British Cattle Conference

Organised by

The British Cattle Breeders Club

Registered in England 480001
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Rounding-up the year

Our Cattle Breeders Conference at the end of January concludes my year as chairman on a high. Such a good attendance speaks volumes about the way in which the British Cattle Breeders' Club has developed. We were particularly proud and honoured to have Defra and AHDB launch TB Advantage – the world's first breeding measure of TB resistance – at the Conference.

Across two-and-a half days the blend of speakers, the quality of their presentations, and their enthusiasm all combined to stimulate debate in the hall, and on-going discussion beyond it. Changing the programme format to end with a panel session on the last afternoon also ensured that delegates could head for home at a good time.

There are too many speakers to mention individually. Suffice to say that the attendee feedback survey confirmed the thread that ran through the programme. Genomics remains an important, and intriguing, technology and was a recurring theme across many papers. Looking outside our own industry, and our own borders, the methodical use of genomics being deployed by Yorkshire Dairy Goats enabled us to learn valuable lessons for the cattle sector; while the focus on precision dairy is raising the stakes in The Netherlands as well.

Similarly, the fast emerging developments in embryo transfer, combined with karryomapping and genomic screening offers scope for ever greater genetic progress. At the same time, it was highly encouraging to hear how other players in the supply chain are partnering our breeding interests to provide more value to consumers.

We were blessed to have some first rate examples from practising farmers. Each showed an enthusiasm, along with attention to detail, which will bring inspiration and success to the cattle industry – from animal health and welfare to marketing to communication.

In conclusion, I would like to thank, and congratulate, Heidi Bradbury after her first year as secretary. It is never easy to follow someone who knows the ropes after a number of years in post; in BCBC's case, Heidi made sure everything went without a glitch. I offer my best wishes to the committee for the forthcoming year, and I have no doubt that Iain Kerr, my successor, will bring the same professionalism and level of achievement that he has shown at the British Limousin Cattle Society.

For anyone who may be tempted to come along for the first time, or who missed this year's Conference, please go to www.cattlebreeders.org.uk and dip into some of the papers, which are available as 'Talking Slides.'

Already I am looking forward to next year's Conference from Monday 23rd to Wednesday 25th January – put it in the diary now.

Roger Trewhella
Chairman

The British Cattle Breeders Club

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1990	Sir Richard Trehane (retired 1997)
1997	Mr John E. Moffitt CBE, DCL, FRASE (retired 2005)
2005	Mr W Henry E. Lewis (retired 2011)
2011	Dr Maurice Bichard

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(Please note, the year of office would be completed at the conference of the following year)

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1999–2000	Janet Padfield
2000–2015	Lesley Lewin
2015 *onwards*	Heidi Bradbury

How to make cattle breeding a profitable business – does genomics hold the key?

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In 2009 an American Hereford cow named L1 Dominette 01449, made history as the source of the first Bovine genome ever to be sequenced. That discovery has, in the intervening 6 years, revolutionised cattle breeding around the world and marked the beginning of an important new chapter in a story that is as old as human civilisation itself.

Cattle breeding and the evolution of human society have been inextricably linked since man first domesticated the cow over 8,000 years ago. Cattle, possibly more than any other animal, have been instrumental to mankind's success, as a source of food, clothing, power, heat, fertiliser, currency and medicine; the word vaccine after all being derived from 'vacca', the Greek for cow.

Evidence of organised cattle breeding can be found in historical records of most early societies, among them ancient Egypt, where the importance of cattle as a source of wealth and power is widely illustrated in preserved artefacts and in the tomb engravings of many prominent ancient Egyptians.

In Britain, cattle breeding reached its zenith in the 19th and early 20th centuries when many of the breeds we know today were first identified and breed societies formed. Breed improvement was a favoured pastime of some of the wealthiest figures in British society, for whom ownership of a prominent pedigree herd was a symbol of success and status, not unlike owning a Premiership football team today.

Up until WWII, Britain was also a key source of genetics for many of the worlds leading beef producing nations, with breeds such as the Hereford, the Shorthorn and the ubiquitous Aberdeen Angus widely exported around the globe. They were particularly successful in North & South America, Africa and Australia where their influence continues to this day, both as purebreds or where crossed with native breeds of both Bos Taurus and Bos Indicus to improve meat quality and productivity.

But in the post war years, UK beef breeding seemingly lost its way. Genetic progress stalled, especially when compared to other livestock sectors such as pigs and poultry or even the dairy industry, whose rate of genetic gain in recent decades has far outstripped that of the beef sector.

Consequently Britain has seen its position as the 'go to' nation for elite beef genetics eroded; firstly by the rise in popularity of continental breeds such as the Limousin, Charolais and Belgian Blue, whose superior growth rates and carcass conformation found favour with commercial producers and buyers of beef and more recently with the return to our shores of our own traditional breeds, improved and optimised for the modern market by our erstwhile customers in North America and the Antipodes.

So what can the industry do to regain this lost ground and what lessons can be learned from the experiences of other sectors?

I have been fortunate over the course of my career to have had exposure to a number of different sectors of the UK food supply chain and consequently have learned the importance of market focus and innovation in maintaining competitive advantage and ultimately profitability.

