A Nuffield Farming Scholarships Trust Report

Award sponsored by

Alan and Anne Beckett

Efficiency Gains through Improved Beef Genetics

Robert Fleming

July 2016

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A Nuffield (UK) Farming Scholarships Trust Report

Date of report: July 2016

"Leading positive change in agriculture. Inspiring passion and potential in people."

Title	**Efficiency Gains through Improved Beef Genetics**
Scholar	Robert Fleming
Sponsor	Alan and Anne Beckett
Objectives of Study Tour	To research and evaluate efficiency opportunities/measures and their relevance to the UK Beef Industry.
Countries Visited	Brazil, Canada, Ireland, Paraguay and United States of America
Messages	- Investment in superior genetics can bring improvements to individual animal performance. - Genomic values can help breed herd consistency. - There are financial benefits in the use of multi-trait breeding indexes. - There are simple steps that allow access to better genetics, for example artificial insemination. - Breeds are a man made vision. Do not be afraid to break the mould.

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DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor, or of any other sponsoring body.

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Chapter One: Introduction

I live near Glenluce, south west Scotland, with my wife Claire and daughter Molly. I farm in partnership with my parents on a lowland suckler beef and sheep unit. My grandfather purchased the original home farm of South Milton in 1956 as a dairy farm. The business evolved over the years and in 1997, after purchasing Castle Sinniness, it changed to solely suckler cows and sheep. My day-to-day duties involve management of the farm and in particular the suckler herd, from feeding and rations to genetics and sales.

Having left school in 1997, I attended the Barony College, Dumfries, to study agriculture. I graduated in 1999 with an SVQ Level 3 in Crop and Livestock Production. I had intended to go on and obtain a degree in agriculture but circumstances within the family business meant my year out is currently in its 17th year!

I regularly attend industry events and currently sit as a member of the Scottish Cattle Industry Group, an advisory group set up by Quality Meat Scotland (QMS), to advise on the future of the Scottish Beef Industry. In 2015 our business was approached by Agrii, a leading provider of agronomy and seeds in the UK, to become the UK's first Forage iFarm. This has allowed us to hold open days for interested farmers and industry members to observe our attempts at best practice, with a focus on home grown forage.

Outside of agriculture, I like to travel and spend time with my family. I also enjoy socialising with friends, particularly if that involves watching rugby at the same time.

Figure 1: The author, Robert Fleming, on his own farm in south west Scotland

Chapter Two: Background to my study subject

In Scotland, we are told that, without subsidies, the beef industry would no longer exist due to our climate, soil quality and distance from market adding extra cost to our businesses. As farmers, we must find a way to make our businesses more profitable. We can invest in agronomy, infrastructure and cost saving practices but we must treat our farms as businesses and in business you must make a profit year on year. If our industry is not profitable, access to finance will be difficult. Our competitors globally as well as other meat protein sectors within the UK wish to have our share of the market.

> *.... we must treat our farms as businesses and in business you must make a profit year on year.*

The National Agricultural Advisory Service (NAAS) was established post World War Two as the advisory and research arm of the Ministry of Agriculture, Fisheries and Food (MAFF) to advise farmers on how to maximise their output. https://en.wikipedia.org/wiki/ADAS_(company). (It was rebranded as ADAS in 1971). My grandfather's generation, through hard work and occasionally incentives, transformed agriculture, through improved agronomy as well as advances in agricultural processes and genetics available at the time. With advances in technology and science now becoming more available to mainstream agriculture, we must be willing to embrace change to increase efficiency and profitability.

The field of livestock genetics gives farmers access to estimated breeding values, based on physical performance of individual animals. Our competitors in the poultry and pork sector have embraced the genes that are linked to profitability through trait selection and the use of more defined breeding goals and the addition of genomic values. They have increased feed efficiency, reduced days to market, and created a more consistent product as a result. In the same time period, the beef industry has not evolved at the same rate. We must be willing to look at new technologies and techniques that reduce the cost of production.

> The variation between performances within the UK beef herd is vast. We need to have a clear focus on the end products we wish to produce, targeting this from day one within our breeding plans. We must provide the market with what they want consistently, and target a reduction in the cost of production. We must identify the superior animals within this UK herd and use these as the foundation of a modern, more efficient beef industry.

Chapter Three: My study tour

Brazil (May – June 2016)

Brazil has one of the largest beef herds in the world and reputedly one of the lowest costs of production. It was important to see what they produced and what farming methods they used to produce it. I also felt that Brazil was in its infancy in embracing genetic improvement but had read on several occasions that the use of artificial insemination (A.I) was becoming increasingly utilised within the Brazilian beef herd. I wanted to find out what the farmers were basing their selection on and how this compared to the UK market.

Canada (August 2015)

Canada is renowned for its beef research and use of technology. Some of the leading research equipment is constructed in Canada and several universities run extensive agricultural research programmes. I wanted to meet the researchers in beef, find out what their remit was and how this fitted into global agriculture.

Ireland (February 2016)

With a very similar climate to the UK but an increasing focus on beef from forage, Ireland was an obvious visit on my Nuffield Farming travels. I wanted to meet farmers who, on a far smaller scale than my own, could comfortably live and could make a clear profit per hectare. The Irish beef industry has a strong focus on technical efficiency which adds to their profitability.

Paraguay (May 2016)

As one of the largest exporters of beef in the world and reputedly with the lowest cost of production, the opportunity to visit Paraguay and see beef production in a less technologically advanced country was a great opportunity. With no subsidies and a lack of investment in roads and infrastructure, I hoped to find key points that I could bring home.

