A Nuffield Farming Scholarships Trust Report

Award sponsored by

Royal Highland and Agricultural Society of Scotland

Selection for efficiency: breeding better beef and sheep

Neil McGowan

July 2016

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A Nuffield (UK) Farming Scholarships Trust Report

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

Date of report: July 2016

Title	**Selection for efficiency: breeding better beef and sheep**
Scholar	Neil McGowan
Sponsor	The Royal Highland and Agricultural Society of Scotland
Objectives of Study Tour	• What are the efficiencies to be gained from scale in breeding programmes? • How do we select for feed efficiency in beef cattle? • How do we run a bull or ram sale to encourage best practice in terms of genetic gain and animal development, resulting in genetic value for the client.
Countries Visited	I travelled down the west side of the Rockies from Alberta (Canada) to Colorado (USA) and east across the Great Plains as far as Iowa. I saw most of New Zealand, then a small corner of Australia (Melbourne to Armadale). I had some good visits around the UK.
Messages	• The best breeding programmes have clear, consistent breeding goals, based on client profitability, irrespective of the size of the programme. • Selection for feed efficiency in beef cattle has great potential to improve profitability in the finishing sector, but the long-term effect on the cow herd is less clear. • There are lower hanging fruit available for the UK suckler herd – fertility, longevity and cow size offer more reliable, affordable opportunities to improve efficiency. • There is no reason why both shouldn't be selected for at the same time. • There needs to be some form of input *regulator* to any output *performance* based breeding programme.

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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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1. Introduction

Incheoch is a family farm in upland Perthshire – home to a beef breeding herd, ewe flock, a handful of chickens, some great wildlife and 3 generations of the McGowan family. Our goal is to be a source of 'functional, efficient and robust breeding stock' for other farmers.

Figure 1: The author, Neil McGowan

Someone once told me that every farm has an unfair advantage, and to have success, you have to find it and exploit it. Ours is an unreasonable interest in cow and ewe families, and a passion for breeding bulls and rams that will have a positive influence on future generations of profitable quality meat production.

Our production line consists of 220 cows and 1100 ewes, all pedigree registered and mostly performance recorded. Our product is 20 bulls and 100 rams, along with some breeding females and finished stock. Rams are sold at our 'Working Genes' on-farm auction sale. The breeds we are working with are Texel and Lleyn (a thrifty Welsh native), and Simmental and Luing (an equally thrifty Scottish native and derivative of the Shorthorn and Highland).

Our kids Tally (12) and Angus (10) have further developed their hobby of 'sheep chasing', helping my wife Debbie when I have been travelling. In addition to my family I am equally indebted to the Royal Highland and Agricultural Society of Scotland for sponsoring my project.

1a. Background

1a.i. What I thought the problem was:

The pedigree breeding sector in the UK is focused very much on small herds and flocks. Although there is a strong performance-recorded section of some breeds, breeder buy-in has sometimes been reluctant, and selection criteria led strongly by fashion and show-ring traits rather than profit-driving traits for commercial clients. A system of collective sales encourages competition between breeders to have animals larger and fatter at sale time – this has resulted in commercially unrealistically high levels of concentrates fed in herds and flocks whose progeny are expected to perform on a lower level of nutrition, and has implications for the young sires' own fitness/ability to work, and also their lifespan.

Basic Assumptions:

To cut the risk of re-inventing the wheel during this study I made the following assumptions.

I was prepared to have them challenged, but at the end of my Nuffield Farming journey, stand by them.

UK beef sector

1. High value, premium product is essential to balance the books of the Scottish beef sector with its high cost structure of land, regulation and climate.
2. Maternal genetics are the key to controlling the main cost-centres, and therefore profitability in beef cow herds. A properly functioning cow herd gives high numbers of calves reared to sale, low replacement rates and keeps a lid on cow maintenance costs (feed, vet and labour).
3. Gains from feed efficiency have the potential to cut enormous cost from the beef sector - both at a cow/calf and finisher level.

UK sheep sector

1. Sheep are a low-capital-cost way of producing a high value commodity product from low value land through simple hard work. The focus of our selection should therefore be to minimise the hard work, so that greater numbers can be managed. A focus on 'operator comfort' and further labour cost saving needs to be adopted by the stud sector.

Genetics

1. With, or without, genomic selection - more measurement and records of more traits will be needed in breeding.
2. BLUP is a reliable and useful breeding tool, but just because we attribute a number to a trait, doesn't mean we need to make that number bigger. We need to select for optimums.

Environment

1. Ruminants have an unfair advantage, and they should exploit it.
2. Stud stock should be bred and reared in an environment equivalent (or tougher than), that in which their progeny will be expected to thrive commercially.

1a.ii. Where I thought the solution could be found:

- Feed costs in cattle – the biggest cost in beef cattle production is feed costs. I'd heard that feed savings of around 15% were being achieved through selection for more feed-efficient strains of cattle. I wanted to go and see how to do this, and what kind of effect selection for feed efficiency had on the cattle.
- Labour costs in sheep – the biggest limiting factor in sheep production is time. The more mundane jobs that we can take out of sheep production, the more lambs we have per labour unit and the easier it will become to attract young people to work in this sector.
- Scale of breeding programmes - we now have the tools to gather so much more data than in the past. Electronic Identification (EID), electronic weigh scales, feed intake bunkers, DNA

parentage and so on, all mean we can record large numbers under commercial conditions. I wanted to know how you best create large recorded populations and how you manage it all.

- I had a notion that, in the UK pedigree beef sector, we could bring together potential sires at weaning from different herds, and test them for Feed Intake. This would tie together selection for Feed Efficiency and provide a structure for a bull sale with the benefits of having bulls reared in a single environment (more appropriate rations and better comparisons), with the benefits of having a collective sale (more bulls, with better choice). I wanted to see if there was a model we could follow.

1b. The racehorse

There's a Bob Seger song lyric that goes:

> '*moving eight miles a minute for months at a time, breaking all the rules that would bend, …..we were running against the wind*'

A Nuffield Farming study tour is a bit like that.

I found myself on a 5-hour car journey in New Zealand's South Island, with questions running through my head. I'd just had all that I thought I *knew,* questioned … again, and was heading for an interview with someone I knew very little about. I'd been traveling for 3 weeks like this: non-stop and not knowing what was round the next corner. It was nearly Christmas. I missed my family. I wanted to go home, but that was a fortnight away.

On the outskirts of Timaru (a town a lot like Arbroath, with less historical refinement), I caught a glimpse of a statue of a horse. I pulled over to try and clear my head. That's when I met Phar Lap.

Alexander Roberts was a farmer who dabbled in breeding horses when he retired nearly a century ago. He bred a 50-guinea mare with a one race, unplaced racing-record to a nondescript stallion of 'sound English breeding'. It's an uninspiring start for any story – save for a little ounce of breeding in the mare's pedigree - a great-grandmother with a touch of class. The result of that mating was a gangly foal born in 1926 who seemed to disappoint enough to be sold as a yearling – a late entry in a sale where the top price was 2300gns, he realised 160gns – bought unseen to go to Australia – on the basis of that little ounce of breeding.

Initially rejected by his new owner on arrival in Sydney, he was kept at the insistence of trainer Harry Telford. Phar-Lap gained his name as a play on words from a Chinese dialect meaning 'lightning strike' … because he was *so* slow on the practice track. But Telford didn't give up on that little ounce of breeding.

Then he started to race. And as a 3 year old he started to win. And he kept winning – 35 wins in 25 months, including 4 in 8 days at the 1930 Melbourne Cup Festival, including the Cup itself, under a record handicap weight. They took him to America – where he raced in the richest race in the world in Mexico, against some of the biggest winners from the US. He won hands down, in track record time. Phar Lap died mysteriously 16 days after that race in 1932. Years later, the secretary of that course was asked '*which was the greatest American horse of the 20th century, was it Man o' War, or Secretariat*?' He replied: '*Neither – I saw Phar Lap'*.

Against all the odds, Phar Lap was a champion, a hero, a legend.

Figure 2: Statue to Phar Lap in Timaru, New Zealand

Standing at the side of the road, struggling to read the end of this story because of the tears running down my face – I realised this is why I do what I do. This is *who* I am.

I am not a farmer. I am a breeder. The reason I have chosen my path is to be part of a story like Phar Lap. Breeding that one bull that's going to become a legend – not a top price, or a show-winner, but a bull that really makes a difference. It's not about the $15 million Australian equivalent in winnings. It's about being Roberts or Telford – the men who saw the potential in the little ounce of breeding, and had the faith to follow it through.

Then it *really* dawned on me – my Nuffield Farming light-bulb moment:

> Phar Lap was a racehorse! He was a legend because when he crossed the finish line, he crossed it first. The end product of what I produce is prime lambs and finished beef – and crossing the finish line first isn't everything – far more important is for every one that starts the race to make it to the end. In our business, un-seated or 'pulled up' are a disaster, but finishing mid-field every race – that's legendary.

Phar lap had that little ounce of classy breeding – way back – and his success was down to Roberts and Telford having the faith in that coming through. In our industry, we've got to stop thinking about breeding the Phar Lap model, promoting sons of record prices and grandsons of champions, or great-great grandsons of a classy mare – we need to start thinking about pedigrees that are stacked full of consistent mid-field finishers.

It's not exciting. They won't make bronze statues of our rams. But we might help to keep our clients in business, and through their winnings, be part of a story that becomes a legend.

I have bred and exhibited Highland Show Champions, brought out a couple of record prices; I am even old enough to have shown a Champion at the Royal Show. I am proud of these achievements, and I am proud of some of the animals who took me there. But what I am really passionate about are my Luing cows with an average calving interval of 363 days, and my Lleyn ewe flock who wean 83% of their bodyweight going to the ram, both in low input systems. This Nuffield Farming adventure has helped me appreciate these 'mid-field finishers' even more.

2. Selection for feed intake

"Look what happened to the dairy industry when all they selected for was output." Dr John Basarab

Feed Conversion Efficiency (FCR), or Feed:Gain is an easily understood measure of feed efficiency. Pigs convert at around 3:1 (that's 3 kg of feed intake to 1 kg of liveweight gain). Chicken is somewhere less than 2:1 – a phenomenally efficient use of feed (and a 250% improvement since 1957). Beef cattle are somewhere around the 8:1 mark in a finishing system, or much higher if you take the whole system into consideration. I'd heard about a bull in California who had been tested for Feed Intake in a pen which had averaged 6:1. This individual bull had gained at 3.2:1 – nearly as good as a pig! He looked like his mates, he gained like his mates, but he did it on half the feed.

My vision for this study was to find the story behind this bull: Leachman TL Valedictorian.

2a. The different measures

There are two underlying philosophies to define efficiency: maintenance efficiency and production efficiency.

- **Maintenance efficiency** is really about the cow who can subsist on low inputs and keep turning out calves.
- Traits of importance:
  - Fertility
  - Longevity or Stayability
  - Maintenance Requirement
- Antagonistic with mature size

- **Production efficiency** is about feeding cattle that take minimum feed and produce maximum gain.
- Traits of importance:
  - Growth
  - Carcase
  - Feed : Gain
- Associated with mature size

Maintenance-efficient cows might tend to be easy fleshing and earlier maturing, whereas the production-efficient counterparts at the finishing stage may be larger, leaner, and faster growing.

Although FCR is an intuitive way to think of feed efficiency, it has been shunned as a method of selection. Dr John Basarab of University of Alberta, Lacombe Research Institute, explained it to me: "*Ultimately, selection for higher growth rates, using FCR, has led to a population of cattle with increased maintenance requirements, higher feed requirements and intake with subsequent higher feed and environmental costs*." FCR is better in the younger animal, so by selecting for better feed:gain, you inadvertently select for cattle at an earlier part in their maturity. Yet, at a standard age, the cattle which are less mature, are those which are later maturing. These grow into larger, later maturing cows whose increased feed requirements outweigh the benefits that their offspring display at the finishing stage. As around 70% of the calories used in the whole system are used in the cow/calf sector and only 30% in the finishing sector, this method of selection is self-defeating in terms of efficiency.

He goes on, "*Selection for animals based on their feed efficiency has to take place with a measure that is independent of body weight to avoid that problem*." Basarab advocates that Net Feed Efficiency (NFE), is the trait to look for.

Figure 3: Dr John Basarab explaining Net Feed Efficiency at intake measurement unit, Lacombe Research Facility, Alberta. Note Growsafe feed bunkers.

The idea of NFE was developed by Koch *et al* in 1963. Known as RFI (Residual Feed Intake) in North America, and NFI (Net Feed Intake) in Australia, there is a discord in the scientific community about what to call it, but a reasonable degree of harmony that it is the best measure we have of feed efficiency at the moment. In the interests of simplicity, I am going to refer in this report to NFE – Net Feed Efficiency.

> You can predict an animal's intake from its body size. If you then correct body size for its rate of gain and fat level, that intake prediction takes into consideration most of what we understand affects intake, other than maintenance requirement. By measuring an animal's actual intake against its predicted intake, you get a positive or negative NFE figure – which is the best measure we can get of its maintenance requirement.

A negative NFE means that the individual's actual intake was less than predicted, so must have a low maintenance requirement, whereas a positive NFE means the animal ate more than predicted and therefore is less efficient. Any group must average zero, and the NFE figure must be converted to an EBV to make meaningful comparisons between groups of animals.