As a potato grower and marketer in the 1990s I witnessed the rapid rationalisation of that industry against the backdrop of rising the multiple retailer power and the removal of the potato marketing scheme. This necessitated a wholesale change of focus among UK potato growers, from a traditional trading mindset to one more focused on consistently producing what your customer wanted, when they wanted it, or risk losing your business to your competitors.

Innovation in terms of product, process and service provision were all key to success and those businesses

that recognised this early on and adapted their business models accordingly thrived, whilst many others fell by the wayside.

As a producer of goat's milk today, I am also acutely aware of the need to consistently deliver a quality product and service to support the continued success and growth of the premium brand we supply. Yorkshire Dairy Goats and its customer St Helens Farm, the business from which Yorkshire Dairy Goats evolved in 2013, has built their 30 year success on this principle.

We are a market driven business that lives and dies by our ability to establish and maintain customer loyalty by producing a consistently high quality product and we do this by constantly innovating and fine tuning our processes to improve performance in every aspect of what we do.

Genomics is now a significant component of this and is an area where the business has invested a significant amount of time and money in in recent years to build and improve the genetic base that determines the potential performance of the herd and ultimately the business.

Historically Yorkshire Dairy Goats has operated a successful in-house conventional progeny testing programme to identify potential elite breeding males. By keeping extensive animal performance and pedigree records, this enabled the business to deliver considerable genetic gain over the flat 25 years but the emergence of Genomics in other species provided an opportunity to harness this technology to potentially accelerate this process and more accurately select for desirable traits in the future.

Building on the experience gained from the dairy cattle sector and using the 30 years of detailed animal performance and pedigree records that the business has collected, Yorkshire Dairy Goats in partnership with Mike Coffey and his team at SRUC/Roslinand supported by funding from InnovateUK, have developed what we believe to be the world's first commercial genomic evaluation platform for dairy goats.

In simple terms, Genomics works by analysing the DNA of an individual animal to look for the presence or absence of Single Nucleotide Polymorphisms or SNPs within that animals genome. SNPS are one of the most common forms of genetic variation and are typically highly preserved throughout evolution within a population and as such a map of SNPs acts as an excellent source of genetic markers for research.

By cross referencing SNP markers with observed Phenotypes or physical trait data, reliable genomic breeding values can potentially be established for a wide range of traits and as such an animal's genetic merit can be established effectively from birth, long before those traits have been expressed.

This potentially allows for earlier and more accurate identification of elite (and undesirable) breeding animals, thus shortening the generation interval and accelerating genetic progress.

It may sound simple but the reality has been a long process that has required very large data sets of reliable Phenotypic data.

Modern High-throughput SNP analysis means that the cost of genomic testing is coming down rapidly and is now a relatively cheap and straightforward process. The challenge and cost lies in the production of a genomic 'key' that can reliably make sense of the genomic data generated.

The real prize however is that, provided sufficient high quality phenotypic data is available, it has the potential to identify genetic markers, not just for the more easily recorded traits such as milk yield or growth rate, but also for harder to measure but equally commercially valuable traits such as disease resistance, fertility and feed conversion efficiency.

For Yorkshire Dairy Goats, the first step has been to identify markers and establish Genomic Estimated Breeding Values (GEBVs) for milk yield, milk composition and functional conformation traits.

Using current and historical phenotypic data we are confident that the GEBVs we now have for these traits are sufficiently reliable for us to use them as the principle selection tool for our in house breeding programme. This allows us to confidently use younger high genetic merit males and females earlier than we would have historically been able to, as we no longer have to wait for the results of progeny testing.

We have also begun validating the genomic key on other populations of dairy goats, with reliable phenotypic data, in other countries. Blind ranking of these animals using GEBVs alone and then comparing the results with their actual phenotypic performance has yielded encouraging results, which when combined with the actual performance of the first daughters of genomically selected sires coming into our own herd, has given us the confidence to invest further, looking for GEBVs for more complex composite traits such as Mastitis resistance and Feed conversion efficiency.

However this has been a long and resource hungry process that would also not have been possible without the extensive and detailed production and pedigree records of thousands of goats going back many years.

Few, if any, individual UK beef producers will have the size of data sets or indeed the resources to conduct such a programme in house, but that doesn't mean that it can't be done.

Genomics has the same potential to revolutionise beef breeding as it has in other species. The key to success in the beef sector, in my opinion is co-operation, co-ordination and clarity of vision at a breed society or supply-chain level, to identify what traits really drive value going forward and how they can be measured, selected

for and improved on an industry scale.

As I mentioned earlier the genotyping component of the process is now relatively inexpensive and straightforward, but to quote Prof Mike Coffey 'In the age of the cheap Genotype, Phenotype is King'.

Accurate and reliable trait measurement is key to unlocking the potential of genomics in any application and setting up the infrastructure to capture, collect and process this data is the big challenge for the beef sector.

However if this can be achieved, then the opportunity for rapid genetic improvement and with it, better physical and financial performance are indisputable.

Beyond simple genomic analysis, the emergence of other advanced breeding technologies such as Ovum Pickup/IVF for cattle and the increasing use of sexed semen to amplify the numbers of elite female animals produced, will help exploit the benefits of genomic selection by further accelerating the rate of genetic gain achievable, thus improving the efficiency and ultimately the profitability of the sector.

All this requires a level of investment and commitment which at an individual farm level might seem extremely daunting during these economically challenging times, but if the industry is to face the future and all the opportunities it offers with confidence, it needs to start co-operating now.