United States of America (August-September 2015)

The U.S.A is renowned for their feedlot system of beef production and consistency of product. It was important to see how these large businesses used technology and genetics to increase efficiency.

****

From all the visits I made to farmers, researchers, university staff and companies large and small, I learned so much. I have summarised the information from all those discussions and demonstrations, in Chapters 4 – 9 inclusive. Chapter 10 highlights visits I found of outstanding importance in covering my subject and formulating my views.

Chapter Four: What is efficiency?

When we talk about efficiency in beef production it covers many areas, from utilising resources such as land, feed, time and genetics, to technical and financial performance. When we look at the conversion of feed to carcase gain we can use the following calculation to define efficiency:

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}}$$

Figure 2: Definition of Efficiency. ***Source: physicsnet.co.uk***

In 1950, the ratio of feed to carcase gain was 10:1 (kilograms of dry matter: kilograms of beef) in beef feedlot efficiency. Today it is around 6:1 (*source:Beef Cattle Research Council*). Many of these gains have come in the form of improved genetic selection, a better understanding of dietary elements and a focus on trait selection for financial benefit. In Chapter Six, I will compare cross sector feed efficiency and look at the improvements other meat protein production systems have made in a similar time frame.

4.1. Technical efficiency

Much focus is placed in the United Kingdom (*UK*) on technical efficiency. Technical efficiency is measured by targets set by the advisory sector, using benchmarking, which they believe will deliver financial benefits if reached. An example of this is presented below:

qmscotland.co.uk

Non-LFA lowground suckler herds - technical performance measures

	Bottom Third	Average	Top Third
Cows per bull	24	22	16
Calves born dead or alive per 100 cows	85	90	98
Calves born dead per 100 cows	5	4	4
Calves died before weaning per 100 cows	1	1	2
Calves reared per 100 cows	79	85	92
Daily liveweight gain (kg)	1.27	1.16	1.03
Weight - kg per calf sold	275	325	391
Weight produced kg per cow	218	276	356
Cow replacement rate per 100 cows	22	18	13
Cow mortality %	6	3	3
Purchased concentrates kg per cow	321	310	274
Home-grown concentrates kg per cow	*58*	*55*	*69*
Stocking rate GLU/ha	*0.7*	*1.13*	*1.2*

Figures may not tally due to rounding

Figure 3: taken from Cattle and Sheep Enterprise Profitability in Scotland by QMS

To maximise efficiency within beef production systems, the three pillars of nutrition, health and environment must be understood and managed, before the potential of genetics can be seen. This said, within any feedlot or farming system the superior genetics such as weight gain or fertility will always shine through. This was evident when conditions were compared on my visits, from lush pastures in Ireland, to dry, dusty conditions in the U.S.A, and hot, humid pasture in Brazil. The best farmers identified these superior genetics and used management systems that minimised cost of production.

Two examples of such contrasting systems, each focusing on similar traits, are Ohlde Cattle Company, USA, and Ney Agilson Padilha, Brazil. Ohlde Cattle Company (see Figure 4) farms in exceptionally dry conditions, resulting in lesser quality grassland, whilst Ney Agilson Padilha (see Figure 5) farms green pasture using a paddock grazing system. Both systems focus on the strengths of maternal traits, utilising artificial insemination and in-herd replacements to accelerate genetic gain. As a result, despite the obvious contrasts in environment, both businesses had identified the best genetics globally to succeed in their goal of forage-based beef production.

Figure 4: Road Sign at Ohlde Cattle Company, Kansas, USA

See figure 5 on next page

Figure 5: Nelore breeding females, Brazil

I believe efficiency is identifying the best management practices and genetics for your environment. By putting financial values to herd fertility and understanding your reasons for herd replacements, less productive animals can be identified and removed from the herd.

Chapter Five: Feed efficiency

On analysing beef systems, up to 70% of the cost of production is feed. This makes feed efficiency a major part of cost control.

An animal's ability to convert dry matter to product has been one of the most difficult traits to measure up until the invention of individual feed intake bunkers (see Figure 6).

Figure 6: Individual feed intake bunkers at Lacombe Research Centre, Alberta, Canada

From the early conception of animal intake monitoring, when the only option was manually weighed feed offered to individually confined animals, to now contemporary batch managed animals eating at computer-monitored bunkers, quality data collection has been key to defining feed efficiency.

5.1. Data collection

Feed Efficiency or Net Feed Intake (NFI) is a measure of an individual animal's ability to convert feed to gain. A positive figure in Figure 7 denotes the requirement of more feed than expected to be consumed and a negative figure shows an animal requiring less feed than expected:

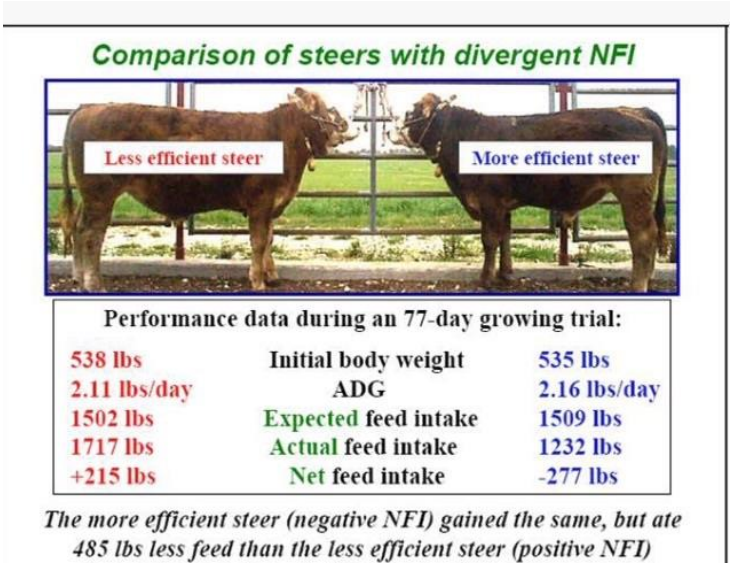

Figure 7: NFI results from Genetic Development Center, Texas, USA

The optimum during a feed intake trial is for an animal to produce the same or more products, be that milk or meat, within the contemporary group it is tested with. During a *GrowSafe* (manufacturers of feed intake monitoring equipment) feed intake trial ranging from generally 50-70 days, following standard 10-21 days acclimatisation, a group of animals of the same sex, age and weight are exposed to the same management, environment and diet. Regular weighing of beef cattle on test allows their growth to be compared to their feed intake data. (See Figure 8)

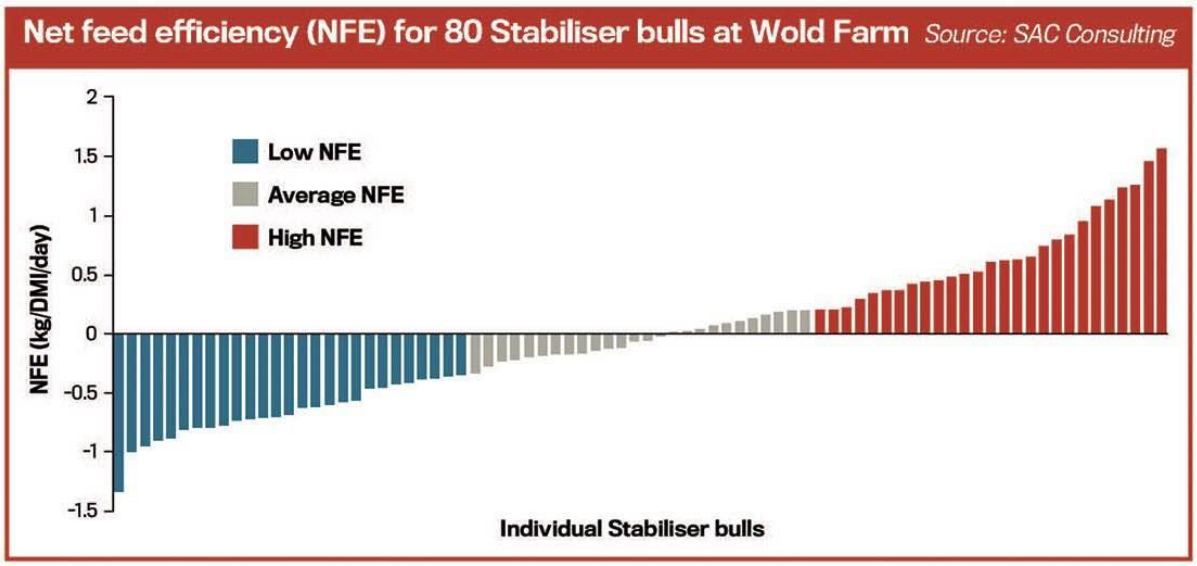

Figure 8: Results from a GrowSafe feed intake trial

Adding a trait for feed efficiency is further supported by the heritability of 0.35-0.40.

Heritability is defined by Bennet Cassell, an Extension Dairy Scientist from Virginia Tech as "***one of the most important concepts in animal breeding. There are several working definitions as heritability is used to help plan breeding programs, determine management strategies, estimate breeding values of individual animals and predict response to selection. In general, traits related to fertility, fitness, health and survival have low heritabilities of less than 0.15***

Production traits like milk or protein yield are moderately heritable, with heritability from 0.15 to about 0.40. Product quality traits such as fat and protein percentage tend to have the highest heritabilities - above 0.40."

5.2. Science

With advances in genomic information it is hoped a simple DNA test will be able to identify low NFI animals by identification of verified genomic markers.

> *"Genomics is an area within genetics that concerns the sequencing and analysis of an organism's genome. The genome is the entire DNA content that is present within one cell of an organism"*
>
> (Dr Ananya Mandal MD, 2014)

During a visit to the University of Alberta, Edmonton, Canada, I met with Dr John Crowley of Livestock Gentec (see Figure 9) to discuss their ongoing trials to link feed efficiency trial data to the genomes. In a 2015 trial, DNA samples taken from cattle involved in the Canadian Hereford Association Trial, had their *GrowSafe* test data compared with their genomic data. Through this work it is hoped Livestock Gentec can construct a database to link the genome to performance data to enhance Expected Progeny Differences (EPDs).

Figure 9: Dr John Crowley, University of Alberta

5.3. Physical and financial benefits

For any industry to evaluate efficiency, the comparison of actual data and the financial benefits must be favourable. The use of intake data allows benchmarking within the contemporary batch, down to an individual animal level. One such example is Eagle Pass Ranch, Highmore, South Dakota. The Munger family have used *GrowSafe* feed intake bunkers to do in-herd intake trials on bulls and heifers since 2007. By using intake results, ultrasound and weaning ratio data as part of their selection criteria, they have reduced intakes by 26% on a feed-to-gain ratio. In 2015, having tested 340 bulls and 125 heifers, they posted a complete year group feed to gain ratio of 4.43:1 compared to an industry norm of 6:1.