> ….or as it was put to me: "*It's the difference in individual animal intakes that nutritionists can't explain.*"

There are other measures of feed efficiency to further confuse matters. However NFE is the measure being used by most of the places I visited, including in the UK by the Stabiliser Cattle Company at Givendale in Yorkshire, where they have a unit with Growsafe feed bunks.

It is broadly recognised that a 1% increase in feed efficiency has the equivalent economic impact of a 3% increase in rate of gain.

2b. Growsafe

Any measurement of feed efficiency requires gathering data on individual animal feed intake. The leaders in this field are Growsafe Systems in Alberta.

Growsafe Systems thrive from a passion for finding out about animal performance. Co-CEO Camiel Huisman says, *'we just don't know how much we don't know yet*'. They developed systems to measure cattle feed intake for use in research facilities, but their attitude to 'making things happen' and a simple-to-use setup that doesn't require much 'tech input' at the cattle end of the system means that 60% of their systems are now on farm.

Measuring feed intake provides the data to give Net Feed Efficiency (NFE) for selection in breeding programmes - one ranch in South Dakota, over 7 years of testing, has seen a 15% improvement in FCR taking it to 4.3:1.

I was keen to know if we were selecting in the wrong direction at the moment by offering seedstock[1] all the feed they can eat. Camiel thinks not – in that you just don't know what is going on, continuing with his mantra that *'if you can't measure it, you can't manage it*.'

The thing that amazed me was the applications for finishers. A Growsafe watering trough measures how much each animal drinks, which acts as a health monitor. It takes a partial weight (2 front legs), the actual weight of which is the best fit they have found for hot carcase weight prediction (no calculations, just that weight)! There is a jet above that will spraymark the animal so it can be either drawn for sale or treated. With the right product and legislation, individual animals could be medicated through the water system in the pen without the need to further stress them by drawing them out to treat in the handling yards.

Alison Sunstrum, the other Co-CEO, says they have data showing healthy cattle on finish in a single feedlot pen with a range of return from between $300 profit right down to $300 loss. This system is helping to identify at what point cattle are maximum profitability, and which cattle ought to be bought next year and which ones want to be avoided.

They are also starting to do things with measuring water intake at pasture, and using that to model a feed intake estimate of grazed grass ... with this company, you get the impression that anything is possible!

I asked Camiel Huisman how he would design a bull sale system that incorporated an intake measurement. His answer was '*you're going down to Midland aren't you? …just take a look around.*'

So I'll describe my visit on the next page.

[1] "seedstock" is the breeding stock of pedigree breeders

Case Study – Midland Bull Test

"95% of the industry doesn't appreciate what's going on with feed efficiency - but if everyone knew the benefits that we have found, we couldn't supply the product." Leo MacDonnell.

His son Steve Williams is the 3rd generation to run the Midland Bull Test in Montana. They started in 1962, wintering 60 bulls and testing them for average daily gain and collating dam production records. A group of breeders had got together with the idea that there must be a better way of picking bulls than just picking the prettiest one in the show ring. Now they test 2500 bulls per year, 1000 of them through their own designed 'Midland Bull Test' which incorporates a feed efficiency test, sending 14 million bits of data a day to Growsafe.

Leo says: "*We tested for ultrasound way back in the 60's, were the first to take scrotals and to semen-test. They all thought we were wrong then, but everybody is doing that now - it's the norm. There has been opposition all the way. We've been testing for RFI for 8 years, and there's opposition to that too.*" But Leo and Steve are convinced measuring for Feed Efficiency by Residual Feed Intake is going to be an important aspect of bull selection. That's not just coming from somebody who is trying to sell his bull test; it's coming from a family run operation that believes in making the beef industry better, cattlemen who also run 700 cows, and a business which is co-ordinating big trials to back up their beliefs.

They have progeny tested 5 or 6 sires per year (including one industry standard bull along with high feed efficient bulls from test) with 100 units of semen from each over commercial cows. Steers have been bought back and fed in a feedlot in Washington with a large Growsafe system, DNA parentage for sire identification, tested for NFE and carcase data gathered. High NFE bulls have bred a 15% improvement in steer NFE, with one bull breeding a 20% improvement.

The Midland Bull Test takes in 1000 bulls from as far away as New York to Hawaii, mostly in lots of between 1 and 20 from different breeders. They all must have good dam production records and a balanced set of EBVs. Bull calves arrive in the autumn and are fed a high roughage diet in feedlot style pens. There is time for two groups to go through the 98 Growsafe bunkers over winter. Bulls are weighed regularly, ultrasound scanned for muscling, fat and marbling and fertility tested. It all ends up in the spring with a 3-day bull sale, selling 700 of the top qualifying bulls from the 1000 on test.

Case Study – Australian Angus Sire Benchmark

Over the last 6 years, 2500 cows over 7 different sites have been AI'd to a total of 230 bulls through the Australian Angus Sire Benchmarking program. Expectation was a 50-60% conception rate to AI to give 20-30 calves per sire across different environments resulting in 12 – 15 steers per sire coming together to have 650 steers fed through a single feedlot just outside Armadale, NSW.

Steers are fed for 250 days on a typical finishing system for the Asian market, spending trial time on Growsafe bunkers. The resulting feed intake data and carcase data was fed into the Australasian Angus performance recording program, resulting in greater accuracies for carcase traits and an EBV for feed efficiency (NFI in this case).

Breeders of the bulls on test pay a share of data collection costs, and sires from other countries are also used as benchmarks. Interestingly three UK Angus bulls have been used in the Sire Benchmarking program. With no outstanding features, they have none the less performed similarly to what their UK EBVs would predict and all three have come out with good feed efficiency EBVs.

An Intake EBV is included in the breeding indexes to avoid double counting growth, but a NFE EBV is reported as the individual trait as it is thought to be the best way to look at the single trait. It is hoped that as more intake data is gathered, a genomic test for NFE could give a 40 -50% accuracy.

2c. Sheep

I visited trial work at Agresearch in New Zealand where 200 nine-month-old ewe lambs were intake-measured, and found similar results to cattle. Split into 3 groupings by NFE (low, medium and high), the groups were similar in their start weights and weight gains, leaving intake as the main variable.

See photo overleaf

Interestingly, the more efficient group of lambs on the trial had significantly higher levels of fat going onto trial and deposited less fat during the trial. As fat is biologically expensive to produce, this makes sense. It may be fair to say that these lambs were at a different level of maturity and had already undergone a 'less efficient' growth stage pre-trial.

These same animals are to be re-tested after they have reared their first crop of lambs. This will give an interesting comparison of how a mature animal performs compared to a growing animal. Since mature cows seem to be difficult to measure, perhaps sheep can give a better understanding of how closely linked the traits are.

The Sheep Improvement Group, in conjunction with SRUC is doing similar trial work in the UK.

Figure 4: Sheep feed intake measurement facility at Agresearch, Invermay.

2d. Discussion: selection for feed intake

Seedstock producers have effectively used Estimated Breeding Values (EBVs) to improve the genetic merit of their cattle. These have been primarily for growth and carcase traits, with an emphasis on revenue generation. What has been forgotten to an extent is the selection for factors, such as feed efficiency, that could lower costs.

I think we have spent much of the last 40-odd years selecting for what we thought was a single trait – growth. Growth is not a single trait though, as it is a combination of a lot of different factors:

- Mature size has a big impact
- Age and Sex are associated
- Body Composition (whether it is mostly bone, muscle or fat that is being deposited)
- Feed Intake, I now understand, is also a factor.

But what is it we are really selecting for when we talk about feed intake? It must have its own individual factors too. My best take on it is this:

- Metabolic Efficiency, which in turn has something to do with 'metagenomics' (which is something about the type of bugs in the rumen).
- There is something to do with the animal's digestion and rumen function
- Metabolic Rate – does an animal with a slow metabolic rate have better digestion because the foodstuff is in the gut for a longer period? Or does it work the other way around? A chicken and egg dilemma.

- Animal behaviour plays a part – why do some animals eat little and often, and others larger amounts and spend more time ruminating?
- And the main factor, which most people seem to agree on – 'a whole lot of things we have no idea about yet'!

Feed Intake is the useful measurement. We can now assess it accurately and easily (although not cheaply) in non-grazing type environments.

How we use the Intake data is where there is some confusion. The purist numbers guys would say *'build the intake EBV into your selection index and select on that index'*.

To simply look at an Intake EBV on its own is just highlighting cattle that eat less, so probably perform less correspondingly. This is not particularly useful.

Leachman Cattle of Colorado show an intake EBV alongside a Feed:Gain EBV and encourage clients to look at both together to get an indication of the feed efficiency component … but *select* on index.

The American Angus Association produce a figure called Residual Average Daily Gain (RADG) as a feed efficiency measure. This is a prediction of gain if all animals in the group were fed the same. This is just another way of pulling intake and production into one number.

Most of the other organisations I visited were confident that NFE was the right way to look at feed efficiency. You can look at an animal with a given level of performance, and with one figure get an understanding if it has required more or less feed than expected to deliver it.

Dr Mark Spangler from the University of Nebraska hit the nail on the head when he said: *"It's not the most productive cattle we want, nor the most efficient – but the cattle that best combine production and efficiency to be profitable."* The name of a paper which is a useful analysis of the different measures of feed efficiency is quoted at the head of References at the end of this report. (National Program for Genetic Improvement of Feed Efficiency in Beef Cattle Dan Loy , Megan Van Emon (www.beefefficiency.org)

2e. Conclusions: selection for feed intake

- Measuring individual animal feed intake is practical and affordable
- Selecting sires for feed efficiency has resulted in savings in feed for finishing progeny in the region of 15%
- Intake EBV used in selection index
- NFE EBV is the individual trait to look at as it is the best measure we have of maintenance requirement
- Any programme to measure feed efficiency needs to be well structured to make sure the most genetic information can be gathered from judicious use of funds, and results leveraged through the use of genomics.

So what became of the Valedictorian bull? Well, there was a fair bit of excitement gathering before the sale, until a DNA test came back showing he was a carrier for an undesirable recessive gene. He sold into a breeding programme, but didn't turn out to be the final answer – just one more step along the journey towards more efficiency cattle.

3. Feed efficiency and the cow

"We are too early in to see what difference feed efficiency is going to make to the cow herd. What really excites me are the smaller framed, big volume cows that look like great range cows that come up with low intake and good feed:gain."

Sam Rempe, Leachman Co-operator, Nebraska

The problem with selection for feed efficiency is that the effect on the cow is a bit unknown, yet 60-70 % of the feed used in the system is eaten in the cow-herd.

3a. North American experiences

I have found difficulty in my travels to get to the bottom of what happens to the cow. In selection for feed efficiency, we are measuring young, growing animals in a finishing environment on what is largely a forage and grain type diet; and expecting that trait to correspond to the mature cow in a grazing environment who has different pressures affecting her feeding behaviour and is doing something totally different with her body (being pregnant, lactating and maintaining body condition, as opposed to growing frame and muscle and perhaps laying down fat).

For every research paper I was quoted showing a good fit between cattle re-tested at different stages of maturity or on different diet types, there seemed to be another saying the opposite thing.

The problem is that cows are hard to measure in a practical sense. They tend to be doing lots of variable things (like milking), or when they are dry they need a low density diet that is difficult to feed in bunkers. And when they do eat, they throw their heads around and spread feed everywhere, distorting the results.

Anecdotal evidence was on the whole positive. When negative and positive NFE cows were wintered together on swathed forage in cold Canadian winters, the more feed efficient cows gained more body fat and body weight than their less efficient herd-mates. In dry rangeland conditions in North Dakota, the more feed efficient first-calved heifers tended to rebreed more quickly and stood up to drought conditions better. But then, if NFE has truly been selecting for lower maintenance requirements, these results would be logical.

There was a feeling that feed-efficient cattle tended to be a little bit longer, not as deep, with a tendency to carry a bit less fat. But at the same time there was a strong feeling that it was just a single trait, and that there were cattle of all types that were feed efficient. The most common thread was that *'it's too soon to tell what effect it will have on the cow-herd.'*

The disbelievers were pretty convincing as well. One breeder pointed out that rather than taking lots of little feeds a day, he wanted his cows to fill their bellies with as much roughage as possible and then go and do something else for the rest of the day while ruminating – like shelter from a storm, shade from the sun, or tend to its calf. He was concerned that by selecting in a feedlot environment, he was risking losing this foraging behaviour. A trial I came across, also looking at behaviour patterns in feeding cattle, questioned this assumption. The more feed efficient cattle in the feedlot tended to eat

fewer times in the day, spent more time lying and ruminating, and were generally more placid in nature.

Another told me in the forthright and hugely practical manner that was quite evident in America's Great Plains country *'Cows are only good for two things: First is they eat a whole lot of stuff that nothin' else will eat; and Second is they taste damn good!'* Although that is pretty rough around the edges and seems a bit simple, it's probably the most important thing there is to know about beef cattle production. We have got to make the most of these two great 'unfair advantages' - and keep our breeding programmes aligned to them.

Case Study – Trangie

If there is a 'spiritual home' of Feed Efficiency it must be at The Australian Department of Primary Industries Agricultural Research Centre at Trangie, Western NSW. It is the kind of flat, hot, dry place where a Scotsman feels uncomfortable. I was shown around the 10 000 acres by David Muik, the manager of the 400-cow Angus herd which fitted in around 1000 acres of irrigated cropping and 2000 merino ewes.