And help is at hand. The UK has a great depth of established and well proven expertise in this field and novel sensor and trait measurement technology is evolving at a rapid pace, as is the ability to process the huge data sets that this will generate.

The UK government has also invested considerable money in recent years through the Technology Strategy Board (now Innovate UK) and more recently via the Agri-Tech Strategy to support commercially led innovation partnerships between businesses and the research community to develop the means of exploiting these opportunities.

The emergence of a number of Innovation centres over the coming months, and in particular the Centre for Innovation Excellence in Livestock – CIEL in York (www.cielivestock.co.uk) will provide a focal point for the industry to access a broad spectrum of research capability to support their ambitions in this regard.

The future for beef breeding in the UK is bright. We have all the components for a world leading industry and the time for that industry to act is now. Co-operation, Co-ordination and Clarity of vision are the three key principles that will make beef breeding a profitable business again.

Beefing up beef breeding in Ireland using DNA technology

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The basics

Genomics is the study of DNA. DNA is the building blocks of genes and it is the genes that determine whether an animal has the potential, for example, to grow or be fertile – whether an animal achieves its genetic potential is dependent on the management the animal is exposed to. DNA is present in all cells and remains the same throughout an animal's life; in other words the DNA of a calf taken at one day of age is the same as that animal's DNA several years later. Apart from identical twins, each animal has a different *DNA profile*. This is commonly referred to as the animal's *genotype*.

The potential immediate uses of genomic information in cattle production is in Figure 1. Other more futuristic uses include personalised management, development of diagnostics and vaccines amongst others.

The use of genomic information in cattle breeding is not new. Genomics has being used routinely in parentage testing. Because each animal inherits half its DNA from its sire and its dam, parentage assignment can be accurately undertaken based on the DNA information of the individual and its parent(s). Genomics is also routinely used in cattle breeding in the screening of (AI) bulls for known lethal major genes or congenital defects. DNA can be obtained from blood, hair or tissue samples.

Interest in the more wide-spread application of genomic technology in cattle breeding has, however, rapidly intensified in recent years. This growing excitement has been fuelled by the rapidly declining cost of acquiring a genotype but also advancements in the statistical methodology to effectively and efficiently analyse the vast quantities of genomic data being generated. While heretofore applications of genomics in cattle breeding exploited knowledge on only a few pieces of DNA (e.g. Merial/Igenity marker panels), today's application of genomic selection utilises information on tens or hundreds of thousands of pieces of DNA of an individual. The increased information available per animal results in a now-proven more accurate genetic evaluation.

The technology commonly used internationally heretofore in genomic selection programs exploits DNA information at 54,001 locations across the animal's DNA. These tiny changes in the DNA sequence of an animal are commonly called SNPs (pronounced "snips") and the platform used to determine the genotype of an animal is referred to as a SNPchip (pronounced "snip-chip"). Ireland developed its own SNPchip for use in dairy and beef cattle. A total of 53988 SNPs are now included on the SNPchip; the characterisation of SNPs on the chip is in Table 1.

Figure 1: Potential immediate uses of genomics in cattle production.

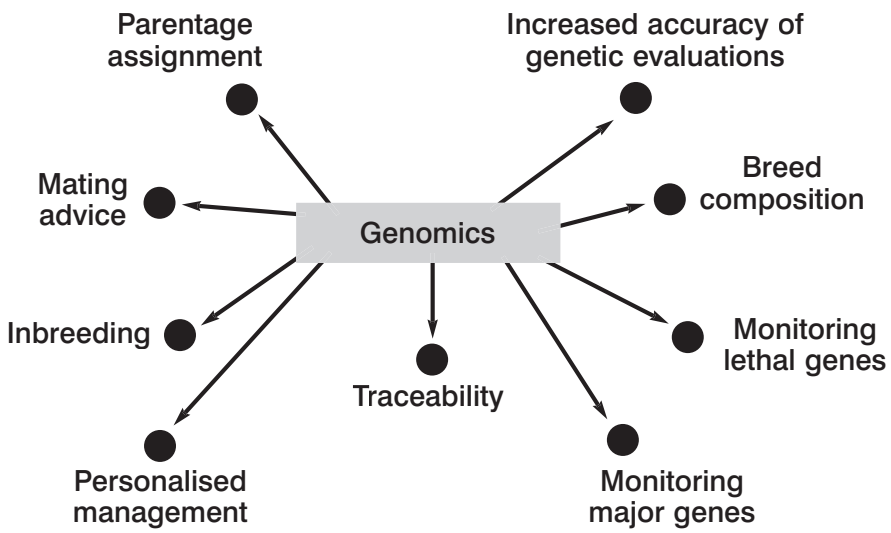

Table 1: Characterisation of the SNPs included on the Irish SNP-chip custom genotype platform.

SNPs	*Number*
Base Illumina commercially available low density panel	6909
Dairy genomic evaluations	40446
Imputation to high density	5765
Imputation to microsatellites	1927
Prediction of Angus and Hereford breed proportion	800
Total "Illumina" SNPs (duplication exists in the list above)	*45521*
Lethal mutations	4
Mutations in known major genes	291
Research SNPs	8173

Table 2: Percentage of carrier Holstein-Friesian animals for known lethal recessive mutations.

