasture and genetics.

The balance of the terminal lambs are sold prior to cold weather setting in at the maximum achievable weight. *‘While most of the lambs get up to weight, the season and feed quality can mean that some lambs are sold prior to achieving goal weights’* (Scott, 2012).

The pellets used in the creep feeder are sourced locally from ‘Harbro’, a local feedstuffs manufacture located in Inverness. Mark Goodwill is a director of Harbro whose advice was that the key to getting the most out of the available pasture was providing a supplement of

starch. This is provided in the pellet using barley. The barley is cracked and not ground; it is not necessary to grind the barley when being fed to sheep (Goodwill, 2012).

United States sheep production

The United States has a small sheep industry, about six million head based mainly in the Mid-West and West with most of the lambs produced going to intensive feedlots for finishing. This is due to the coyote and wolf predation issues (Hasbrouck, 2013).

Jeff Hasbrouck, manager of the lamb division of Double 'J' Farms, is one such lamb finisher based near Ault, Colorado. In this area there are a number of large feedlots servicing local abattoirs. Jeff runs up to 75,000 lambs a year through his operation, taking lambs on consignment for feeding through to slaughter.

The induction system for sheep entering the feedlot provided the focus for this visit, as this is the major shortcoming in pen weaning lambs. Lambs inducted too rapidly onto a cereal grain based feed can quickly succumb to acidosis. The whole point of an advanced weaning strategy is to reduce losses not cause them. At Double 'J' Farms the induction process only took about seven days, starting at 100 grams per feed (twice daily) and rising to about 1.2 kg per day by day seven, in two feeds. The ration was corn based and also used distiller's grain and processed hay. The ration is purely price and availability based. When other similar products are available that will achieve protein and energy requirements for less price, they will be used instead.

The availability of cheap and plentiful labour is the key to success for enterprises like Double 'J' feedlot. Animal health problems are monitored constantly and detected and managed quickly.

The subsidised energy market is skewing the price of corn unfavourably for livestock feeders, the price rising from 35 cents/kg to 65cents/kg. A take home message is that we can look for other opportunities to feed sheep rather than be locked into one type of ration regardless of cost.

Enteric methane

Ruminants, as part of the fermentation process, produce methane which is known as enteric methane. This is expelled from the rumen by belching. Methane (CH₄) contributes to 20% of climate change and is the second most important greenhouse gas after carbon dioxide (Chadwick, 2007). Livestock contribute about 18% of greenhouse gas (GHG) emissions. In a ruminant production system enteric methane makes up about half the GHG produced. Small ruminants are expected to increase in numbers due to the increase in demand for meat and milk (Morgavi et al, 2011). The United Nations says that in the last 35 years the annual per capita meat consumption in developing countries rose from 11 kgs to 29 kgs (Alexandratos, 2006).

There are various means of reducing enteric methane:

1. Inoculation – using pro-biotics and vaccinations.
2. Diet – planting grasses high in sugar.
3. Reducing the time required to finish the lamb.
4. Introduction of a high starch grain diet.

Clearly option four holds a parallel with this study topic and while discussion of this is somewhat academic, studies have shown that starch concentrates in the diet cause a decrease in methane production per kg DM intake. In high starch diets the percentage of methane corresponding to gross energy intake can be as low as 3% when compared to 8% in forage diets (Morgavi et al, 2011).

This provides an opportunity for graziers to reduce their carbon footprint. While understanding that the future of carbon farming is unclear, the message is that there is potential to develop methodologies which may assist graziers to gain a benefit from adopting weaning and animal production strategies that reduce methane emissions.

Recommendations

High sheep and meat prices since 2005 have provided opportunities for woolgrowers to enter the meat marketplace with Merino sheep. While woolgrowers have always sold surplus or aged stock to the trade, prices now reflect that woolgrowers are genuine dual-industry participants. Replacement sheep are extremely expensive to purchase, therefore, it is important for sheep breeders to capitalise on the opportunity to wean as many lambs as possible from their flock. The recommendations for sheep producers arising from this report are:

- Weaning by any means or protocol requires research and careful implementation. Seek advice from nutritionists before adopting any new weaning protocol that involves a concentrate feed.
- Starch is the key driver of rumen development and function. Providing starch in any weaning system can improve feed conversion efficiency and growth rates.
- Lambs which perform well during weaning will tend to be more productive during their life.
- Pen weaning is a useful tool provided costs and risks have been identified.
- Creep feeding with a high starch concentrate ration is the most cost effective and successful weaning strategy identified by the author.
- Weaning early, at 10-12 weeks, provides more opportunity for the ewe to be more productive.
- Weaning early reduces the dry matter intake potentially leading to a higher stocking rate.
- Rangeland grazing systems are at a disadvantage to grazing systems with improved pasture so there is a need to adopt new weaning strategies to remain competitive. Tailored weaning advice for rangeland producers should be developed and disseminated by the lead pastoral and wool industry bodies with a view to increasing production and profit.

A wool growing enterprise has an opportunity to gain benefit from the sale of surplus livestock due to decreased weaning mortality, increased productivity of ewes, increased stocking rates and as a result increased surplus sale stock numbers.

The cost of production for graziers has continued to rise and is can be mitigated by increased sale price and increased productivity. This report shows that graziers can

improve and adopt weaning protocols that assist in achieving both improved sale price and improved productivity.

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Plain English Compendium Summary

Project Title:	Improving Sheep Efficiency through Weaning Nutrition
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Objectives	The focus of this report is to identify opportunities to introduce starch into the diet of lambs at weaning to improve the feed conversion efficiency and therefore improve the lifetime production of the subject animals.
Background	Adverse seasonal conditions resulting in ill-thrift in lambs following weaning and lower than acceptable lambing percentages during a period of low wool prices have challenged me to seek opportunities to improve animal health and husbandry on our semi-arid rangeland properties.
Research	This study consisted of the Global Focus Program, visiting India, Bahrain, Ukraine, Turkey, France and the USA. Specific study on the subject matter saw visits to the USA, New Zealand and the United Kingdom. Sites visited included sheep farms producing both wool and meat, dairy operations, and intensive feedlot enterprises for both sheep and cattle. Extension officers and feedstuffs producers were also interviewed.
Outcomes	Introducing starch to the diet of lambs during weaning is widely practiced throughout the world. Starch is also introduced to calves in the dairy industry. This study showed that starch can improve the rumen function of lambs allowing for better feed conversion efficiency and resulting in better performance of the lambs. Better performance in the dam was also demonstrated due to earlier weaning. Weaning on a high starch diet allows for earlier weaning where it would otherwise not have been possible. Better feed conversion efficiency and performance of the animal leads to a better expression of the genetic potential of the animal. Improved performance leads to more lambs and ewes being produced.
Implications	Sheep production in the semi-arid rangeland environment relies on natural pastures and rainfall. The ability to improve the feed conversion efficiency of a sheep leads to increased production and reduces the amount of dry matter required. This leads to improved production and improved stocking rates.