Where NFI is being monitored, the differences within contemporary batches can be as much as 30% of feed consumed for the same weight gain. Figure 7 (on page 8) is an example of finishing cattle, fed in feed lot conditions, and the variability in feed conversion as well as the physical and financial contrast.

> NFI (Net Feed Intake) is just a single trait and must not be the only selection criteria but I feel it has been proven to have a place in multi-trait selection indexes. With around 70% of feed consumed required for maintenance, mature weight is an area requiring focus. Cows weighing between 500-600 kilograms consume 12.5 – 15 kilograms of dry matter per day; an 800 kilogram cow requires 20+ kilograms per day. Can we really expect these larger cows to compete on %age of dam weight weaned?

Chapter Six: Meat sector comparisons

Many lessons can be learnt from looking at the advances in efficiency within other meat producing sectors of agriculture. When we talk about efficiency gains there are areas of carcase yield, feed efficiency and management that have made a huge difference in the cost of production. Protein derived from meat is an area that has seen poor returns since the late 1990s. The beef industry is lagging behind poultry and pork production in terms of cost of production, as well as improved genetic, scientific and management practice uptake.

6.1. Pork

The image below shows the improvements in feed conversion in the pork sector from 1972 until 2007. It shows a 14.5% reduction in feed requirement and a live weight gain of 25%.

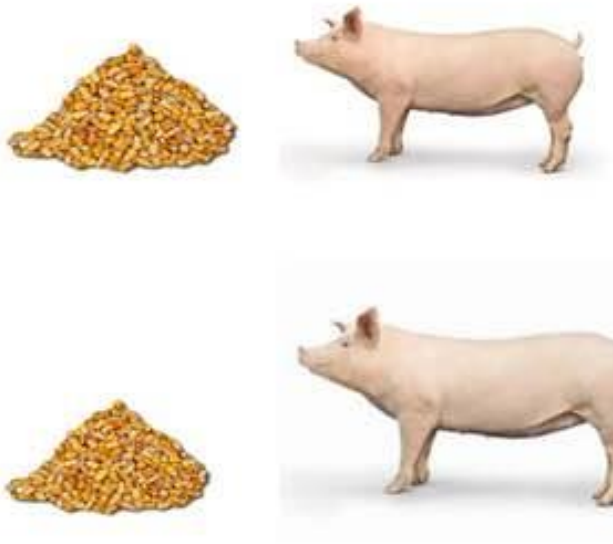

Figure 2. **Improvements in feed conversion ratio.** Feed requirements moved from 836 lbs to produce a 220 market hog in 1972 to 715 lbs of feed in 2007 to produce a 275 lb market hog. (Adapted from Graham Plastow, 2012)

Figure 10: Improvements in Feed Conversion in Pork Sector 1972-2007.
Adapted from Graham Plastow, 2012

6.2. Poultry

Even more dramatic improvements have been made in the broiler industry. See figure 11 on next page. These improvements are all due to genetics.

Figure 11: Improvements in Chicken Genetics 1957-2001. *Source Peter Best*

"Whilst beef feed conversion has not improved measurably in the last thirty years, the poultry sector has seen a doubling in growth rates and the feed conversion rate halved to around 1.6:1"
(Peter Best for WATTagnet.com, November 24, 2011)

The poultry and pork sectors have embraced the need for a simplified system of commercial breeding. Genetics are targeted for the final product, providing consistency and allowing research to be targeted on the profitability of certain traits.

Can we afford not to provide a more consistent eating experience for beef consumers?

Chapter Seven: Breeding traits and multi trait indexes

When constructing a breeding plan or assessing genetics for a breeding programme, specific traits are used to evaluate the strengths than can be brought in to the herd.

7.1. Calving ease

Calving Ease is a trait used to advise on expected ease of birth, which makes it among the most important traits in cattle breeding. If focus is not kept on traits that influence viability in terms of survival and the effect on future fertility and management, then the foundations of beef production will be lost. A sound breeding plan must aim to maximise the number of weaned calves. The trait for calving ease is built on data from calving difficulty, actual birth weight and, where possible, gestation length, with the aim to display the animal's influence on birth. Larger framed calves at birth, smaller than average pelvis size and longer gestations all have an impact on the chances of getting a live calf at birth.

Efficiency begins with maximising live calves.

Efficiency begins with maximising live calves. The cornerstone of breeding must be fertile, easy calving females with minimum days to post calving ovulation. Calving difficulties can cause long term damage to the dam and affect lifetime fertility. High herd replacement rates and high calving indexes (days from calving-to-calving) are clear signs of an issue in fertility that is often a side effect of problems in the calving period. Conventionally a replacement female should have a value higher than the cull cow she replaces.

> Focus on Calving Ease as a production trait can lower replacement rates of breeding females and maximise progeny able to be sold.

7.2. Milk

An animal's milk production is measured by using weight of their progeny at 200 days. Using this measure allows farmers to predict the ability of a female to rear its offspring to an acceptable weight when compared to its contemporary group. Solely using 200-day weight as a measure of mothering ability will lead to trait selection for the female capable of maximum milk production. However, if focus is solely on maximum milk production, other aspects of maternal ability, such as maintaining body condition, can be lost and there can be a detrimental effect on her subsequent fertility.