Figure 5: Trangie Angus herd, with calves by Australian Angus Sire Benchmark program sires.

I'd travelled around the world looking at feed efficiency and this was where it all started, so I felt a hushed reverence when he opened the door into the shed which contained the original intake-measuring bunkers. I caught my breath as I got the first glance of the big steel feed hoppers, their precision straight edges with their right angles muted slightly by rust and cobwebs. Coming through the door, the atmosphere changed from the beating heat and glare of the mid-day sun to the kind of quiet, shady coolness you find stepping into a grand cathedral. Just as I was

soaking in the atmosphere, David broke the spell with a warning of '*watch out for the snake'*. This Scotsman could not have felt more uncomfortable.

Trangie research centre trialled some Angus cattle in the early '70s to evaluate their performance in this tough environment. Then came some work looking at the effectiveness of performance recording: selecting divergent lines of growth – a high growth line, and a low line (selected for less growth). Starting from the same base, the divergent lines were bred for numerous generations in opposite directions, quickly creating two distinct populations. The 'Low-line' were disposed of in the '90s, when the focus moved to measuring individual animal intakes and researching feed efficiency. For the record, the Lowlines were taken to the local sale yards where some sold for breeding. They caught a rising tide of interest in the smallholder cattle market. They are now a recognised breed in many countries, with over 1000 members of the American Lowline Registry.

In 1993 a similar 'divergent line' breeding programme was started with the sole selection criteria being for negative and positive NFE. This programme ran for 6 years, with the final 3 heifer crops' average EBV for NFE being -0.3 for the feed efficient group, and +0.5 for the feed inefficent group (in the current Australian Angus herd, both groups would be placed in the opposing 1% extremes of the population).

185 cows from these 3 age groups were then mated for 3 seasons to industry bulls by AI, managed together and were recorded for maternal traits. That is a trial of 450 matings over 3 years in commercial conditions but with research facility recording practices, on two extreme NFE populations. This was the gold-dust they were looking for in the States – a 10 year old paper, gathering dust in outback Australia.

So the results:

Number of calves born/cow exposed	No significant difference
Number of calves weaned/cow exposed	No significant difference
Calf Birth Weight	No significant difference
Calf Wean Weight	No significant difference
Pre-wean gain per day	No significant difference
Milk Yield	No significant difference
Cow Weight	No significant difference, but more feed efficient cows (negative NFE), were consistently marginally heavier
Cow Fat Depth	More feed efficient cows (negative NFE), were significantly lower fat level
Calving Date (measured from start of calving)	No significant difference, but a trend towards more feed efficient cows (negative NFE), to be later (by a mean of 5 days).

In a mating period of 2 cycles of AI followed by 1 turn of natural service, the negative NFE cows had 22% of calves born to natural service sire, compared to 13% in the positive NFE group. This didn't seem to be enough of a difference to worry

a statistician, but it is probably enough to worry a cattleman who knows that speed of re-breed is the most important thing in the production system.

The trial concluded that any future work with NFE females would need to look at traits relating to age of puberty and how early females return to oestrus activity after calving.

That was the result of 10 years of research, where they had created a fabulous resource in the divergent lines of cattle. It seems such a waste to get to that stage and not follow it through another few years to get some lifetime productivity data. Thus is the nature of research projects I fear.

So what now with the famous Trangie herd? There are currently no big research projects – a little bit of methane measuring, and trialling a new measure for age of puberty (sounds familiar?) – ultrasound scanning heifer calves every month post-weaning to look for signs of Oestrus (CLs in ovaries). It is also one of the herds feeding into the Australian Angus Sire Benchmarking program. David says it's a good, steady income project to be involved in, and he gets access to some of the best genetics in the world – a good chance to upgrade his herd.

3b. Discussion: feed efficiency and the cow

One scientist I met put it to me that: '*There is a difference between what is going on in the growing animal to what is going on in the mature animal. It looks like fat is expensive to put on but cheap to maintain.*'

It looks like feed efficiency in the cow is a different trait to feed efficiency in the growing or finishing animal. So long as selection for Feed Efficiency doesn't compromise the cow's ability to be a low maintenance good forager we should be selecting for it. That is why we should not be looking at FCR (feed:gain), but NFE. Perhaps one day we will have separate NFE EBVs for growing, finishing and mature animals. Hopefully there will be a strong correlation between these traits.

3c. Conclusions: feed efficiency and the cow

- The cow's unfair advantage is that she '*eats a lot of stuff nothing else will eat*'.
- The efficient beef cow needs to be able to put on condition when it is cheaply available, and be able to maintain that condition by having a low maintenance requirement.
- NFE varies at different stages of maturity.
- NFE may have an effect on fat levels and return to oestrus in the breeding female.
- We are not absolutely sure what exactly we are measuring with NFE, nor of the long term impact on the cow herd – but indications are positive.

4. Other measures of efficiency

If selection for feed efficiency is not the 'silver bullet' I was looking for, is there another?

"At a herd level, efficiency is about all the things our grandfathers knew, and we have sometimes forgotten:

- *The cow lives on the feed resources available on the farm*
- *She calves every year*
- *That calf has got to survive and grow into a useful beef animal*
- *She's got to keep doing that year after year.*

But from a seedstock point of view, we need to drill down to individual animal performance level if we want to identify the genetics to drive us forward."

My initial plan was to have a good understanding of Feed Efficiency after my trip to North America, and concentrate on sheep in New Zealand. However, I was disappointed to feel that I hadn't identified a clear way forward. I have often found by looking at a problem from a different angle, an answer presents itself, so I went to the other side of the world to get a different vantage point. That was the start of my fascination with the New Zealand hill country Angus.

4a. The New Zealand hill country Angus

The effects of New Zealand's dairy expansion are well documented – sheep have been moved up the hill and ewe numbers reduced. Beef cows have probably been pressurised even more so and are used as a grazing management tool for sheep production on the steepest and toughest country.

Hamish Williams of Turihaua Angus in the East Coast of the North Island explained the concept of the hill country cow: "*A cow should be fertile in her own environment and be structurally sound to have longevity; and a steer should be 600kg at 2 years old. It's not much more complicated than that."*

The Turihaua philosophy was to pressurise the cow in her environment and select the ones that stand up to it and perform. With 450 cows and 100 heifers bred in a 6 week breeding season, cows had to be fertile. After that, they were looking at EBVs – primarily calving ease, then cow size (smaller) and scrotal (fertility indicator), and then maybe carcase (muscle and high fats) … and only then, if you can get it, some growth. There were plenty of replacements coming through the system to substitute anyone who 'dropped the ball'.

The message on performance was that average is OK. They don't want the bottom end, but likewise they are not looking for the high performers either. "*You're less likely to stuff up your cow-herd that way*", says Paul Williams.

Figure 6: Yearling bulls at Turihaua, developing on New Zealand hill country – no grain fed to them

Willie Falloon of Pinebank, part of Waigroup Angus, had a similar philosophy. "*Our objective is not about making big gains in any one direction. It's real easy to go off in a hurry in completely the wrong direction. It's about making small, incremental steps in all traits together, and making progress across the whole balance of traits*."

"*The Waigroup cattle are a bit like the kind of cattle we used to have in New Zealand - smaller, more robust and long lasting - that's our 'Point of Difference'. They are not the same cattle - we've kept up with performance. When we have gone back to using semen from old bulls it brings home the genetic progress we have made through the small steps - the old bulls seldom stack up*."

This was a closed breeding programme, with no introduced US bloodlines. Using a weaning ratio of adjusted 200-day weight over cow weight, and culling the bottom 10% each year, the Pinebank cows had gone from 42% to 59% in a space of 15 years.

I heard the same message time and again in New Zealand – don't stuff-up your cow-herd, average performance is OK, and pressurise your cows (or, in the vernacular: 'Sh*t, we're tough on our cows').

John and Anne Chapman run Inverary Station in the foothills of the Southern Alps with a great view of the Canterbury Plains from their elevation of 1700-4500 feet. Sheep were the main enterprise, but I could feel that John had a passion for his 600 Angus cows. He has been involved with a fairly simple performance recording programme with them for over 50 years, initially in conjunction with Lincoln University.

Heifers are weighed at mating, their first weaning and their second weaning. Calves have an adjusted 200-day weight calculated (wean weight – birth weight/age *200) and corrected for sex (heifer calves weights x 1.1).

Thereafter, it is the weight relative to the group in which he is interested. The table below uses fictitious weights to illustrate the calculations.

		Heifer A			Heifer B			Heifer C		
Weight	Average	wt	+/-	overall	wt	+/-	overall	wt	+/-	overall
Mating	400	400	0		400	0		380	-20	
1st Weaning	475	455	-20	-20	495	+20	+20	455	-20	0
2nd Weaning	530	505	-25	-5	560	+30	+10	525	-5	+15
1st Calf Wt	225	240	+15	*53%*	200	-25	*40%*	235	+10	*52%*
2nd Calf Wt	245	265	+20	*52%*	215	-30	*38%*	255	+10	*49%*

Heifer A is average weight at mating but loses weight while rearing her 1st calf, and is a further 5kg behind the group after rearing her 2nd calf. Both calves however were well above average.

Heifer B is also average weight at mating, but manages to be ahead by 20kg after her first calf, and a further 10kg after her second. Both calves are behind in weight.

Heifer C was 20 kg behind at mating and maintained that in her first season. After weaning her 2nd calf, she is still lighter than the group average, but she has gained weight in relation to it. She has also managed to rear above average calves both times.

The percentage figures shown in the shaded box next to each calf weight are the traditional calculation for weaning %age (calf weight/cow weight at weaning). You can see how this figure quite correctly sorts heifer B as the poorest performer – but gives most credit to heifer A, who perhaps doesn't have the condition to see her through the winter as she has put all her effort into her calf.

Inverary findings, by sorting the group into the top third adjusted calf weight in Year 1:

- *Heifers that rear calves in the top third in year 1 almost all have top 50% calves in year 2.*
- *Those same heifers lost more/ gained less weight on average.*
- *However, 25% of those heifers were among the best gainers.*

John says, "*These are the gems we are looking for. Those cows are the industry changers. I want my stud breeder to be finding these ones in his herd. I'm not really fussed about the herd who are throwing out the bottom 2 or 3, it's in finding the top 10% that is going to drive us forward*."

The Inverary heifer testing system is a test on getting into the herd. Top performers – those that manage to rear above average calves, but not at their own expense – go into the elite (A) herd, used to produce bulls. The middle performers go into the main herd (B) with replacement heifers coming from both A and B herds. The bottom heifers go to the (C) terminal herd – with all offspring sold.

John maintains he has made good progress with this system, but without the co-operation of a stud breeder who is following the same path, he likens it to trying to fill a bucket of water with a hole in the bottom. Without getting the bull right going in, any progress can be lost as quickly as it's gained.

He is an advocate of choosing your stud breeder well – by benchmarking relevant performance indicators from your flock or herd with his. John is a good client of Hamish and Paul Williams at

Turihaua – he appreciates their integrity, and the fact that he can ask about the mother of a bull and he'll get a straight answer. His rams come from Wairere, a flock which is benchmarked on the same system as Inverary.

4b. A regulator to performance

I have had a great time researching this project. I have been in some beautiful country and met some great people. I have hugely admired not only some great cattle and sheep but also the depth of breeding programmes behind them. I have been humbled by the way complete strangers have taken me into their confidence and explained to me what makes their programmes tick – and these people have been really passionate about breeding cattle and sheep, so this is really about what makes *them* tick. I have also been on the receiving end of a lot of wonderful hospitality, and look forward to reciprocating some of it one day. One thing that I have been told time and time again on this study tour is '*There is no such thing as a free lunch*'. In fact, that very phrase came up so many times, that I was starting to get a bit of a complex about turning up to meet someone in the middle of the day!

Over a hamburger for lunch, I discussed the breeding programme behind Leachman Cattle of Colorado (LCoC), with sales manager, Ryan Petersen. This is the programme behind the bull I went to find, Valedictorian. LCoC have developed their own '$Profit' Index. With feed intake data on over 13 000 animals, the resultant EBVs are incorporated into this index, which also includes fertility, milk, mature size, carcase value and weight – in short, everything they can measure that predicts the bottom line in beef production (both on the receipts and payments side of the equation).

Although the $Profit index has fairly recently been developed, it is possible to track the LCoC cattle's progress through time – a kind of analysis in hindsight if you like. Ryan explains that in the '80s and '90s when they were flat-out busy selecting for more growth and carcase; in terms of $Profit – they made no progress. All the gains on the one hand were cancelled out by increased costs in feed intake, mature size and milk, on the other hand.

In the mid '90s, by capping Mature Size and Milk in the selection criteria, $Profit gives them a $2 per head per year genetic gain. Over a period of 10 years that accumulates to a $20/head increase in profitability, which is not to be turned down.

Now, however, by adding the feed intake data, LCoC claim to be making $10-$15 per head, per year progress in cow profitability, and they have plenty of customer testimonials to back it up.

It is pretty impressive stuff, but the big lesson for me was all the running about in the '80s and '90s to no effect. We were doing that here back then too ...and we are mostly still doing the same thing.