	Percentage carrriers
Brachyspina	1.76
CVM	2.28
BLAD	0.53
DUMPS	0

Imputation is a process where our knowledge of inheritance of DNA facilitates the prediction (called imputation) of SNPs that are not actually genotyped. Therefore a lower density, lower cost genotype platform can be used to generate higher density genotype information. To avoid the necessity of imputation in dairying, all 40,446 SNPs used in the Irish dairy genomic evaluations are included on the Irish SNP-chip. Parentage testing to date is undertaken using microsatellites which are a different form of DNA variation to SNPs. Microsatellites are more expensive to undertake, can contain errors, and can only be used for parentage testing (i.e. cannot be used for genomic selection). SNPs, in contrast, are considerably less expensive per unit genotype, are, on a whole, more accurate for parentage (in)validation but also assignment (even without the dam being genotyped), and can be used for genomic evaluations. Ireland is in the process of transitioning all parentage testing in cattle (and sheep) to SNPs. Embarking on such an initiative, however, would require all back-pedigree to be re-genotyped with SNPs. An innovative approach was developed to predict (termed *impute*) microsatellites from the available SNPs. This therefore eliminates the necessity to re-genotype back-pedigree with SNPs with obvious cost-savings. SNPs are also included on the custom SNP-chip to aid in the accurate prediction of the proportion of Angus and Hereford in a (meat) sample. Mutations in genes of known lethal effects (e.g. CVM, BLAD, DUMPS, Brachaspyina) as well as mutations leading to congenital defects (e.g.Congenital contractural arachnodactyly also known as fawn calf, Arthrogryposis Multiplex or Curly Calf Syndrome) or in genes of known major effect (e.g.myostatin, DGAT1) are also included on the SNP-chip. All tests can be undertaken with just a single biological sample which could be blood, hair, ear biopsy, meat, or semen and is available to all farmers for €22; this price is 8% of the cost several years ago and is expected to become cheaper in the coming years.

Frequency of major-gene variants in Irish cattle

Knowledge of the carrier status of candidate parents for different genetic mutations (e.g.myostatin) and the impact of mating animals of different genotype status is crucial to a successful herd-breeding program. Knowledge on how the frequency of these mutations is changing across time can provide useful information for breed societies of the impact of prevailing breeding strategies on likely future consequences. Table 2 summarises the frequency of different mutations in a population of 14,128 Irish Holstein-Friesian animals; Table 3 summarises the prevalence of several mutations in Irish purebred beef cattle. The proportion of Holstein-Friesian animals with the A1A1, A1A2 and A2A2 genotype was 14, 45, 41% respectively. Of the

Table 3: Allele frequency for a range of mutations in the myostatin gene for different purebred beef animals.

	nt821	FL94	Q204X	nt748	nt324	nt267	nt414	nt748	nt419
Angus	2.0	99.7	50.0	20.8	100.0	0.0	79.2	20.8	0.0
Blue	99.1	100.0	100.0	0.0	100.0	0.0	100.0	0.0	0.0
Charolais	0.0	83.6	85.2	32.3	95.3	0.0	67.7	32.3	0.0
Hereford	0.0	99.8	49.9	57.2	99.9	0.0	42.8	57.2	0.0
Limousin	2.3	5.7	97.5	5.3	100.0	0.0	95.3	5.3	50.4
Simmental	0.0	99.9	100.0	31.3	97.7	15.8	68.8	31.3	0.0

animals that were carriers of the lethal mutations, 66% (Bracyspina) to 79% (BLAD) were females. Of the animals that were CVM carriers, 2.5% to 3% of them were also carriers of brachyspina and BLAD, respectively.

It is well known, for example, that calvings from the mating of animals carrying the nt821 variant in the myostatin gene (i.e. the *double muscling* gene) have a greater likelihood of requiring assistance at calving. Knowledge of the nt821 status of the cow and potential mates for such mutations can therefore be extremely useful in making mating decisions but also in the management of the cow prior to and around calving. For example, the progeny from a mating between two carrier parents has a 25% chance of being a double copy carrier, 50% of being a single copy carrier, and a 25% of not carrying the deleterious allele.

Although extremely useful for an individual mating decision, farmers are generally limited to using the sires that are available to them. Therefore, close monitoring in the trend of genotypes for each mutation at the population level can provide an early warning of likely future issues, at the population level, both for herdbook breeders but also commercial farmers. The advantage of the Irish SNP-chip is that with just a single sample, the status of each animal for each mutation is obtained as well as also parentage testing and more accurate prediction of genetic merit.

Genomic evaluations

The first step in a successful genomic selection program is to accurately quantify the impact each of the pieces of DNA have on the plethora of animal characteristics recorded such as growth rate, carcass traits, fertility, and other traits of economic importance. To achieve this, genotype and performance records on several thousands of animals are required. These animals can be either cows themselves or their sires. The greater the number of animals with both genotype and performance records available, the greater will be the accuracy of genomic predictions of young calves.

Based on earlier research in beef cattle in Ireland, it was obvious that a very large population of genotyped and phenotyped animals would be required to develop an accurate genomic evaluation that worked well across breeds. This led to a national initiative to genotype a large population of Irish beef cows (http://www.icbf.com/wp/wp-content/uploads/2013/07/Selection-of-animals-for-use-in-beef-genomic-selection-program.pdf).