> Balancing milking ability with the ability to maintain or gain body condition post calving must be included in selection criteria. Both these abilities can have dramatic effects on herd fertility.

7.3. Growth

When selecting genetics for use within any breeding program, careful consideration should be taken of the intended market for the offspring. Requirements for selling calves at weaning, selling yearling spring-born young stock or producing finishing cattle are all very different. In terms of growth, maximising growth potential to desired weights in the shortest period of time for the given production system, can be planned with the use of high 200-day and 400-day weight EBVs. Extremes in growth can often lead to detrimental effects on birth weight and resultant calving ease. The use of certain breeds of cattle has historically been used to bring breed-recognised traits to breeding programmes. For example – Aberdeen Angus for calving ease, natural-fleshing ability and meat quality, and Charolais for extreme lean growth for heavier weight finishing stock.

> Understanding the end market for your produce is key to evaluating the importance of each trait, be that 200-day, 400-day or 600-day growth and each would influence future breeding goals.

7.4. Carcase

The ability of an individual animal's genetics to improve carcase quality, meat yield, and time to desired weight can bring financial benefits to beef production. With correct use of Eye Muscle Area (EMA) and Fat Depth traits, it is possible to increase the percentage of higher value cuts from a beef carcase with more control over fat cover to meet desired market specification.

> Careful selection of carcase traits within a breeding programme must be weighed against any requirements for maternal traits. Excessive carcase muscling comes at the detriment of milking ability.

7.5. Fat cover

Subcutaneous fat levels are key to maximising return on finished carcases and these fat levels are also linked to maternal fertility. The ability of an animal to convert feed into fat cover can be clearly displayed in the production of bull beef. In production systems where an intensive, grain-based diet is used to rear young bulls, the bull must reach an acceptable level of fat cover to avoid a financial penalty when slaughtered. Selecting maternal and paternal genetics that bring together terminal traits and include positive breeding values for fat cover can increase the chances of meeting market specification. Figure 12 displays the carcase payment grid and Figure 13 shows an example bonus and penalty structure for certain carcase grades.

see figures 12 and 13 overleaf

Figure 12: EUROP classification grid

	2	3	4L	4H	5
E		+27	+27	+7	
U		+27	+7	Base	
R		+7	Base	-7	
O+		Base	-7	-17	
O		-7	-17	-27	
O-		-17	-27	-27	
P		-27	-27	-27	

Figure 13: Example of a Classification Grid Penalties

7.6. Multi-trait indexes

Beef producers are provided with numerous formats of breeding values from EBVs, Estimated Progeny Differential (EPDs) and Euro-Star ratings, as a guide to bull selection for natural service or when purchasing straws of semen. A simplified system with multi-trait indexes for maternal and terminal traits that allow across-breeds comparison would help aid identification of superior genetics. With access to multi-breed comparison data, a new era of hybrid breeding utilising heterosis (the tendency of a crossbred individual to show qualities superior to those of both parents)

could begin. Simplifying beef cattle breeding to a limited number of maternal and terminal types, no matter the parental breed make-up, could allow the creation of new dedicated lines of genetics for more efficient beef production.

Division of traits required for maternal and terminal strains could be as follows:

Maternal	Trait Index Weight
Calving ease	25%
Calving ease daughters	10%
Gestation length	10%
Birth weight	12.5%
200 day weight	10%
Milk	12.5%
Scrotal circumference	10%
Fat cover	10%

Terminal	Trait Index Weight
400 day	35%
600 day	15%
Eye muscle area	7.5%
Fat cover	35%
Retail beef yield	7.5%

Multi-trait indexes should lead to defined types of maternal and terminal animals. These should be targeted to specific roles within cattle breeding.

The national breeding herd needs to be divided into clear groups: animals for reproduction and animals for the terminal market. The traits we require for these two types are very different. I see little value in dual purpose types. Instead, breeders must provide genetics for either the maternal or terminal market.

Chapter Eight: Utilising science

The beef industry has access to science to inform, identify and aid cattle management, from blood tests for vitamin and mineral levels to in-vitro fertilisation (IVF) as a multiplier of genetics. Whilst travelling, I wanted to find out the opportunities that Methane Emissions Monitoring could give the beef industry. Is there a market place for carbon credits on the back of emissions data? Can we learn more from emissions data?

8.1. Sexed semen

The most cost effective route to superior genetics is through artificial insemination (AI). A straw of semen is available from £5 - £40 for most bulls, with the added option of a pre-sexed straw of female or male semen for an extra £10 - £20 per straw.

Sexed semen has changed the dairy industry and allowed it to multiply females rapidly through sexed female semen. With accuracy rates quoted of 85+% female births from sexed semen, the opportunities for the beef industry are obvious - using maternal genetics across bulling heifers to aid calving ease and produce the next generation of breeding females from the latest genetics to join the beef herd. Opportunities for use of sexed female beef semen across the dairy herd would allow lowland suckler producers access to greater numbers of first cross dairy heifers as replacements for the beef herd. With semen providers battling to have the best bulls in the stud through AI, beef and dairy farmers have access to genetics that realistically would be uneconomical if having to purchase the bull for use within their own herd.

8.2. GreenFeed system

Whilst visiting with Dr John Basarab at Lacombe Research Center, Alberta, (see Figure 14 on next page) I was introduced to the GreenFeed Enteric Methane monitoring system.