There is no such thing as a free lunch – you can't keep looking at the receipts column, without thinking about the payments side too.

Dr Dan Brown of the Animal Genetics and Breeding Unit, Armadale, Australia, when looking at the relationship between ewe condition score, fatness and mature weight pointed out that '*ewe condition score is correlated with lamb fat level – if we are going to do something about one, we've got to be measuring or monitoring the other*.'

Therefore if you select for leaner lambs without looking at what is happening in the ewe, you are likely to end up with lower condition score ewes.

It was explained to me in a similar way at the Meat Animal Research Centre (MARC) in Clay Center, Nebraska, when I was asking where all the 'curve-bender' cows in America were. The two traits of weaning weight and birth weight are correlated – if you increase one, the other will increase – but the North American seedstock sector has been pretty successful at pulling that correlation apart. Birth weights have dropped and weaning weights have increased, genetically – by measuring and careful selection. Weaning weight and Mature Cow Weight are similarly correlated and if more mature weights were measured, there is prospect for these traits to pull apart too.

4c. Tools available

Estimated Breeding Values

EBVs are the strongest tools we have available to manage these traits, but not all the traits we are interested in have enough data available to either develop or publish an EBV. There are other traits which we simply just don't know how to measure – as one scientist put it to me, "*It is inexcusable that we don't have in place a better measure for fertility traits in beef cattle*."

It would be wise to gather data on traits that are of interest, whether or not there is an EBV available or in the pipeline. Cow and ewe mature weights and condition scores through different stages of the breeding cycle might one day be of interest.

Although we have EBVs available for Mature Size in the UK for both beef and sheep it is not widely available, through lack of data input from breeders. I am not aware of any cow weight EBV that is actually published, other than for Stabilisers, and this is not a particularly hard to measure trait.

Mature Weights are published for most of the recorded sheep breeds, but there is far from a full set of data being submitted. One of the original benefits of the Lleyn breed, was the ewe's smaller mature size in comparison to alternative maternal breeds. With the help of EBVs, lamb weaning weights have increased dramatically over the last 10 years. As mature weight is correlated to weaning weight, this trait is likely to have increased in a similar way. From the 16 000 Lleyn lambs recorded on the Signet database however, less than 1800 go on to get a mature weight recorded. There is a risk therefore that the Mature Weight EBV is driven by its correlation to lamb weights, rather than actual ewe weights.

A similar shortage of mature weight data was found in the New Zealand sheep industry, where the maternal index incorporated a heavy weighting on minimising the increase in mature weights. The result was that some low growth sheep were coming up the index, because of the assumed benefit of their lower mature weight, even though it hadn't been measured.

In Australia, where very few mature weights were taken, this problem was resolved by running a separate index for those breeders recording ewe weights.

Fates of the breeding flock/herd will be important in gathering data for a future longevity or stayability EBV. When that EBV gets developed, we will need to populate the database with information about why different animals left the flock or herd: whether an animal left through no real fault of her own

(eg sold for further breeding), or she had come to an unexpectedly early stop to her productive life (eg not in lamb, or culled with mastitis).

In the absence of EBVs for the relevant traits, there are other measures we can look at.

Weaning Percentage

Weaning %age has been proposed by previous Scholars as a quick and easy way to get a handle on individual cow efficiency in a herd. The weight of calf weaned can sometimes be adjusted for age and sex (as in my Inverary Station example). Similarly the weight used of the cow can be taken at different times (although mostly it is at weaning), and can be adjusted for Condition Score (CS).

My concern with the weaning % age figure is the following scenario: Take two cows. Each weans 300kg calves. Both cows are similar body size, but cow A weighs 550 kgs and cow B weighs 650 kgs. They have weaning figures of 55% and 46% respectively; cow A is more successful. But if she is going to have to gain 50kg during the winter to be in the correct body condition to calve again, whereas cow B can lose 50kg of body condition, it would seem to me that cow B is the more successful.

Correcting weight for CS can help overcome this, although it would be simpler to have one single measurement of mature size for each cow.

Then there is the question of what we are going to do with the information. If both cows are in a commercial cow herd, we need to manage them for the best margin. The costs of getting them into the herd are already 'sunk' and we need to make the most of what we have got. We can perhaps decide which individual to breed a replacement female from. These objectives need to be weighed up with our objectives for genetic gain.

A more appropriate time to have a mature size measurement would be at the point when heifers are joining the herd.

By good fortune there is a well-documented, single, lifetime measurement of mature size that can be taken as a young animal. I had to look up the history books to find it though – Frame Score.

Frame Score

A convenient way of describing the skeletal size of cattle, Frame Score (FS) was used as a tool particularly in the 1980s to increase size in beef cattle: taken as a measurement of height in inches at the hip (over the hook bone), and converted to FS using tables available through the Beef Improvement Federation's (BIF) Guidelines taking into account the animal's age and sex.

Most animals should maintain the same frame score throughout their life, regardless of when they are evaluated; however FS may change for animals that mature earlier or later than average for their breed. No one frame size will be best for all systems (feed resources and markets), with large-framed animals tending to be heavier, leaner and later maturing. Frame Scores can be monitored to maintain body size, fatness level and rate of maturity to the optimum level for a specific herd.

Our replacement Luing heifers at home were measured as yearlings with hip heights ranging from 46-51 inches which converted to FS 5 – 7. The corresponding BIF estimates for mature weights for similar framed cows is 550 – 650 kgs. (see www.beef.msu.edu). I would expect our cows to be heavier than that at weaning, but that is perhaps because I am looking for a higher CS.

In the absence of a mature weight EBV, I would recommend looking at Frame Score as a way of controlling cow size in the breeding herd. Measuring yearling heifers is a good way of focusing selection on the most appropriate ones to join the herd.

Another useful application would be in selecting the future sire of replacement heifers. It is unlikely a FS 10 bull will sire FS 6-7 daughters.

4d. Looking at the problem from another angle

"If you are strict at culling open cows in a 60 day joining period – you'll soon get rid of the ones that milk too much." Dave Nichols, Iowa

Efficiency and Fitness for Environment

Let us go back to the statement at the start of this chapter – efficiency is about what our grand-fathers knew: a cow lives on the resources on the farm, she calves every year, it's a useful calf, and she keeps on doing it. This is all really about a cow that is 'Fit for her Environment'. Her inputs suit the farm's resources, she is fertile, has longevity and can do a decent job of rearing her calf. All of that fits in with a cow (or ewe) who is content with her circumstances – not fighting a lack of nutrition or weather conditions for example.

Breeding for a sustainable pasture based livestock production system is all about striking the right balance between two factors. I've heard different versions of the same thing, but it boils down to:

• The ideal steer	vs	The ideal cow
• Kg weaned/whatever cost factor is critical	vs	Fitness for Environment
• Performance	vs	Inputs
• Price/kg	vs	Cost/kg

Our breeding programmes have been focusing on the left side of this equation for too long. The 'Regulator to Performance' on the right side of the equation is where we need to focus more. Fitness for Environment, or robustness is the key to this.

Fitness for environment and fertility

No matter how you add the numbers up, the most important thing in pasture livestock systems is fertility. Fertility is also the first thing to 'switch off' if things get too tough. Fertility, therefore, is the key to unlocking 'Fitness for Environment', and efficiency. Fertility is the best measure we have of Fitness for Environment.

Selection for fertility

Dr Mark Thulman of US MARC at Clay Center said, '*it is inexcusable that we do not yet have a better measure for fertility in beef cattle*.' If fertility is simply a measure of whether the cow is in-calf or not in-calf, it is essentially an indicator of an amalgamation of a lot of other traits coming together. It seems to be hard to pull out the genetic part of 'fertility'.

In fact, I have been told by scientists that fertility is not very heritable. This is a very hard thing for a shepherd from the Perthshire hills to get his head around. Surely anything to do with an on/off switch in reproduction has everything to do with heritability.

That's when it became clear to me. I'd been looking at the problem from the wrong angle, asking the wrong question.

Fertility might not be particularly heritable, but infertility *surely* has to be heritable.

Selection against inefficiency

In the same manner, if selection for efficiency is difficult, maybe selection against inefficiency would work. And that is exactly what the New Zealand hill country Angus breeders have been doing. That is really easy to do:

- Run big numbers
- Keep replacements flowing through the breeding programme
- Pressurise the system to highlight the under-achievers:
    - Those that are either not productive
    - Or not 'Fit for their Environment'.
- Remember that to select against infertility, some have to fail – the system has to be tough enough to push some out.

It is not very academic. I don't imagine that the geneticists like it very much. But it is simple. All it requires for implementation is a change in mind-set. Stud breeders need to think about running bigger numbers and challenging their stock with hoops to jump through instead of pandering to their every need. Bull and ram buyers have a responsibility to pick the breeding programme and the production system, and not get so hung up on the individual animal.

4e. Conclusions: other measures of efficiency

- There is no such thing as a free lunch – there must be a regulator to performance.
- If two traits are correlated and you want to move one, you had better monitor the other one.
- We need to collect relevant data and drive forward EBVs for traits such as mature size and longevity.
- Meantime, Frame Score is a useful measure of mature size in a herd.
- Fertility is our best measure of 'Fitness for Environment'.
- Selection for efficiency is complicated – fertility, feed intake, moderate milk and mature size.
- Selection against inefficiency is easy – pressurise your cows or ewes in your environment and cull the non-performers.

5. Bull and ram sale systems

"Going to a big collective sale like Kelso or Builth to pick your next ram is a bit like swiping left or right on Tinder." UK ram buyer.

The system of selling bulls and rams fascinates me. Some of my earliest memories are of the cobbled floors, wooden gates and dark nooks and crannies of the old Perth Mart at bull sale time. The smell of saddle soap, leather halters and sawdust. Old men in dungarees, hob-nail boots and flat caps (all with their distinctive style). And bulls and hairspray and whisky and stories …. yes, mostly the stories. Stories about bulls, and the people with the bulls.

It is a great part of our heritage and culture. But are all the old characters gone now? Is the atmosphere lost now it's in a new mart in Stirling? I don't think so. It is still exciting – and it is still about the people … and the stories about the people. And it's not just Perth – it's Carlisle, Kelso, Builth, Hawes, Lanark, Lairg, Castle Douglas….

The collective sale structure, however, encourages competition between vendors to have their wares looking that little bit more eye-catching than the next. For bulls and rams, that too often means a bit more grain-feeding, or a bit more hairspray or trimming. It also creates a bit of distance between the vendor and purchaser. Often the purchaser is faceless, lost in a sea of bidders at the ringside. That can encourage a lapse in integrity – a ram that will find a home, but one you wouldn't like to go to a friend.

I have been an advocate of on-farm sales, and at Incheoch we were one of the first in Scotland to hold an auction for our rams on the farm. Part of this study was to look at ways of improving our sale and researching a sale for our bulls in an on-farm format.

Case Study – Kelso

Roger Marshall, now in his 80s, was one of the clearest thinking, most forward looking people I met on my trips. His 'Kelso' sheep have developed from Romneys, through Coopworths to the Maternal and Terminal composites that they now are, incorporating some of the 'exotic' breeds which Roger was involved with getting into New Zealand – Texel and Finn.

His focus on client's profitability has stood the Kelso flock in good stead through almost 60 years of ram sales. There is no doubting Roger's passion for sheep breeding and his direction is clear – business-like, and client focused, but with a healthy emphasis on being proud of the look of the sheep he sells too.

"Why limit the potential of our sheep by 'straight-jacketing' their genes and voluntarily limiting genetic diversity by being bound by strict breed society rules?" explains Roger. As a past president of the NZ Texel Association, I don't think he has anything against breed societies, but he seems to me to be someone not prepared to let convention get in the way of a good idea.

Convention hasn't stood in the way of succession in his ram business either. Long-term ram client, Matt Holden, now runs the ewe flock on a hill property a couple of hours away in Hawkes Bay. He has a stake in the Kelso business alongside David Marshall, Roger's son. The home property is just used for rams now, as stud ewes have had to follow commercial ewes up the hill to keep relevant. No use in breeding rams on a dairy farm, if their progeny is to be used in hill country. In the same vein, Matt does no shepherding at lambing time, but uses DNA sampling to determine parentage, and with the same test identifies lambs with the 'myomax' muscling gene.

In fact lambing time is when Matt does most of his flock visits. He tries to visit each client on their farm once a year – part of the 'Listening, Thinking, Innovating' way of doing business at Kelso. I was lucky enough to witness a day's ram selling.

Ram Selling

Matt Buckley has been using Kelso maternals for a good while, and arrived for his usual trailer load of 13 rams early morning, after a 3 hour drive. He had pre-ordered his selection indicating maternal or terminal, which price bracket (based on performance index) and the number required.

There were four clients that day, all in the second top price bracket ($1300), so the appropriate mob had been brought in, of what might have been about 300 rams. As the top bracket buyers had all been in previous weeks, the rams which they had passed on were joined in amongst this mob too, so there were some of the top performing rams available. Clients get a random selection of rams put in front of them, four times the number booked – so we'd drafted 50 rams for Matt to look over.

Figure 7: Matt Buckley reviews EBVs on his initial selection, buying rams at Kelso.

Upstairs in the Kelso wool-shed on wooded slats is a big round pen – ideal for getting a good look at 6 or 8 sheep at a time - Buckley went through his 50 rams.