Genomic evaluations were undertaken using 104,169 beef genotypes including a combination of AI sires, natural mating sires and cows. To test whether genomic information could aid in the prediction of future performance, a genetic evaluation was undertaken using data up to the year 2008; the genetic merit of animals born after the year 2008 was predicted based on DNA information only and compared to their genetic

Table 4: Heritability (h^2), traditional reliability, genomic reliability and progeny equivalents of the improvement in reliability from including genomic information in 2014 born beef animals.

		Reliability – validation		
Trait	h^2	*Traditional*	*Genomic*	*Progeny equivalent*
Calving difficulty – direct	0.1	0.34	0.52	21.8
Calving difficulty – maternal	0.04	0.34	0.52	56.2
Calf mortality – direct	0.02	0.35	0.53	113.6
Gestation length	0.4	0.28	0.49	4.6
Farm docility	0.35	0.13	0.45	6.3
Linear docility	0.35	0.23	0.47	5.5
Cow docility	0.35	0.23	0.47	5.5
Milk Score	0.337	0.25	0.48	5.7
Maternal weaning wt	0.252	0.15	0.38	5.9
Age at first calving	0.3119	0.21	0.46	6.3
Calving interval	0.024	0.16	0.44	95.7
Survival	0.017	0.14	0.43	139.5
Car. Weight	0.402	0.25	0.48	4.6
Car. Fat	0.352	0.22	0.46	5.4
Car. Conformation	0.32	0.21	0.46	6.1
Feed intake	0.434	0.12	0.42	4.2

merit in the year 2015 (which included their performance information). The prediction accuracy varied per trait but was approximately 0.60 to 0.70. The improvement in reliability for the individual traits is in Table 4. The relative improvement in reliability (in terms of progeny equivalents) was greatest for the lower heritability traits of fertility and survival; this is particularly relevant since it actually takes longer in the life of a bull to receive information on the fertility performance of his daughters. Having genomic information on an animal is equivalent to the animal have fertility performance on almost 100 daughters – not bad for an animal who is potentially only 3 weeks of age!

Other uses of genomic information in cattle production

Knowledge of the breed proportion of an animal or meat sample is useful for meat provenance but also in the design of mating programs to maximise heterosis. The breed composition of an animal resulting from the mating of at least one crossbred parent cannot be known with certainty without exploiting DNA information. Only a small number of SNPs are required to achieve extremely accurate traceability systems from fork to farm. Incorrect or missing pedigree information seriously biases inbreeding estimates of animals but also the estimated extent of relationship between animals. For example, the estimated relationship between two full sibs with no parentage recorded (or incorrect parentage) is zero while in fact we know this is not true – genomic information can help resolve such discrepancies and therefore aid in decision support to avoid the mating of close relatives but also facilitate the mating of animals related in pedigree but not related at the genomic level. Genomic information through the development of more accurate predictions of genetic merit also facilitates personalised management or more tailored management strategies where, for example, animals of greater potential for growth rate or milk yield can be fed accordingly. This is currently undertaken at a breed level but we know within breed differences in performance clearly exist.

The future of cattle breeding

Every cell in all cattle contain approximately 3 billion (3,000,000,000) tiny pieces of DNA. Genomic evaluations globally currently exploit approximately 54,001 of these. By exploiting information on all 3 billion (in reality tens of millions), more accurate genomic predictions could be achieved which persist across generations and breeds.

One of the greatest benefits of genomics in the near future will be genomic matings or *precision breeding*. Full sibs on average share half their DNA but considerable variation exists around this average. The mating of two full sibs could (theoretically) result in no inbreeding. This phenomenon exists because although each full sib received half its DNA from its sire and dam, the two full sibs could actually have received a totally different complement of DNA from each parent and are therefore "unrelated". By knowing the DNA of each full-sib, the expected inbreeding of the progeny could be determined. Similarly, a grandsire-granddaughter mating could result in a non-inbred progeny; again knowledge of the DNA of the grandsire and granddaughter could be used to estimate the likely inbreeding accruing from such a mating. Moreover, many lethal recessive mutations (i.e. DNA mutations that result in the death of the embryo, foetus or calf) have been purged out of most populations by restrictions imposed that AI sires cannot be carriers of known lethal mutations. Firstly every individual (including humans) are carriers of at least 2–20 lethal mutations which have yet to be detected but secondly culling genetically elite sires carrying a known lethal mutation can reduce overall genetic gain. In the future, when (almost) all animals, male and female, are genotyped, it will be possible to develop more accurate mating advice schemes to avoid the matings of carrier animals and minimise the accumulation of inbreeding.

Conclusions

The new technology called genomic selection will increase the reliability of genetic evaluations of cattle; the extent to which the reliability improves will depend on the number of animals with genotype and performance information available. The increased reliability from genomics means greater confidence that the published values of a given animal will translate into progeny performance or in other words less fluctuations in proofs over time. This all results in accelerated genetic gain.

Improving carcass traits using genetics and genomics in the beef sector

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Introduction

The UK beef industry produced 885,000 tonnes of beef in 2012 from 2.7million head of cattle. However, the UK is not self-sufficient with nearly 20% of beef consumed needing to be imported. As an industry we are striving to increase production but at the same time improve the overall sustainability (environmentally and profitability) of the industry. Genetic improvement is a cost effective, sustainable and cumulative way of increasing both production and sustainability in the UK beef industry. This is even truer with the development of genomic technologies that allow accurate genomic prediction of an animal's genetic potential for carcass traits (an end of life trait) from birth. In order to use genetics to improve production and sustainability, ABP UK (ABP), British Limousin Cattle Society (BLCS) and Scotland's Rural College (SRUC) undertook a four year project to produce Visual Image Analysis (VIA) carcass trait genomic breeding values for UK Limousin cattle. The project was co-funded by the government-backed Innovate UK and BBSRC. The project was completed at the end of 2015 and the first UK genomic breeding values (GEBVs) will be available for VIA carcass traits in the 2016 official Limousin genetic evaluations.