The GreenFeed system was designed to allow measurement of the levels of post-digestion gases emitted by an individual animal. The process works by feeding a supplement pellet via an individual access bunker with a canopy which incorporates a gas monitoring system. As an animal enters, it is identified by an Electronic Identification Device (EID). Feed is dispensed at a given rate and as the animal consumes the pellets, gases emitted from its muzzle are gathered and passed through an infra-red sensor. The system measures methane, carbon dioxide and oxygen. This data is then linked with feed intake data to allow calculations of feed intake to gas emissions.

see photo of Dr Basarab on next page

Figure 14: Dr John Basarab – Lacombe Research Center

8.3. Emerging science

If we wish to keep pace with other meat protein providing sectors, beef producers must be willing to look at all viable methods to increase efficiency. Whilst meeting with Dr John Crowley, University of Alberta, Edmonton, I was introduced to Dr Leluo Guan, Head of Functional Genomics and Microbiology. Dr Guan is undertaking research in bovine 'Omics' and 'Microbes'. One area of interest is the ***"association between microbial ecology and feed efficiency, methane emissions and gut immunity development in beef and dairy cattle***" (Dr Guan). When asked about feed additives to increase feed efficiency and/or reduce methane emissions, Dr Guan spoke of research into 3Nitrooxypropoanol (3NOP). 3NOP is a feed additive which acts as an inhibitor to methane production.

> *"The 3NOP supplement blocks an enzyme necessary to catalyze the last step of methane creation by the microbes in the rumen"*
>
> (Jeff Mulhollen, Penn State News, 2015)

Trials have shown a link between rumen microbes and feed efficiency/NFI (Net Feed Intake). During a study of dairy cows supplemented with 3NOP, no adverse effects on lactation, fertility or body conditions were observed over the twelve-week trial. In fact, during the trial up to a 60% reduction in methane emissions was observed from the test group when compared to the control group. The Penn State Group findings found the 3NOP supplemented group had gained 8% more body weight than cows in the control group. From this we can see that the 3NOP working as an enzyme inhibitor

has allowed more dietary energy to be put towards post calving body condition gain. While the use of 3NOP does not add to increased lactation, if a cow is gaining more weight in early lactation, she should ovulate earlier and increase the window of time for rebreeding to minimise calving index. Gains in fertility to add to Greenhouse Gas (GHG) reductions may offset the price of using the 3NOP feed additive.

With environmental concerns and pressures from Government and consumers for responsible agriculture, beef producers need to be willing to embrace the latest sciences in efficiency. There are products and techniques available to agriculture that are designed to maximise environmental benefits (with many also reducing cost of production).

Techniques and products are available today that can improve efficiency and reduce the environmental impact of beef production. We must be willing to use all the scientific advances available to the industry, to benefit the environment and bring cost savings for agriculture. We must ensure investment in agricultural research and product testing to get products to market.

Chapter Nine: Ease of change

With the use of artificial insemination (mentioned earlier) and in particular sexed semen, opportunities to target the beef herd for specific roles become more accessible. No herd requires 100% maternal genetics, unless a considerable increase in cow herd numbers is required or a secondary market for surplus breeding females is undersupplied. Through selection for ideal mature weight, conditions score and production, the herd can be divided into three categories:

Breeding cows to be removed

- Cows that require assistance calving
- Cows over 800 kgs mature weight
- Cows having a calving index in excess of 400 days

Calving difficulties increase replacement rates, calving indexes, and a risk of injury to the farmer. These are not desired outcomes of any breeding programme that intends to be profitable.

Cows with immediate value

- Cows weighing over 650 kilograms mature weight
- Cows that require rebreeding periods in excess of six weeks
- Cows producing weaning weights in the middle third of the herd

The group containing cows with immediate value, dependent on its percentage of the herd, can be a work-in-progress for replacement production, or ideally suited to terminal progeny production. A moderate frame maternal sire could produce a more preferred mature weight daughter, while adding milk to increase weaning weights from the progeny of these daughters.

The ideal herd

- Cows weighing 500-650 kilograms at 4-5 years old (mature)
- Cows producing calves with a target 365 calving index
- Cows that calve unassisted and have good feet and udders
- Cows that produce calves within the herd's top 30% daily liveweight gain

Farmers should target maternal sires to the 'Ideal Herd' group. This can be achieved using sexed semen, conventional semen (if numbers permit) or maternal sires for natural service. With herd replacement rates conventionally of 15%, this only requires 20-40% of the herd to be used for replacement production. Maternal strains should bring calving ease and shorter gestation lengths. Replacement heifers and younger cows should be the group best suited to maternal sires.

9.1. Breeding values

As previously mentioned, it seems a new format for cross breed comparison is required. Recorded cattle in the programmes for estimated breeding value (EBV) that have calving ease scores in the bottom 30% of their breed should not be eligible for a maternal index score. A clear message must be sent to breeders that the industry requires genetics that ease management and contribute to the goal of profitable beef production by increased technical efficiency.

9.2. Genomic indexes

When meeting with Professor Jose Bento Steman Ferraz of University of Sao Paulo, Brazil, genomics and their place in breeding were central to our discussion. Describing the beef industry as "*machines to manage and harvest pasture into products*" Dr Bento discussed the pillars of production. Nutrition, Genetics, Management, Labour, Infrastructure, Animal Health and Environment are all necessary to allow potential to be expressed, he said.