He picked about 20, based on the type, stature and wool type that he preferred. We then ran them up a race and an EID reader was run over them which brought their individual records up on a large screen above the race. Matt Holden was then able to rank the rams based on index, or whatever trait the client required.

In this case, Matt Buckley had been using Kelso maternals for a few generations, so wasn't particularly looking to increase litter-size, and focused more on weaning weight. The bottom performing rams for weaning weight were identified and pulled out, which left him with 15 rams. We let them out into the round pen again and he had a selection of rams that were very even on type and performance. I think he might have taken them all had his trailer been big enough, but he pulled out another two based on wool type.

A cup of tea sealed the deal, and there was nearly an hour for a chat and catch up before rams were loaded and sent on their way. This was a very professional, business-like way of selling rams but at the same time was relaxed and quite social. There was time to discuss particular requirements and an even pick of rams was ensured. Innovative use of technology meant that although figures were used, no paper was involved and the buyer didn't need to have an understanding of the performance data – the Kelso team could rank the rams based on what he wanted to achieve with his flock.

Roger's parting advice to me was: "*You have got to stick to the middle ground – performance is what drives your client's bottom line, but you can't just follow figures because he has to be proud of the rams when you deliver them."* I think I can learn from his professional outlook on the ram business, use of expert advice when needed, and finding novel ways of overcoming challenges. Listening, Thinking, Innovating – there's a lot of that going on at Kelso, New Zealand.

Case Study – Nichols Farms

My great-grandfather, Walter Biggar, judged the Chicago Winter Fair thirteen times between the 1920s and 1946 – the final time, he was inducted into the American cattle-breeders' hall of fame – in that his portrait was hung in the 'Saddle and Sirloin Club'. In 2015, for the first time, a Simmental breeder was inducted - Dave Nichols, of Nichols Farms, Iowa. Quite by coincidence I visited him on my trip.

Dave is the guy who started into breeding cattle with a heifer in 4H (young farmers), because he claims: *'the girls that showed Angus heifers were better looking than the ones that showed the steers, and a lot better looking than the ones that showed the pigs'*. He now runs 1500 cows and sells just short of 600 bulls a year - Simmentals, Angus and Composites.

The Nichols Farms bulls are all sold by private treaty at a fixed price – 80% at $4750, the rest a little less. Dave claims that '*people say I sell my bulls too cheap – I say that I know what they cost to produce, and that I just can't supply enough yet*'. Bulls become available at that fixed price on 'opening day', when about half of

them will sell – at an average of about $1000 on top of the fixed price. When more than one person wants the same bull, they bid up in $50 increments.

There is viewing for a few weeks prior to opening day, and there is plenty of help at hand to help clients find the right bull for them. About 40% of buyers get help to pick bulls – usually just picking 5 or 6 out on paper. A growing number are leaving bull selection totally up to the Nichols team.

The bulls go on test straight after weaning and are fed a roughage based diet, but grown to their genetic potential. They are gaining 4lb(1.8kg)/day and converting at 5:1. A Growsafe system is being considered – they would like to identify the bulls gaining at 3:1 but especially the ones out at 8:1. Nichols have already incorporated a degree of feed efficiency into their breeding programme through sourcing some bulls from the Midland Bull Test.

Dave's enthusiasm for breeding the right sort of cattle and using the best tools available to help him meet his motto was an inspiration to me, and I am sure is the reason for his honour. His motto – '*Sell the bull the customer <u>needs</u>, not the one he <u>wants</u>*'.

5a. Discussion: bull and ram sale systems

Another format which was particularly relevant was of course the Midland Bull Test (see page 4). Hundreds of small vendors, a single venue with plenty of choice for the buyer – right in the middle of cow-country – and the deal made with the reputation of Midland behind it. Bulls all given the same chance – same feed, same challenges, same steer-jockey. A proven performance recording system giving accurate data on performance, including feed efficiency data.

There is no real reason why this could not work in the UK. In fact, with our structure of many small breeders, it ought to work better here than it does in the US. There would be cattle health scheme issues, but resolvable. I would imagine there would be a bit of vendor scepticism, but if it were market-led it is a powerful model to base a breed-improving, buyer-friendly, low-cost system of developing and selling longer-lasting, healthier bulls than we currently have.

I have a lot of comments on sale systems in my notes. I thought it might be interesting just to share a few with you:

- '*Sell a breeding programme, not a circus act.*'
- 'When you are selling at home, you aren't just selling the bull – you are selling the whole programme: guarantee, service, the whole breeding programme.'
- 'It is about Cause and Effect – the sale is just the 'Effect', the end product of the 'Cause' – which is '*Something you are doing really well*.'
- '*Selling at home on a one-to-one basis gives me the chance to talk things over and get the right ram for my clients*.'
- '*This is the first year we didn't put bulls in the ring – we just put up a big TV screen and ran the videos. The bulls were all walking about in the pens outside. It worked fine.*'

- '*Partner with 'philosophically' like-minded people – you need numbers to attract people and share fixed costs.*'

Perhaps the best comment was from an Australian, really challenging the paradigm: I asked where he would buy a bull. "*I'd find a breeder, or group of breeders where I could trust their data, that had a bit of integrity, and I liked their breeding direction – their genetic trends are going in the direction I want to go. The bull has to be right in terms of structure, fertility and temperament – but that's all part of breeder integrity. After that, I should provide the criteria, and the breeder should be able to send me the bull. I don't see why there should be a sale*."

I found that there is not one answer to a bull and ram sale system, but endless possibilities. The use of videos on the internet has opened up a whole new avenue. Video gives a much truer reflection of an animal than a still image.

The next generation of bull and ram buyers is more likely to do research on the internet than at shows. The most important decision to make in terms of your genetic direction, in a system of single-vendor sales, is 'which sale you go to'. Once that has been decided, which bull or ram you select is fine tuning. A good website with clear breeding goals, genetic trend lines and KPI (Key Performance Indicator) benchmarks will increasingly become the focus of advertising for sales.

On reflection, I think that getting the important factors right is more important than any particular system – and the Kelso (New Zealand) ram sale ticked most of the following boxes:

Business-like and professional	Genetic trend graphs on display A general look of 'job done right'.
Innovation	Clever use of EID and EBVs on big screen
Comfortable environment	In woolshed
Relaxed	Not pushed for time, nobody rushed.
Confidence in breeder	EBVs fully explained, able to answer any questions
Social	Time for a cup of tea and chat about outside interests
Help at hand	A semi-independent guy there that was good at quietly offering an opinion if suitable.
Inclusive	Everyone left with a branded cap or shirt – gave the impression of 'joining our successful team'.

5b. Conclusions: bull and ram sale systems

- There were very few multiple-vendor ram and bull sales in the countries that I visited in a similar format to the UK
- There are endless other possibilities for sale formats.
- No circus acts.
- The focus should be about getting the right ram or bull for the client.
- Client profitability and breeder Integrity are the common threads.
- The next generation of bull and ram buyers will do their research and choose their breeder on the internet.

6. What is the role of breed associations?

Breed improvement programmes and sale structures are run, by and large, by breed societies or associations. These organisations have been around for the last 150 years, with the main objective of maintaining the breed herd-book – or standing behind the purity of the animals. Usually run by a council of representative breeders and managed by a CEO or secretary, they also organise show classes and member events, generic breed promotion activities, collective sales and are the normal route for communication with the genetic evaluation provider.

Over the last few years in the UK, we are beginning to see the rise in the development of a different organisational format. The 'corporate breeder' format is modelled more on the pig and poultry sector, with a private body at the head. 'Membership' may still be open to other producers through a franchise system. In some cases, the creation of different crosses and composites has allowed for good branding opportunities. Some, like the Meatlinc, have been around for many years, and perhaps been ahead of their time. These organisations can be a good source of large numbers of rams or bulls, often at reasonable commercial values and with well thought-out breeding programmes behind them.

There were similar organisations in the countries I visited. Many had a much greater market than some individual breed societies here. It begs the question: in the world of the corporate breeder, how does the breed association stay relevant?

Case Study - New Zealand Romney Association

New Zealand is a country built on a sheep's back. The roaring wool trade in the '50s was boom time for the sheep industry, and the king was the Romney. Big fleece-weights of good quality wool, shorn twice a year, brought in a ransom. Large framed sheep clipped heavier fleeces, and the wool was bred down the legs and over the faces in a bid to get even more. 70% of the income came from the wool clip. Lambing percentages were less than 100% and the sheep needed shepherding, not least because they got wool-blind.

The Romney Association held shows and collective ram sales, and maintained the flock-book of pedigrees that were a testimony to a history as long as that of sheep in New Zealand.

But the world changed in the '60s and the wool boom slowed down. Having lambs to wean began to become as important as wool to shear. Shepherds needed to look after more sheep. That trend has continued ever since, with the gap between meat and wool growing all the time. The Romney didn't fit. It was a slow end, but the king was dead.

Two Romney breeders in the late '60s, Holmes Warren and John Daniell, recognised that the best sheep for the industry were no longer in the flock-book, but out on commercial farms. They proposed that these unregistered sheep be 'brought into the fold' as it were, to make the stud Romney more suited to meat production.

Their idea was rejected, but they did it anyway – only, outwith the Association.

There has been a lot of water under the bridge since then. Subsidy removal speeded up thinking, the 'exotics' (Texel, Finn and East Friesland) were introduced, and the spread of composites of these breeds has been profuse. However, they have all had Romney at the heart. I got the impression that commercial flocks were using a shot of composites to boost productivity levels and then tending to go back to either the Romney or perhaps a composite with a bigger percentage of Romney.

So what of the breakaway breeders? What became of the mavericks? Their flocks are still going strong – Turanganui and Wairere. There was a consensus among the people I spoke to that these flocks – individually – will sell more rams each year than the whole of what is left of the New Zealand Romney Association.

The king is dead. Long live the king.

Case Study – American Simmental Association

With approximately 110,000 new animals submitted to the database annually, the American Simmental Association (ASA) is a force to be reckoned with. That places them behind Angus, and about level with Hereford as No.2 breed in the US. That is a pretty impressive statistic, when you think it all started from the importation of some semen from a bull from France less than 50 years ago. It is even more impressive when you realise that after the first 20 years they found themselves breeding cattle that were not commercially relevant.

'*We could not make the cattle we had in the '80s any worse than they already were*,' admitted a leading breeder. They had chased show-type, gone too tall and had too high a maintenance to be any good as a range cow, and not enough fleshing qualities to be a useful terminal sire.

About 50% of the current herd-book are purebreds (that is cattle that have been upgraded to be 'pure', and are 7/8ths or more Simmental), and the bulk of the rest of the population are SimmAngus (seedstock with a minimum of 1/4 Simmental and 1/4 Angus. Then there are what we would call 'pure' Simmentals, the fullbloods - which account for less than 1%. To be considered a fullblood, an animal's entire ancestry must trace to European Simmental. American Simmentals are not what we would recognise as Simmentals, they are black or pure red, polled, stout but feminine. The American Simmental is, however, a very relevant cow.

It seems to me that the Angus is a pretty good cow for America - but the undisputed king of the feedlot is the Angus steer. They have the branding (and the marbling to back it up), and absolutely suit the feedlot system. But while the Angus breed has been courting the feedlot, the Simmental cow has come along and picked up the crown of the range. US MARC data shows that Angus mature weights have risen in tandem with carcase weights, at the same time as the Simmental cow has reduced in size. The Simmental now has a mature weight 15% smaller than Angus, and is even a smaller cow to keep than a Hereford.

Dr Wade Shaffer, ASA Chief Executive, says this change was driven by EBVs - the American Simmental now has better growth than they did when they had the taller cattle of the '80s, even though cows now have a much lower mature size and maintenance requirement.

Changing the genetic composition of any breed has traditionally been a slow and painstaking process. This has often been further hindered by restrictive policies or practices that were unrelated to the goal of profitable beef production. ASA has been innovative and flexible in allowing breeders to make the changes required. Quite simply, they have been open to change, but there are other ways in which they have remained relevant. See http://georgiasimmental.com/pdf/2011/mar29/final-2011-simmenthal-diectory.pdf

Figure 8: Simmental heifers and calves at Nichols Farms, Iowa.

50,000 commercial cattlemen receive an interesting and informative magazine five times a year from the ASA. This publication pays for itself through adverts mostly for bull sales.

They run a 'Carcase Merit Program', where 40- 50 young, breeder-nominated sires are used by AI over commercial cows. 6-700 offspring are fed through a Growsafe system, with intake measurements and carcase data (including tenderness measurements), utilised in the breed genetic analysis. DNA markers are being used to try to lever more genetic gain from this investment. This is a significant service for breeders and part of the ASA goal to be the best source of genetic advice for breeders.

By providing a culture of innovation, the ASA has helped enable the Simmental cow to become Queen of the Range.

6a. In the world of genomics, are we all going to have Angus?

Genomics will play an increasing role in evolving EBVs into a more accurate measure of an animal's breeding worth. The Hard to Measure Traits (HMTs) such as Feed Intake, Longevity, Disease Resistance and Eating Quality traits are where genomics can have the most impact. However, before DNA

technology can help us select for these traits, we need to gather more data on relevant training populations and invest in DNA analysis.