Using Visual Image Analysis (VIA) to genetically improve carcass yields

Analysis of the VIA data revealed a £25/carcass (4kg) difference in the retail value of strip loin between the very best and very worst carcasses. As part of the project it was shown that these differences have a strong genetic component with the heritability of strip loin being 0.28 after adjusting for the carcass weight. Moderate heritabilities were also estimated for the other primal cut yields considered.

The project combined abattoir VIA carcass information on slaughter animals and genotypes from Limousin animals (mostly sires, but also influential cows) to produce a UK Limousin SNP key for carcass traits. The SNP key can be thought of as a library containing the different DNA signatures represented in the Limousin population and matches these signatures to the different carcass attributes. Therefore from looking at the DNA signature alone (i.e. when the animal is a calf) we can predict with high accuracy if the animal has good or bad genetics for the carcass traits at slaughter. This will allow Limousin breeders to more accurately select beef animals that meet processor and retailer specifications. The project was the first of its kind to be carried out in the UK and was truly innovative in that the selection tools produced will allow selection for new previously unavailable, but economically important, traits. It has the potential to increase value along the whole supply chain for British beef by focusing breeding on carcass traits of real economic significance.

Using these new breeding tools to increase beef production and help to increase the UK's self-sufficiency which will be important as the worldwide demand for beef increasing as developing countries grow. The project provided a first step in developing an integrated supply chain in which UK producers could profitably increase beef production by circa 220,500 tonnes before the UK market is saturated. It has also helped to protect the UK market by enabling home produced beef to benefit from being closely linked to UK Customer requirements. Benefits have and will be even more noticeable overtime as more and more carcass data accumulates. The whole supply chain has and will continue into the future see an increased benefit, and this includes benefits for Pedigree Limousin breeders, ABP finishers, ABP, retailers and ultimately the customer.

Not only does the introduction of GEBVs for VIA carcass traits now provide opportunity for substantial

genetic progress of carcass but it also now provides opportunities that strengthen market signals between the individual sectors within the beef supply chain. The processors are having increasing issues within their sector with cattle delivered out of specification. Increases in animals that meet required specification will now be possible as a result of this new technology and over time increase in yields will be seen as the uptake by breeders is increased.

The Limousin breed – the largest breed in the UK – now has the extra value of offering another tool to aid management and selection decisions on farm to increase animal performance, increase efficiency, sustainability and to ensure there is a future for the Beef industry in the UK. The current methods of genetic evaluation used within the pedigree sector are EBVs for 400 day live weight and ultrasound fat and muscle depth of animals. These EBVs provide information for the commercial sector when choosing bulls to purchase and produce offspring for slaughter. However, when the commercial sector sell cattle to the abattoir they are paid according to the EUROP grid based on carcass weight and EUROP conformation grid and 1–5 fat class. The different methods of assessing carcass information along the supply chain mean that market signals are diluted along the chain. Using the same method of assessing carcass – VIA carcass traits – along the whole of the supply chain, from pedigree breeders to the abattoirs will enable the beef industry to produce animals with improved carcass that consistently meet market specification.

The introduction of VIA machines delivers greater transparency and consistency in Cattle Grading for ABP Farmers. The VIA machines now enable ABP to introduce the new improved 15 point grid which more accurately reflects the retail value of carcass meat. For example: The R+ will now have a premium of 5p/kg. Using the old method of grading previously wouldn't reward for this. One of the clear signals ABP is now receiving from the market and their customers is that they require primal's, joints and steaks supplied from lighter carcasses which will satisfy ever changing consumer demands. From 10th November 2015 ABP have been using the new 15 point VIA grid to pay their farmers.

ABP now have the opportunity to reward farmers more fairly and more accurately compared to the old method of grading cattle. In the past, cattle could have been deducted payment due to human error, and/or rewarded when they should have been deducted for poorer yielding cattle. VIA and the new payment grid allows for fair and consistent way of grading cattle. ABP also have the ability to be able to use the carcass trait genomic evaluations for further developments within its breeding programmes, health scores, animal performance.

How Genomic breeding values will be implemented in UK Limousin cattle

Genomic breeding values (GEBVs) for VIA carcass traits will be provided as part of the 2016 official Limousin genetic evaluations. In order to gain a Carcass Trait GEBV, a DNA sample (hair or tissue sample) needs to be genotyped for the animal. To coordinate the process of genotyping cattle, the project partners have developed Genesure. Genesure Ltd is a company set up by the project partners who will administer the genotyping of the animal's DNA and produce the GEBV results. In addition, Limousin breeders will also be able to order and manage testing for single gene tests (e.g. myostatin, polled, colour etc) that are undertaken with the breed society.The website www.genesure.co.uk will be available very soon.