Genomics was described as the last 2% in any breeding prediction - the ability to tell from a genomic test what the future potential of any given animal is. An animal's DNA carries the blueprint (from conception) of the potential within that animal. If these seven pillars of production are optimised, the data from genomic testing can be used to decide that animal's future by the time it reaches 21 days old (estimation of days from genomic sampling to results).

> ***"DNA is bundled into chromosomes. Beef cattle have 30 chromosome pairs, each pair including one chromosome inherited from the sire and one from the dam"***
> *(Understanding DNA technology. Southern Beef Technology Services, ABRI, University of New England)*

The key to genetic improvement is to know where the herd is strong or weak in certain traits. Current genomic tests compare the tested animal's results to a database of previous test results that were linked to actual data. For example, Feed Efficiency genomic markers were linked to actual feed intake test results and the test animals genotyped on that basis. Thus the larger the genomic database the more accurate the genomic tests become.

Genomics in beef production can be used to bridge the time gap between birth and production. The accuracy of breeding values, historically, has been reliant on progeny results. It is 38+ months from birth before progeny carcase data is known and 54+ months before daughter's milking ability is known. So if the blueprint of that animal's potential is set on conception, we must increase the

genomic database in the UK and use actual performance data to ensure the effects of genetic markers are known. In many cases multiple genes affect a trait. I believe that we must harness the power of this emerging science in beef production. This starts with building the database of genetic markers and raw animal performance data. With this we can increase accuracy and take more control of animal breeding from better informed decisions.

For bio-security and consistency of breeding program, replacement animals should be bred from within the herd. Our youngest animals should have the most appropriate genetics for the current market. Investment in breeding females brings long term reward and is ultimately the foundation that the herd will be built from.

With the need to drive efficiency into beef production, it must begin with highlighting performance of individuals within a herd. One clear message globally from my study tour was that calving ease is key. A cow must work for you. It should not be you working for a cow.

Chapter 10: Best practice examples

10.1. Brazil - Campo Triste

Address:
Fazenda Campo Triste,
Tres Lagoas,
Brazil

Owner: Katayama Pecuaria (see Figure Fifteen)

Date visited: 18th May 2016

Figure 15: Katayama Farm's Manager, Carlos Eduardo dos Santos Dias

Fazenda Campo Triste is a large scale suckler cow and finishing system, utilising pivot irrigation (see Figure 16). It has one of the few dry lot cow wintering facilities in Brazil. Campo Triste has honed a system of artificial insemination using fixed time synchronisation by means of a standardised controlled internal drug release (CIDR) to synchronise groups of heifers - up to 300 head at a time. Through use of ultrasound assessment for fertility before synchronisation and removal of sub fertile animals, they have a rolling first time conception average of 80%. They are finding through careful management they can get conception rates comparable with natural service. Their advice before and during synchronisation is as follows:

- Ensure adequate protein levels within the diet. If necessary, supplementation at grass.
- Use ultrasound assessment of internal reproductive organs for selection as suitable replacement females.
- Follow an advised CIDR synchronisation program. Minimise stress and use proven, high-fertility semen.

Figure 16 (on right): Pivot irrigation system at Fazenda Campo Triste

10.2. Canada – GrowSafe

GrowSafe Systems
Airdrie, Alberta, Canada

Owner: Alison Sunstrum

Date visited: 5th August 2015

GrowSafe systems are manufacturers of individual feed intake and monitoring systems. Their 'GrowSafe Bunk' (see Figure 17) uses radio frequency tags to record individual animal feeding events whilst recording intake by using a weigh cell mounted feed trough. Their system is designed to identify outliers (animals that eat less, yet gain the same as their contemporary group) within feed intake-tested batches. Their belief is that through careful selection of efficient genetics, reductions in green-house gases, particularly methane, can be recorded at up to 30%, thus allowing an audit for potential carbon credits in the future.

Figure 17: Set of GrowSafe feed intake bunks

- Selection for feed intake can reduce cost of gain and greenhouse gas emissions.
- Residual feed intake is a single trait but powerful when used as part of a multi trait index.
- The UK beef industry requires more research in to feed intake and efficiency within beef production.

10.3. Ireland – Ger Dineen

Address:
Knockroe
Kilnamartyra
Co. Cork, Ireland

Owner: Ger Dineen

Date Visited: 21st February 2016

Ger Dineen farms a 31.2 hectare farm near the coast. The farm is set up in a paddock grazing system and targets early turnout and maternal genetics to get maximum weight gain from grass. He practises forward creep grazing of calves which means allowing young animals the first access to the next paddock. His cows are a mix of Simmental and Fleckvieh genetics, known for their maternal strengths. His breeding programme is designed around home bred replacements with demand for surplus heifers in the area. The male calves are finished as bull beef (which for Ger means slaughtering bulls at twelve to sixteen months old). The farming system had a clear focus – grow and utilise as much grass as possible. This meant careful selection of genetics for forage conditions with maximum milking potential.

His best practices include the following:

- Match the genetics of your herd to the system you are able to run, utilising your farm's potential.
- Artificial Insemination allows access to bulls outside your price range and allows an individual cow mating programme.
- Separation of the cow and calf for twelve hours, one month pre-mating, stimulates the cow into a period of ovulation, due to separation stress.
- Access to Fleckvieh (dairy genetics) allows him to monitor the butterfat levels of sires he is using in his herd.