Large scale data collection for HMTs and DNA analysis requires large R & D budgets – beyond the scope of many smaller breed associations. Much of the work seems to have been done on the Angus breed so far. There is quite a degree of genetic linkage in the Angus breed between the countries I have visited (UK included). The Angus Associations are all large, well-resourced organisations that can afford a significant R & D budget.

If the research budget goes into Angus, it seems logical that they will make more progress more quickly, and become even more dominant in a similar way to the Holstein breed.

I put this thought to a lot of the people I met. Most disagreed. Even the Angus breeders. The key reason was that *'the environment dictates the cow – get that wrong and cost of production is too high*.' Another was that '*beef systems need to extract every efficiency they can – that includes heterosis*.'

We will rely on utilising the most adapted cattle breeds, and crossbreeding. However, I fear that R & D budget will have a significant impact for the larger breeds.

Particularly in the UK beef sector, there are many native 'regional' breeds that fulfil a similar role. The genetic diversity that they hold is an important resource. The key thing about genetic diversity is that we do not know what will be important yet – something in the future might depend on a trait that is in danger of being lost right now. We could leave these breeds to the 'stubborn fanatics', hobby farmers and show-enthusiasts, but a commercial function is essential if they are going to be useful in the future to the wider industry.

These small breed associations need help to keep abreast of change and remain relevant in terms of genetic improvement. They could pool resources in areas such as genetics advice, working with genetic evaluation providers, DNA collection, and technical briefings for members. I do not see these breeds as competitors, but as allies trying to keep up with the more prominent breeds.

6b. Discussion: what is the role of breed associations

There is a misfit at the heart of the relationship between breed associations and performance recording. A 'breed' is about the traits that make one group of animals stand on their own, away from other groups – it is about 'being the same', having prescriptive breed specifications – resistance to change. Performance recording is all about change – chasing profit driving traits.

In New Zealand, I found that the sheep breeders' associations had tended to not really engage with performance recording. This left a lot more freedom for the genetic evaluation provider to engage with individual breeders, and was seen as a strength.

Breed associations need to work out what need they ought to be fulfilling. Part of the demand on their resources are the services to members catering for the 'leisure activity' that is keeping and showing pedigree livestock. Another part is being a source of genetics for an efficiency-driven, cost-sensitive livestock industry, and helping align breeders' stock to the commercial buyers of 5 to 10 years' time. They need to weigh these things up and divide their time and resources appropriately.

Peter Parnell, CEO of Angus Australia, summed the situation up very well when he said: *"Holding the herd-book, shows and multi-vendor sales used to be the key business – but not now. These things don't add value to our members' businesses. Now it's about*:

- *Managing the gene-pool –*
    - *DNA for parentage verification, assisting selection and managing recessive conditions.*
    - *Pedigrees – but for EBVs, not in terms of genetic purity*
- *Services for commercial and stud herds.*
- *R & D for breed enhancement, and*
- *Being an education hub for members and the industry*."

Breeds will adapt to new environments and markets. Breeders can help make this happen, or fight against it.

Breeders will adapt to new environments and markets. Breed associations can help make this happen, or fight against it.

Change will happen.

6c. Conclusions: bull and ram sale systems

- The role of breed associations is:
    - A source of good genetic advice
    - A communications channel between breeders and commercial customers.
    - Provide structures for breeders to network and work together
    - R & D for breed enhancement.
- We need to protect the genetic diversity we have in our small breeds, by helping them stay commercially relevant, particularly in the world of large R & D budgets and genomics.
- It is the animals and their breeders that make the running. Breed associations are just along for the ride. They need to ensure they provide a useful service and don't become a dead weight.

7. Scale of breeding programmes

Finding out how to manage large scale breeding programmes was part of the intent of this study. How to create larger selection populations as well as the practical things, such as how to sort ewes into mating groups for different rams, were among the points I have been looking at.

7a. Is the size of the population important in population genetics?

The production of EBVs relies upon looking at the difference in performance between individuals in a contemporary group. At the most basic level, in a contemporary group of 2 cattle, with an average adjusted 200-day weight of 300kgs, the one that weighs 315kgs is +15kg, and the one that is 285kg is -15kg. If there was only one in the contemporary group, the BLUP[2] system which generates EBVs can only see it as an average performer. Therefore, the larger the contemporary group, the better it can identify the high and low performers.

Additionally, the more individuals there are in a population, the more likely you are to identify the one outlier that is really going to drive the programme forward.

To that end, the larger the programme, the faster the genetic progress.

The law of diminishing returns must come into effect however. As one geneticist put it to me – 1000 records are good, 10,000 records run the risk of losing accuracy and attention to detail, and might not in reality bring much more to the table.

Another point that was made to me centred around the practicalities of running a stud flock. If, for instance you need 50-60 progeny per sire to get a good evaluation, that probably means 30-40 ewes per sire. You probably want to use at least 2 good, proven sires; perhaps 4 young sires ought to be trialled; and a further 1 or 2 reference rams to link with other populations. That gives 8 rams with a minimum flock size of 250-300, and that is not utilising the sires to their potential.

Cut that down to scale for a beef herd: 10 progeny per sire, 1 reference sire, 1 proven sire and 2 young sires – that's nearly 50 cows at a minimum, all in one breeding period (not split spring/autumn calving), and basically relying on AI.

The median number of lambs recorded in New Zealand performance recording flocks is 600 lambs for maternal breeds, and 200 lambs for terminal breeds. 10 flocks record over 3000 lambs per year. Some of these numbers are huge, but the median numbers are achievable. We are recording a higher number in our own maternal programme at Incheoch.

7b. Efficiency of scale vs attention to detail

"I like to buy my rams from someone who has a bit of passion for what they are doing. The big corporates are too big and rely on too many people. At the end of the day, someone has got to put

[2] Best Linear Unbiased Predictors

their hand up and be accountable for the sheep they are producing. As a client, I've got to believe they are doing the right job and they are in control." New Zealand ram buyer.

I started this journey with a bit of an assumption that 'bigger was better'. I have seen evidence that supports this, but also some that contradicts it.

Case Study – Leachman Cattle of Colorado

With sales of 1200 bulls a year, LCoC is one of the big players in the US bull market. They used to run 13000 acres in Montana, but now concentrate 100% on the genetics business, without the distractions of running a ranch. Bulls are mostly bred by a team of co-operators more than 40 strong. "*The co-operator system is about helping us all be low-cost producers,"* says Gary Rolland, LCoC Semen Sales division and Co-operator.

The Rempe family in Nebraska started in the cattle business 3 generations ago with Herefords. They cross-bred into Red Angus, eventually becoming co-operators for someone producing Simmental x Red Angus bulls. They are now producing Stabilisers for LCoC. With 4-500 cows and 200 heifers to calve, Sam Rempe likes the co-operator system: *"We can do what we're good at – stay on the ranch and raise cattle."* Sam has a bigger role in the LCoC business, as a genetics advisor in his local area organising semen sales to clients.

It is easy to see how such a large programme, spread out over thousands of miles, could lose direction, focus and the attention to detail that makes things work. I saw pride in the co-operators, an appreciation that everybody was playing to their strengths, and a feeling of ownership of the programme right down to under the cow's tail at breeding time. Matings were sorted by computer to optimise genetic progress and minimise in-breeding, but the AI team could over-ride the system and use a different bull if it suited the cow in the crate. Guys like Sam Rempe - the guys with their arm inside the cow – had the passion for the programme, the knowledge and a share in the vision, and were empowered to make it happen.

Case Study - Pharo Cattle Company

Kit Pharo, of Pharo Cattle Company (PCC), also in Colorado, must be almost the nemesis of Lee Leachman, but they are doing so many things the same way. Kit is another great marketer, he has set up a structure of co-operators to bring more cattle into his breeding programme and sales; he puts in the speaking engagements, publishes the brochures and newsletters; he has developed a clear breeding goal and recording system to deliver it.

But at PCC it is quite the opposite to LCoC. The bulls aren't sold fat - they are developed on grass - the catalogues aren't glossy, the bull sale has no hype. Even the test-centre is at the opposite end of the scale - where Leachman's is part of

the respected Colorado State University, Pharo says his cattle are tested on the *'Father Time/Mother Nature System'*.

Figure 9: Cows and calves in a paddock grazing system at Pharo Cattle Company, Colorado

Kit is not following the mainstream, he has been going his own - low input - way for years. He encourages the rest of us to leave the status-quo and become 'Herd-Quitters' - that is to drop the herd mentality and think for ourselves. His principle is to let the cow get on and do her job - by herself, with very low inputs. The 'solar bulls' that come out of the PCC system are smaller framed, big bodied, easier fleshing type cattle than what he describes as the mainstream 'diesel bulls' bred on high input systems.

His views on co-operators are "*When there are other people doing the same as us, we bring them into our program - it's better for us to work together than to compete. Overall there will be 2500 - 3000 cows in our program, producing 800 sale bulls per year*". Kit can sell that number of bulls, and his share of the market is growing. He has put the breeding programme together and is using co-operators to help grow his production to meet the market.

Kit Pharo is passionate about his vision for the future of the beef industry and has developed that into a clear breeding goal. He is very good at communicating, has attracted a following and incorporated the best of them into his team ... and he keeps good cattle.

Case Study – Cole Creek Angus

One of the most impressive breeding programmes I visited was Cole Creek Angus, on the banks of the Yellowstone River, not far after it left the National Park on the Montana/Wyoming border. Greg Golden is the 3rd generation on 4000 acres of dry, rough 'cattle' ground, with a rusty old centre-pivot irrigation system to grow winter feed. 170 Angus cows produce 50 bulls a year for his own sale at Midland. Imagine a well-put-together North American bull marketing strategy. It would be glossy and slick, with short inspirational quips about the positive future for the industry, padded with a bit of propaganda and linked to a colourful website

showing sleek, fat cattle. Well, the Cole Creek marketing strategy is just about the exact opposite. But it seems to be working just fine.

Figure 10: Cole Creek Angus herd, Montana.

Cole Creek is about a breeding programme that is going really well. The pedigrees are the most linebred I have seen; he is back using bulls he used in the '60s; there is no use of high fashion bulls; any new blood is regarded as highly suspicious until it has been fully tested the 'Cole Creek' way. The cattle are like peas in a pod, but Greg knows exactly who they are and how they fit into the programme. He is totally in control and knows exactly where he is going …. and he has been going that way for at least the last 50 years.

He has been breeding against the tide – all out for maternal, when everyone else has been looking at growth, yield and marbling, so he is catching clients on the re-bound, trying to '*fix their cow-herd again'*. He has been working on his own, but has been able to use genetics from a few other breeders doing the same, like the late Larry Leonhart of the Shoshone herd.

Case Study - Blackdale Stud

Another family-run unit doing a similar job with sheep in New Zealand's Southland was father and son team Peter and Leon Black: selling 6-800 rams a year from a ewe flock of about 6000. Leon sells privately – he likes to get to know his clients, and makes sure they are getting a ram that is going to take their flock in the direction they want to go. With a marketing strategy not dissimilar to that of Cole Creek, he says the best advertising is when a neighbour of a client looks over the fence and wonders where the sire of the lambs came from.

Leon relies on results of the Central Progeny Test (CPT) as publicity for his genetics. The CPT is mostly about connecting all the individual bits of unrelated performance recording together by providing some genetic linkage. About 20 new rams are tested every year in a breeding programme covering 5 sites, with progeny performance recorded since 2002. It is a similar idea to the Australian Angus Sire Benchmarking project discussed on page 5.

He is using the CPT to increase the size of the genetic pool he is working with. It gives a benchmarked evaluation of performance between all breeds and composites that are involved, effectively giving a huge population from which Leon can pick his next stock ram.

Although 6000 recorded ewes might seem like a large number, it is a two-man operation in New Zealand. The Black family have used industry collaboration to increase the scale of their breeding programme.

7c. How to create a large population?

I visited a few large operators who were running the whole breeding programme themselves. Some had their own customised index or even genetic evaluation. Others worked within a breed association structure. Some had developed a network of co-operators to increase the population they were controlling.

Frameworks to help create linkages and measure HMTs, so creating larger, better recorded populations had in some cases been put together by breed associations, and in others by industry bodies, such as with CPT.

Some formal groups worked together swapping rams and sharing information, other less formal groups swapped bulls and motivated each other with the occasional yarn on the telephone.

Some of the best breeding programmes I saw were relatively small, going their own way, and doing their own thing. But they relied on outside genetics in some form.

I saw good examples of all of these.

I think the important common aspect was in having a clear vision of where the programme was going, a well thought-out breeding strategy to take it there, and the common sense to acknowledge when to stop or change course.

7d. Discussion on scale of breeding programmes

Only a small proportion of any generation is truly genetically superior. The larger the population base, the greater the potential for selection of superior individuals.

The size of the population in the breeding programme is a bit like the size of the car's engine – it governs the speed at which you can get to your destination. Getting to the destination still relies on the guy in the driver's seat steering in the right direction and making the right choices.

If I have learnt one thing in my Nuffield Farming Scholarship it is that when it comes to breeding programmes, and when it comes to driving a hire-car in a foreign country, getting to the right destination is far more important than how fast you are going.

Note to future Farming Scholars: Save money on the hire-car, don't scrimp on the map and sat-nav.

7e. Conclusions: scale of breeding programmes

- The larger the population base, the greater the potential for selection of superior individuals.
- There are inefficiencies as well as efficiencies of scale. Attention to detail can't be compromised.
- There are many options to create large populations – working together to a common vision can increase the potential for speed of gain.
- Direction of gain is reliant on this 'common vision' being right.