As breeders use the BASCO webpages for registering cattle, performance recording and viewing and searching for animals based on their EBVs, Genesure have used the BASCO platform to provide online tools to allow breeders to order GEBVs for animals that they own. The online pages can be accessed directly from BASCO www.basco.org or by using links from the Genesure web pages. If you already have an account with BASCO then when you log on to 'My Page' you will see a few more options that are used to order tests and view results. If you don't already have accounts with BASCO use the 'register here for free' option to set up an account. Using the 'Place My Order' option will show a list of animals in your ownership and you can select the animals you would like to test, for these animals you then pick which combination of genetic tests you would like. Once your order has been submitted, the Society office will dispatch the required bags for sampling. These will be bar coded and will also show the animal's UK number. Collected hair samples are returned to the Limousin office that will then coordinate sending the sample to the genotype laboratory. At any time breeders can track the status at the order by using the 'Track My Order' option.

GEBVs will be reported back to the owner on the BASCO member area via the 'View/Publish Genotyping Results' option. It is not compulsory for the GEBV to be made public and the owner of the animal will decide if the GEBV will be published (by clicking a publish box on the webpages) and once published the GEBV will remain published. Once published the GEBV results will be published via BASCO in the same way existing EBVs are presented, and will be available at the same time conventional EBVs are published, or when the publish box has been ticked by the owner. If the animal has a GEBV available but the owner has decided not to publish it, a message conveying this will appear on the BASCO search engine for that animal.

As part of the genomic evaluation used to calculate GEBVs, some animals will receive EBVs for these traits even though they are not genotyped. This is because we have sufficient VIA abattoir data and pedigree information to compute the VIA EBV. VIA EBVs for these ungenotyped animals will be published on the BASCO webpages provided the EBV accuracy is greater 50%.

Whilst this may seem confusing have EBVs and GEBVs published, it will be clearly marked if it is a GEBV. However, GEBVs and EBVs are both breeding values that can be directly compared as they are computed at the same time, and thus can be used in exactly the same way. As with the GEBVs, these EBVs are produced from completely independent sources of data and once a high accuracy EBV is available then it is not economical to pay for a GEBV. Once an animal has been genotyped for GEBVs, publication of carcass trait EBVs will cease so that it only ever has one breeding value at one time.

Conclusions

The implementation of the VIA carcass trait genomic selection has been an exciting time for the beef industry. It will now provide many benefits and opportunities for the UK Limousin beef population as well as the wider beef industry as we genetically improve animals to have better yielding carcass.

Acknowledgements

This project is a collaboration involving ABP UK, British Limousin Cattle Society and Scotland's Rural College and is co-funded by the government backed Innovate UK and BBSRC.

Development of a pen-side diagnostic test for liver fluke infection in cattle and sheep

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Introduction

Fasciola hepatica (the liver fluke) is a common parasite of cattle and sheep that affects animals worldwide and is the cause of the disease, fasciolosis. Recently, it has been shown that prevalence of liver fluke has been increasing significantly within the UK. This has been linked to many factors including climate change, changing farming practices (e.g. extended grazing periods), increased movement of animals and stewardship schemes. In UK dairy herds, infections with liver fluke are estimated to cause decreases in milk yield of approximately 8–15% per cow per year, or 1100 litres per cow. In beef cattle, infections can result in reduced weight gain, leading to individual animals taking an extra 80 days to reach market weight at a cost of £30–200 per animal. Estimates in sheep also show that fluke infection increase costs by £3–5 per ewe, through reduced daily live weight gain.

The liver fluke has a complex life cycle involving an intermediate host, the mud snail *Galba truncatula*. This means that typical 'flukey' areas are wet and muddy pastures which are the main habitat of the snail. The lifecycle begins with an infected host passing eggs onto pasture within its dung. These eggs then develop and hatch to an aquatic larval stage, which is able to infect the snail. Warm (above 10°C) and wet conditions favour an increased rate of development for the stages of the parasite in the environment. Following a period of development within the snail, infective cysts called metacerariae are released from the snail; they attach onto the grassand are eaten by the cattle or sheep as they graze. Once ingested the juvenile fluke emerge and burrow through the gut wall to the liver. Once there, the juvenile fluke spend about 6 weeks migrating and feeding on the liver tissue and blood, before finally reaching the bile ducts as mature adults which are able to produce eggs which are passed out onto pasture within the animal's dung. It takes approximately 8–14 weeks from ingestion of the cysts before eggs are detectable.

There are two types of fasciolosis, acute disease and chronic disease, determined by the number of cysts ingested by the animal over time. Acute infections are usually associated with the ingestion of large numbers of infective cysts over a short period of time. This leads to severe abdominal pain, weight loss and anaemia as a result of the extensive liver damage caused by the sudden migration of large numbers of juvenile fluke through the liver tissue. The acute form of the disease results in sudden death in infected sheep, and farmers can lose up to 10% of their flock in a matter of days with little warning. This form of the disease however, is rarely seen in cattle. Chronic infections result from ingestion of smaller numbers of cysts over a longer time period, allowing the adult fluke to establish themselves in the bile ducts of the liver before clinical signs appear. Anaemia and weight loss are typical of chronic disease and it can occur on both sheep and cattle. Many fluke infections, characterised by low burden are sub-clinical, so rarely diagnosed but they with infection cause reduced weight loss and lower milk yields.