"Milk quality is every bit as important as milk quantity.
No calf can thrive on water alone."
Ger Dineen

10.4. Paraguay – Massimo Coda

Date Visited: May 2016

My host in Paraguay was Massimo Coda (see Figure 18), an agronomist and farm manager throughout the country. During my travels, Mr Coda endeavoured to show me as much as possible of the agriculture of Paraguay, from a pair of oxen pulling a wooden cart to a state-of-the-art JBS slaughter plant under construction, estimated to cost $70millionUSD.

Figure 18: Massimo Coda (left) with Louis Griffith, Feed Merchant and farmer

I saw a country in the early stages of agricultural evolution, where great variety in soil type and elevation meant there was no standard farm practice. Cattle were grazed almost solely on pasture and very little supplementation was ever offered. Beef production was simplistic, cost of production was low, and relative returns were high. Due to the dry climate and poorer quality

pastures, first calving at three years old is still the norm. Mr Coda spoke of the potential to increase beef production in Paraguay, something which was evident. Through improved agronomy and focus on genetics, he saw the potential in ten years for Paraguay to increase beef production by 150% and increase exports by 150%.

- Beef production does not have to be elaborate. Knowing your cost of production and realistic return on your investment is more important.
- Agronomy is the anchor that holds back genetics from reaching full potential.

10.5. USA – Profit Maker Bulls

Address:
Paxton
Nebraska
USA

Owner: Dave Bittner (see Figure 19)

Date Visited: 15th August 2015

Dave Bittner is an Angus breeder and co-operative member of Profit Maker Bulls, who have established themselves as a seller of performance tested bulls. Bulls get put through a rigorous fertility and structural soundness assessment and are then subjected to feed intake trials. Bulls are offered for sale or lease and are sold in the catalogue that also lists their multi trait index values. Profit Maker Bulls is based on the ethos that profitability is key to production. They have found that Calving Index and longevity are among the main factors in the history of profitability in beef production. Profit Maker Bulls pride themselves on repeat custom.

Figure 19: Dave Bittner, owner of Profit Maker Bulls, on right

- Breed a consistent type of animal: structurally correct and fertile.
- Use of Multi Trait Indexes that are developed on in-herd ratios for birth weight, weaning weight and yearling weight.

"Sell a type you can consistently breed, not extremes." Dave Bittner

Chapter Eleven: Conclusions

- The beef industry is behind other agricultural livestock sectors in selection of efficient breeding animals.
- Genomics is a powerful tool in cattle breeding when correctly used.
- Traits are central to building a profitable breeding programme.
- Scientific advances are still not being utilised to their full potential within the beef industry.

Chapter Twelve: Recommendations

- Increased focus is needed on Calving Ease and Fat Depth in breeding programmes
- We must use clearly defined, multi-trait indexes to allow across breeds comparison
- The industry must focus on identifying feed-efficient sires and dams and then use this data to reduce the cost of production.
- We need industry research into genomic data and its correlation to actual production carcase and feed efficiency data within the UK
- It is time for a new era in cattle breeding, learning from the poultry and pork sectors. We should undertake a programme to identify a select few maternal and terminal types based on financial performance.

Chapter Thirteen: After my study tour

The Nuffield Farming experience has benefited me greatly. Not only has it given me access to a great network of people but as a result of solo travel and training courses, I have an increased confidence in myself. Thanks to the Nuffield Contemporary Scholars Conference I now have a more rounded view of global agriculture as well as having gained valuable experience in public speaking.

It has given me a drive to help improve the beef industry and I am currently in discussion with partners regarding building a Feed Efficiency Beef Centre on farm, testing feed efficiency and developing more profitable genetics for the wider farming community. As well as this, I have hosted groups of farmers from different parts of the UK to demonstrate our use of genetics and our profitable breeding system.

Having met many different people on my travels, I have learned the importance of a good breeding programme and as a result have implemented some changes to our own. Since returning, we have benchmarked our own herd and removed less efficient cows. This has already increased kilograms of weaned calves when compared to the mature weights of their mothers.

I am looking forward to sharing the information I found with the industry in any way I can, be that through the meetings I already attend or through interviews already scheduled publicising our iFarm projects.

Chapter Fourteen: Executive Summary

The global beef industry faces many challenges, for example price volatility, environmental concerns and cheaper meat protein sources. As an industry, the beef sector has lagged behind other meat sectors in technical efficiency. It has been slow to embrace change available through access to science and genetic trait data.

During the study into efficiency in the beef sector, it was important to gauge the current standing of the beef industry, both in the UK and globally, as well as evaluating the evolution of technical and financial efficiency and beef's standing against other meat sectors.

Whilst undertaking my Nuffield Farming travels, I intended to find out where our industry was, where we have come from, and to evaluate the best route to improve profitability through utilisation of superior genetics. I selected Canada and the USA as my starting point due to their use of genetics, genomics and various methods to measure the resultant performances. Next I travelled to Ireland to see the gains the Irish have found through investment in superior AI sires and the tools they use to seek out the best bulls. I then travelled to Paraguay and Brazil to visit large scale farmers beginning to embrace genetics and AI, where I was able to see the early drivers of change and get an understanding of the benefits to the beef industry of selecting for bio-economic or profit traits.

It is my belief that a better understanding of the traits and identification thereof will be the key to improved technical and financial performance of beef cattle. If the main driver of a breeding programme is success in the show ring, that is detrimental to efficient beef production. A balance of functionality and economic trait selection must be found to drive the efficiency of beef production forward. Using the latest science-based technology, improved management practices, and embracing the need to change is important. The meat protein sector is very competitive and we must understand the potential we have to improve, and ensure the beef industry is always evolving.

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