8. How do we become better stud breeders?

"Seedstock breeders around the world spend most of their time correcting mistakes – and they correct extremes with extremes." Steve Radakovich

8a. A geneticist's theory of change

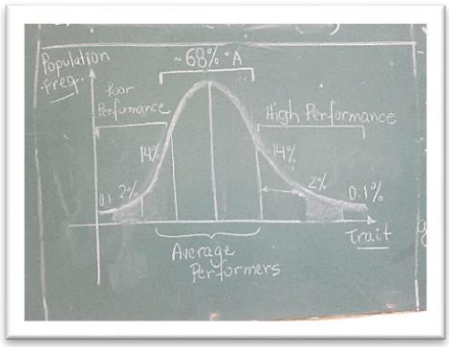

Figure 11: chart to show the basic principles of genetic gain: typical population distribution for any given trait. *From the woolshed at Wairere*

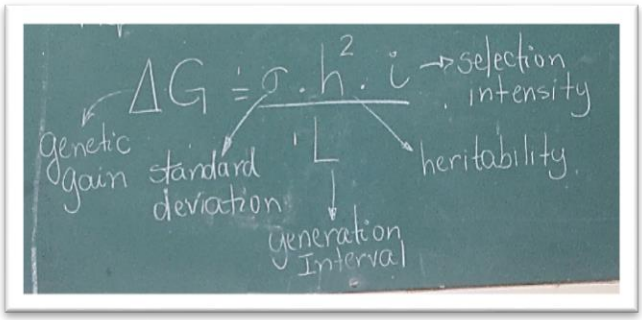

Figure 12: formula to show the basic principles of genetic gain: how to achieve it. *From the woolshed at Wairere*

These charts above show the basic principles of genetic gain. The bell curve is a typical population distribution for any given trait – there are a lot of average performers, a few at the bottom that we need to get rid of, and a few at the very top end. The goal would be to move the whole graph to the right – improve the whole population.

The formula in the **second picture** is about how to do that:

- Genetic gain is the rate of progress in whatever trait or grouping of traits we are looking at.
- Standard Deviation is a phrase scientists like to use when they mean *variation* – that is, there has got to be some distance on the curve between the high and low performers. If the leaders are way ahead of the followers, then it's easier to shift the population.
- Heritability is about how much of the variation in performance is down to genetics – some traits are very high, like colour or polling – some are low, such as longevity, because there are many factors affecting an animal's longevity (a ewe could leave a flock for a whole host of reasons, many of them just by chance).
- Selection Intensity is a measure of how well you pick the top performers. It is unlikely (and probably unwise), that this particular trait is the only thing that is being considered in the breeding programme. It is also about how heavily you can use the top performing sire, or if you can put top females into an embryo transfer programme, to further their influence in the population.
- Generation Turnover is about how good you are at culling out the existing herd and sire pen, allowing the next generation to take their place. Breeding with yearlings is a way of speeding generation turnover.

I've seen these charts before somewhere – I've been to some pretty obscure conferences. These ones (at the head of the previous page) I photographed on the wall in the 'smoko room' underneath the woolshed at Wairere – one of the leading ram producers in New Zealand.

The 'smoko room' at Wairere is a living, vibrant place – busy with young shepherds, group visits, passing Nuffield Farming Scholars …. When I've seen them before, it's just been with all the usual people that go to a conference. Perhaps we need to break down some of the barriers that make talking about genetics a bit of an 'elite sport'. Geneticists and livestock breeders talk a different language. If we could build a better understanding in our breeders about the words, the meanings, the culture of genetics – we would be opening up better communication, paving the way for 'better breeders'.

Back to the charts - they show a theory of genetic change, but really they show a theory of change in anything. If we think of the bell curve as a population of stud breeders, then generation turnover becomes about getting new ideas implemented. Heritability is about how transferable new ideas are. Selection Intensity is about profile of new ideas – how keen people are to get them. Standard Deviation or variation is still about how far ahead the top stud breeders are from the rest of the pack.

The implementation of new ideas into UK beef and sheep stud breeding has been focused at providing the science, and stimulating commercial demand – providing the means at one end, and trying to pull it through at the other. The 'engine room' of genetic improvement in the middle – the stud breeder – has to an extent been left on his own, to fulfil the demand with the tools provided.

I think it is time to turn some of the focus into developing the engine room.

The Australian industry decided to take the breeders at the top end of the bell curve and guide them through the use of all the tools available – trained them to be better stud breeders. By pushing the best forward, it created a bit more variation, and raised the profile of new ideas. Once the leaders started talking about the tools they were using, some of the followers weren't long in getting involved. These leaders were identified because theirs were the genetics that were being used in other herds anyway, and would transfer genetic gain automatically.

Methods employed included on-farm visits, discussing breeding programmes and the sires used over the last 5 years; field-days; webinars and social media. The tools they were explaining included use of optimum mating programmes; understanding in-breeding co-efficients; making the most of contemporary groupings and such like – just tinkering with the engine to help it run more smoothly. One of the breeders they have worked with is Te Mania Angus, in Victoria.

Case Study – Te Mania Australia

Te Mania Australia is run by the Gubbins and Mcfarlane families, 3 generations on from herd founder, Edwyn Wilding who started breeding Angus cattle in New Zealand's South Island in 1928. The New Zealand herd is also still to the fore, but with different environments to cope with and markets to aim for, the two herds have diverged in recent times.

The Australian herd is aimed at the 'Jap-Ox' market – a 500kg carcase weight (cwt), high marbled steer. Tom Gubbins explains: "The feeders are investing $1000 in a 450kg liveweight, 14-17 month steer, and they are going to invest a further $1000 in feed to get him to market. To be assured that he is going to grade and marble well, these buyers want to know they are getting the genetics right."

He says that 6-8 years ago these cattle were fed for 350 days to ensure the correct degree of marbling. Now they are achieving the same marbling levels on 270 days' feed – a massive saving of 80 days. Genetics have been the driver for that improvement, and that in turn has been driven in part by carcase data from Te Mania's own progeny tests.

Sires are extensively progeny tested and recorded through 'Team Te Mania' which is a coalition of around 40 cow herds. 11 of these herds are fully performance recorded to a level higher than many stud operations. This marketing alliance and progeny test uses latest cutting-edge genetics to fast-track commercial production. They have collected well over 40,000 progeny scans, 10,000 structural scores, 7500 docility scores and 9000 mature cow weights. They have received over 5300 carcase data, and now they are starting to look at feed intake data.

This is all coming from a herd of around 1700 cows, but they have made their progeny test population much larger, by offering access to some of their most advanced genetics through an innovative leasing arrangement, and discounted semen from top sires. Team Te Mania is a win-win, Team herds get higher quality calves and the nucleus herd benefits from progeny data to advance the genetic programme.

Figure 13: Analysing young sires at Te Mania, Victoria.

I spent a really enjoyable couple of days working bulls in the yards at Te Mania. They had recently all been independently structurally assessed to give data for linear measurements, and also identify culls. While I was there, they were being vet checked for fertility and drawn to different sales, with some potential future sires going on lease to Team members.

Te Mania was a great example of what a stud breeder could be. Integrated with the market, thorough in data, valued level of service to clients, innovative use of technology, insightful alliances with research… …and the cattle looked great too!

8b. How can one breeder make a difference?

A French farmer told our Nuffield Farming group on our Contemporary Scholar's Conference that the problem with the world was that it was full of people who had paved their lawn to park a second car, while complaining about the treatment of the rainforests and the resulting lack of biodiversity. His point was that if we all implement something in our own small scale, the results could outweigh the big thing we are concerned about.

If you put rams out with ewes, or bulls with cows, and keep the next generation for breeding – then you are a breeder. If you are a breeder, then your choices in genetics affect your future production potential, cost structure and market. If you are a stud breeder, your genetic choices affect those same elements for your clients … and also for the breed you are involved with. The future of your breed is in your hands.

It doesn't matter if you have 2 cows, or 2000. If you pick the bull, and you choose which one to keep a daughter from, then you are in control of the future of the breed. You are the guardian of the genetic resource. This privilege goes hand in hand with the responsibility to ensure that the breed stays commercially relevant.

I think it is too easy sometimes to think that a problem lies with a breed association, the genetic evaluation service, the large breeders, the market …. the rainforest. When in fact, if you have 2 cows or 10 ewes and you are a breeder, then you can change things.

8c. The left side of the brain

I have mostly discussed what could be described as the 'science' behind breeding, without mentioning what is sometimes called the 'stockman's art'. I think that the basic principles of structural soundness for longevity and temperament, and the correct health status to provide a comfortable level of risk, are a given in any breeding programme. There is more to it than that however.

In an interview, the Russian ballerina Anna Pavlova was asked '*What were you trying to say in that dance*?' She replied "*If I could have said it, I shouldn't have had to dance it.*"

There is perhaps more going on in the left side of the brain than we sometimes give it credit for. Some things about breeding livestock have no logic and can't be described.

There is a man from Arkansas called Gearld Fry, who has studied the works of Dr Jan Bonsma from South Africa. From Bonsma's work and a lifetime of studying cattle, he has developed his own linear measurement system – with emphasis on girths, lengths and widths, body proportions and ratios. He

claims that cattle of the right proportion are high in reproduction and meat production, and low in maintenance.

Unfortunately I didn't know about Gearld Fry at the start of my trip. Kit Pharo had been using some of his measurements, however. It wasn't until I looked at cattle with Kit, that I could see what it was about. The cattle he is looking for are exactly what my father and grandfathers have taught me about 'type' and 'balance'.

I think Gearld Fry has tried to put measurements to the things that some stockmen know, but can't 'say'. Although they can 'breed' them, in an 'Anna Pavlova' sort of a way.

8d. Skillset of the modern stud breeder

I have had the privilege of talking with a lot of great stud breeders during this study. I have often asked '*how you learn to be a stud breeder*'? The replies have often been interesting and surprising – I have shared a few here, and the pie-chart gives a rough illustration of the impression I was left with.

- '*Coming from a commercial background with no 'stud-breeder baggage' has helped – you've got to keep a real commercial focus.*'
- *'The old school who don't understand the numbers will tell you it's about the 'stockman's art', but it's not – you've got to study the animals, and study the numbers.*'
- '*Most stud breeders learn from their father – maybe he'll send you to another stud to learn – but they should be going to work with their clients and getting a real-life commercial view of things. That is where change is driven – out of necessity.*'
- '*You've got to learn to be a breeder, but you need good commercial understanding to give you* direction *– and that's the most important thing – direction.*'
- *'I'd do a masters in Quantative Genetics – if you had the knowledge of Dorian Garrick, and an understanding of the cattle industry, you'd be in a pretty good position.*'
- '*Be open to new ideas, and think them through. Have the perseverance to stick to your breeding goal. It's a bit about madness really!*'

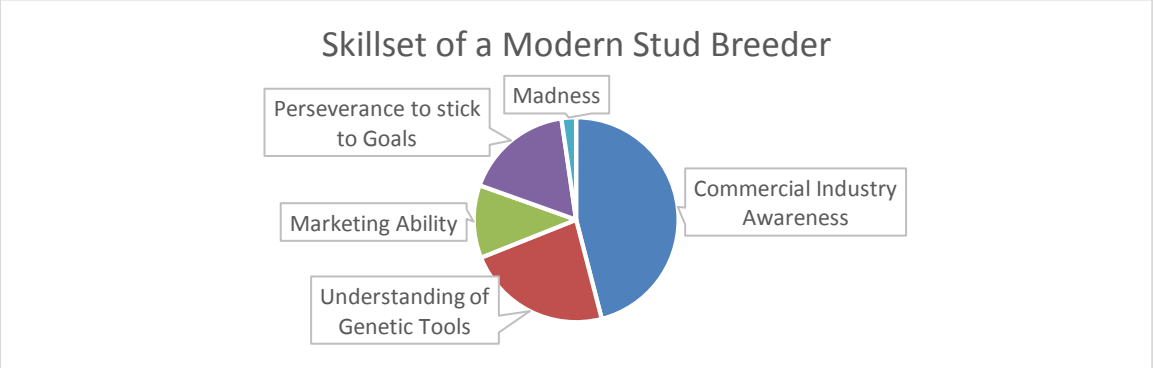

Figure 14: pie chart drawn by author to give rough illustration of the skill set of the modern breeder

8f. Conclusions: how do we become better stud breeders?

- Our industry needs to shift knowledge transfer in genetic improvement towards helping stud breeders better utilise the tools that are available.
- Being a good breeder is about Balance. You have got to:

    - Breed the bull or ram that your client **needs**, and make him look like the one that he **wants**.
    - Like animals – observe, study, think.
    - Have a commercial 'industry-wide' understanding.
    - Use that to develop a clear goal
    - Follow that goal with perseverance
    - Be a bit analytical:
        - understand the science behind the genetics
        - know the strengths and weaknesses of genetic improvement tools
        - be skilled at recording data.
    - Trust that the left side of the brain will keep you breeding the right 'type'.

8. Conclusions

I have been giving my Conclusions at the end of each chapter as I went along, because each of these sections has been on a very different aspect of breeding the beef and – sometimes - sheep animal. In this report Conclusions seem to sit better at the end of each section rather than at the end of the report as a while.

However I will here re-endorse what were the main findings of my study tour:

- The best breeding programmes have clear, consistent breeding goals, based on client profitability, irrespective of the size of the programme.
- Selection for feed efficiency in beef cattle has great potential to improve profitability in the finishing sector, but the long-term effect on the cow herd is less clear.
- There are lower hanging fruit available for the UK suckler herd – fertility, longevity and cow size offer more reliable, affordable opportunities to improve efficiency.
- There is no reason why both shouldn't be selected for at the same time.

There needs to be some form of input *regulator* to any output *performance* based breeding programme.

9. Recommendations

9a. For bull and ram buyers

1. Bull and ram buyers need to focus more on the programme behind their potential sires, rather than the individual animal. Remember the story of Phar-Lap - it is the consistent, mid-field finishers we need – not the once-in-a-lifetime champion.
2. Think of your future breeding herd or flock, what changes do you need to make to regulate costs, and what genetic tools are available to guide you? Perhaps limiting mature weights would be applicable. If mature weight EBVs are not available, look at Frame Scores.
3. When you look to pick your next sire, know what you want to improve – have a destination in mind. As one kiwi ram breeder put it: '*If you don't know where you're trying to go, it's bloody hard to get there.*'

9b. For bull and ram breeders

1. Selection for efficiency is about merging economics and genetics. These two make uncomfortable bedfellows. The geneticist will know that great leaps forward are made by those who don't count the cost. The economist will know that there is no such thing as a free lunch, and that for every gain there is to be made, there will be a cost to pay at some point – even if we haven't thought of it yet. The cattleman will know that neither of them are likely to pick the right bull anyway. It all comes down to him to learn from both, and build a balanced breeding programme.
2. Selection for efficiency is complicated, it is tied around 'Fitness for Environment', and the best measure we have for that is fertility – but also feed intake, moderate milk and mature size. None are easy to select for. Selection against inefficiency is easy – pressurise your breeding stock in your environment, set them up to fail, and work with the ones that don't.
3. If two traits are correlated, and you intend to move one of them, you'd better monitor the other one.
4. Someone has to stand up and take responsibility for feed intake in beef cattle. There are bulls with the potential to make huge gains to beef profitability in terms of lowering feed intake. Right now, they are passing us by like fish in a pond, because we don't know which ones they are. Someone has to start fishing them out.
5. Stud breeding is fun, but it is a serious business – you are providing the genetics that will drive profit or loss in the commercial sector. Breeders have a responsibility to learn how to become 'Better Breeders'. There are some key skills we need to develop – balancing the knowledge of the geneticist, the economist and the ballet-dancer.

9c. For breed societies

1. Breed associations need to position themselves as a service hub to breeders and commercial buyers. They need to be a trusted source of timely, good genetic advice. They should offer a communications channel between breeders and commercial customers, bearing in mind the next generation or buyers will research and chose their breed and breeder on the internet

rather than at shows and markets. They can help create larger selection populations by providing structures for breeders to network and work together, and be the guidance for R & D for breed enhancement.

9d. For industry

1. Some of my recommendations don't fit any of the above headings, and there is a need for industry bodies to lend a hand.
2. We need to protect the genetic diversity we have in our small breeds, by helping them stay commercially relevant, particularly in the world of large R & D budgets and genomics.
3. Our industry needs to shift knowledge transfer in genetic improvement towards helping stud breeders better utilise the tools that are available.

10. Objectives revisited

(My original objectives were stated on the title page at beginning of this report)

What are the efficiencies to be gained from scale in breeding programmes?

I discovered that scale of breeding programme has a lot to do with speed of progress – the larger the population, the faster you will go. I also discovered that **speed** is only relevant once **direction** has been established. And direction is only any good if there is an end-point or **destination** in mind. Sometimes successful breeding is about staying where you are – making no change – and avoiding making mistakes.

How do we select for feed efficiency in beef cattle?

Selection for Efficiency is about Breeding for Balance:

• The ideal steer	vs	The ideal cow
• Kg weaned/whatever cost factor is critical	vs	Fitness for Environment
• Performance	vs	Inputs
• Price/kg	vs	Cost/kg

For too long we have focused our attention on the left side of this equation, without placing enough selection pressure on the right side. Selection for Feed Efficiency is a useful step in rectifying that, although there are perhaps easier ways to make a start, such as limiting mature size, focusing on longevity and fertility. It is perhaps easier to select against inefficiency, by pressurising the breeding herd or flock – set them up to fail, and work with the ones that don't.

How do we run a bull or ram sale to encourage best practice in terms of genetic gain and animal development resulting in genetic value for clients?

A sale is the end result of a programme that is going well. Focus on client profitability, turn that into a breeding objective, build a breeding programme to fulfil it and follow it stubbornly. Co-operate in R & D, learn from science to find a way of getting your client the bull or ram he needs, and breed it to look like the one that he wants.

11. What changes for the author?

"The show-ring is a neck-tie that we've forgotten to take off – and it's slowly choking our industry. It's got into the sale-yards at bull and ram sale time, and into the cattle yards when we are making our breeding decisions.

It's pushing us to have bigger and bigger cattle, when they are already too big; and feed hotter and hotter rations when bulls and rams are already not lasting long enough.

We've got to take it off. Let us not throw it away – we will keep it for a few days a year. Don't wear it when working cattle in the yards, nor when you go to buy the next stock sire. Show your children how to wear it, but also teach them when to wear it. Don't let it choke us anymore.

We must get away from the glitter and the hair-spray of the cat-walk that our bull and ram sales have become." Neil McGowan, December 2015, somewhere over the Pacific Ocean, at the end of this study.

My Nuffield Farming Adventure has resulted in a sale of a large proportion of our family's Simmental herd, in the first step towards a more efficient type, maternal cow. Our Luing herd is now the first recorded with Signet, and is expanding in number. My goal is to develop a herd of cows that are tested in their environment, performance recorded and benchmarked to industry standards to be 'functional, efficient and robust'. Leading on from that, to be able to offer a source of genetics that my clients need, while looking like the kind of bulls they want.

I have seen the kind of cattle I want, and I don't think we are far away, particularly with our Luings.

I was all excited about selection for feed efficiency at the start of my trip. I still think it's important, and I'd like to select our Simmentals on NFE and would support a broader industry move to start doing so. I feel what we have in our Luing cows, however, is something a bit unique and we *'can't afford to stuff-up our cow-herd'* as they told me in New Zealand. I'd like to see how it works out for someone else first.

I've seen the type of meat-sire rams I want to have, and there is more to be done there. Our Texel flock needs to expand and start lambing outside with minimum intervention. I think we need to co-operate with other breeders to create a larger population of Texels subjected to the same management pressure, alternatively open up our breeding programme to different breeds.

I am more content with our maternal ewes – although I feel we need to ease-off selection pressure on growth and carcase because we have reached an appropriate level. Instead, our selection pressure should turn to lamb survival, ewe longevity, lower mature weights and worm resistance.

I take encouragement from understanding that we don't have to become massive 'corporate' breeders to have a good breeding programme.

I have discovered that I am a breeder, not a farmer.

I'm going to keep dreaming of Phar-Lap and trying to breed a legend, but stack pedigrees full of consistent, mid-field finishers.

11a. Footnote

Bearing in mind the lessons I have learnt on my Nuffield Farming study tour, my interest in the Luing breed (originally Shorthorn x Highland, or 'Scotch Cow') and with a nod of appreciation to my sponsors, I would like to share a note I found during my research:

> *'Native British cattle are the well from which genetic improvement has been drawn for over a thousand years. The Blue Roan (Angus x Shorthorn), Blue Grey (Galloway x Shorthorn), Albion Blue (Shorthorn x Welsh Black) and the Prime Scot (Shorthorn x Scotch cow) … exemplify this system.*
>
> *Recovering those types will restore a proven grass fattening beef animal of first quality. These genetic blends are time-tested to breed strong constitution, early maturity, marbling and tenderness in a harsh climate.*
>
> *Grass beef farmers of the future owe a great debt to the iconoclastic breeders and stubborn stockmen before us, who faithfully conserved the old types of all beef breeds. We can only honour that debt by carrying those functional genetics forward.'*
>
> From: Transactions of the Highland and Agricultural Society of Scotland, Fourth Series, Volume VIII page 160, in the year 1876.

1876 rung a bell. During this trip, I took a break during a long drive on my to visit a historical site in Wyoming, where on June 25th that same year, the 7th US Cavalry under Colonel George Armstrong Custer was wiped out by Sioux and Cheyenne at the Battle of the Little Bighorn.

Figure 15: The 'Peace Through Unity' Indian Memorial at the Little Bighorn Battlefield National Monument was unveiled in 2003, not far from the memorial on Last Stand Hill to the Seventh Cavalry soldiers erected in 1881

12. Executive Summary

There is a need for keener cost-control in the UK beef and sheep sectors. In beef systems feed costs are paramount, and ease of management is often the limiting factor in sheep systems. Cow and ewe efficiency and sheep 'operator comfort' are worthy approaches to tackle these challenges. The genetics to drive these approaches have been somewhat ignored.

This study was to identify how to measure feed intake, test and select breeding bulls for feed efficiency. Additionally, what efficiencies could be gained from scale in breeding programmes and how to run a bull or ram sale to encourage best practice in terms of genetic gain and animal development resulting in genetic value for clients? In short, how to become better breeders of more efficient beef cattle and sheep.

I travelled to Canada to understand selection for feed efficiency; America to see it in practice and understand how large recorded herds work. I went to New Zealand to see ram breeding and selling on a large scale, but found a different approach to cattle efficiency; and finally, Australia, where I was curious to explore where feed efficiency research started. I visited mostly with stud breeders, also breed associations, genetics service providers and research institutes.

There are large gains to be made in selection for feed efficiency. The effect on the cow is not yet fully understood but indications are largely positive. It is equally important to select for other measures of efficiency such as limiting mature size, focusing on longevity and fertility. Whatever we select for, we must incorporate some form of regulator to performance in our programme – we can't continue to select for output without thinking about inputs.

I discovered that scale of breeding programme has a lot to do with speed of genetic progress, but that speed is only relevant once direction has been established. And direction is only any good if there is an end-point or destination in mind. Sometimes successful breeding is about staying where you are and avoiding making mistakes. Stud breeders must focus on client profitability, turn that into a breeding objective, build a breeding programme to fulfil it and follow that stubbornly. There is a responsibility to learn to become better equipped breeders.

Selection for efficiency is about merging economics and genetics. These two make uncomfortable bedfellows. The geneticist will know that great leaps forward are made by those who don't count the cost. The economist will know that there is no such thing as a free lunch, and that for every gain there is to be made, there will be a cost to pay at some point. The cattleman will know that neither of them is likely to pick the right bull anyway. It all comes down to him to learn from both, build a balanced breeding programme and become a better breeder.

Neil McGowan

13. Thanks and Acknowledgments

I would like to thank the Nuffield Farming Scholarship Trust for giving me this fantastic excuse to knock on doors all over the world. Doors which have opened so easily with the help of your backing.

To my Sponsors, the Royal Highland and Agricultural Society of Scotland, you have been instrumental in all aspects of my 'growing up' and education. The Highland Show is where I learned to drink beer, where I've met my best friends, where we've had our greatest adventures, where I met the girl who became my wife, and where we have had great times with our own kids. I recognise Nuffield as being another big step in my 'growing up'.

My family, and the team at Incheoch for affording me the time away, helping and putting up with time spent planning and report writing, and not looking too sceptically at ideas brought home! Special thanks to Debbie, my wife, without whose help this trip would have been much longer or not happened at all due to my ineptitude at booking flights, hire cars and general organisation.

Those I have met during my trips – people have been hugely helpful in spending time with me. You are too many to mention here, about 60 visits in all. I hope to get the opportunity to return your kindness, openness and hospitality someday.

I don't like to single any out, but I would like to share some of strange moments I found myself in.

- Steve Radokovich – I thought he must have been a professor, I'd seen him quoted so many times. Turns out he's a bull breeder – I helped him and a couple of Amish lads put up a cattle shelter one day.
- Derek Daniell, probably the largest ram breeder in the world – I spent a day fishing with him. Didn't catch much, but learnt heaps!
- Dave Nicholls, the guy who started breeding cattle because 'the girls in 4H with the Angus heifers were a lot better lookin' than the ones with the hoggs', and who now sells about 600 bulls a year – I shared a pizza with him.
- Prof. Dorian Garrick – not in my wildest dreams did I think I'd ever get to meet one of the most highly regarded beef and sheep geneticists in the world - I spent the morning with him in his kitchen, eating scones.

These people, and many more like them, were my heroes – and now they are my friends. Thank you Nuffield Farming.

Abbrevations

EBV – Estimated Breeding Value. There is a minor technical difference between an EBV and an EPD (Expected Progeny Difference) which is used in North America. For simplicity's sake, I have called them all EBVs in this document.

FCR – Feed Conversion Ratio

NFE – Net Feed Efficiency – also known as NFI (Net Feed Intake), and RFI (Residual Feed Intake)

RADG – Residual Average Daily Gain

CS – Condition Score

CPT – Central Progeny Test – part of the New Zealand sheep recording setup.

Cwt – Carcase Weight

Lwt – Live Weight.

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