The rising prevalence of liver fluke over recent years has led to an increased dependence on the use of anthelmintics. The drug of choice, triclabendazole (TCBZ) (for example Fasinex, Combinex, Tribex, and Endofluke) is used mainly for its unique ability to target both adult and juvenile fluke within the host and is therefore able to combat the large numbers of migrating juvenile fluke during acute infections. Advice on the treatment of liver fluke can be found on the COWS (Control of Worms Sustainably) website: http://www.cattleparasites.org.uk/fluke.html. The emergence of resistance to TBCZ is therefore an urgent concern to UK farming. These results highlight the need for reliable and sensitive diagnostic tests.

Current diagnostics

The diagnosis of liver fluke infection is traditionally based on the detection of eggs in dung, using faecal egg counts (FEC) and presence of eggs is indicative of current infection. However, over recent years a number of highly sensitive and specific diagnostic tests have been developed to replace these traditional methods. These tests are largely based on the detection of specific molecules within samples.

One such test is the Copro-antigen test, which has been developed to detect specific fluke molecules within the dung of infected animals. Another test is able to detect host antibodies against fluke using individual serum samples or milk samples. Milk samples are a great advantage in dairy farming as they are much easier to collect and less invasive. Bulk milk tank samples can also be tested to estimate how much infection is present within the herd. These tests hold a slight advantage over FEC in being able to detect infection earlier, before the adult fluke are present.

Why we need improved diagnostics

All of these tests have significant limitations. For instance, FEC are only able to confirm infection once the adult fluke have matured and producing eggs at approximately 10–14 weeks after infection. This test does not detect the presence of the migrating juvenile flukes, which can cause clinical disease as early as 3 weeks after exposure. The sensitivity of FEC can also be very low and variable, particularly in cattle; this test may only detect fewer than 7 out of 10 infected cattle. To add to this, studies have also shown that liver fluke eggs can become trapped in the gall bladder leading to intermittent egg detection.The use of composite FEC (pooling dung samples from several individuals within the herd) is able to give an idea whether a herd or group of animals is infected; however it does not give information about the level of infection within the individual. This therefore does not allow for targeted treatment to the individual.

Whilst the Copro-antigen test is able to detect infection slightly earlier that the FEC (at approximately 8 weeks post infection), we have found that the Copro-antigen test is no more sensitive than the FEC. The detection of host antibodies is complicated by the fact antibodies have been found to remain circulating for several weeks following treatment.

All of the above tests require samples to be sent to the laboratory for testing. This can add significant time and cost to the diagnosis, especially in cases of acute disease.

What is the aim of this project?

The aim of this project is produce a pen-side diagnostic test which is able to provide the farmer with accurate and immediate results for detecting liver fluke infection in individual animals. The test itself would be one that farmers could use themselves through for example blood taken from an ear prick, or even through saliva or milk. This would remove the need for samples to be sent to the laboratory for testing and therefore reduce costs for farmers, but also speed up the time taken to get results. By testing individual animals treatment could be targeted at the individual, reducing costs and slowing the spread of resistance to flukicide drugs.

The test could be used to detect liver fluke infection in dairy cattle at drying off as there is a very limited time window for treatment. It would also be valuable in detecting infection in individual beef cattle during housing, and ideally provide a much earlier detection system for liver fluke infections in sheep and help in the treatment of acute fasciolosis.

Designing the test

This design of this test will be based around antibody detection because antibodies are produced early in infection. The first aim of this project was to identify which fluke molecule would be the best to use in the test. The picture in Figure 1 is the results of analysis of the major secretions of the fluke on a gel. The gel shows that a specific molecule, Cathepsin L1 is easily detectable within these samples.

CL1 is a protease enzyme which is secreted in large amounts by the fluke and is thought to permit the parasite to infect a wide range of mammalian hosts and play a key role in its pathogenicity. This enzyme is responsible for digestion of nutrients, facilitating the migration of the parasite through the liver and also has been implicated in the inactivation of host immune defence molecules. This has resulted in this protein being recognised as an important target for vaccine studies.

CL1 is a highly immunodominant molecule, which means that is one of the main targets of the host immune response. The host immune response involves the natural production of antibodies to help combat infection, and it is these antibodies against

Figure 1: Results of analysis of the major secretions of the fluke run on a gel. It shows that the molecule Cathepsin L1 (CL1) is easily detectable in these samples, as highlighted by the arrow.

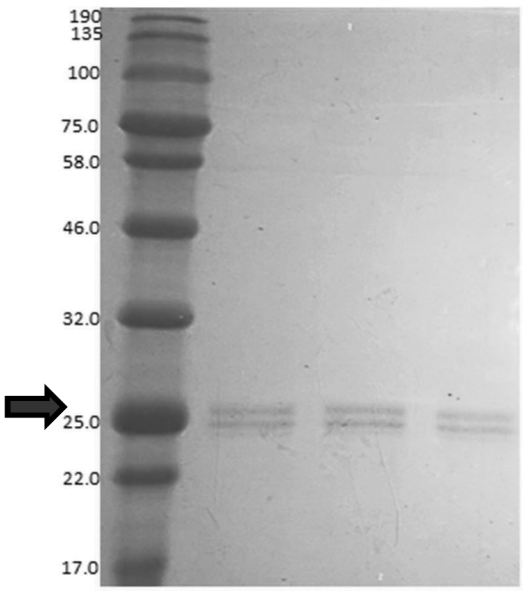
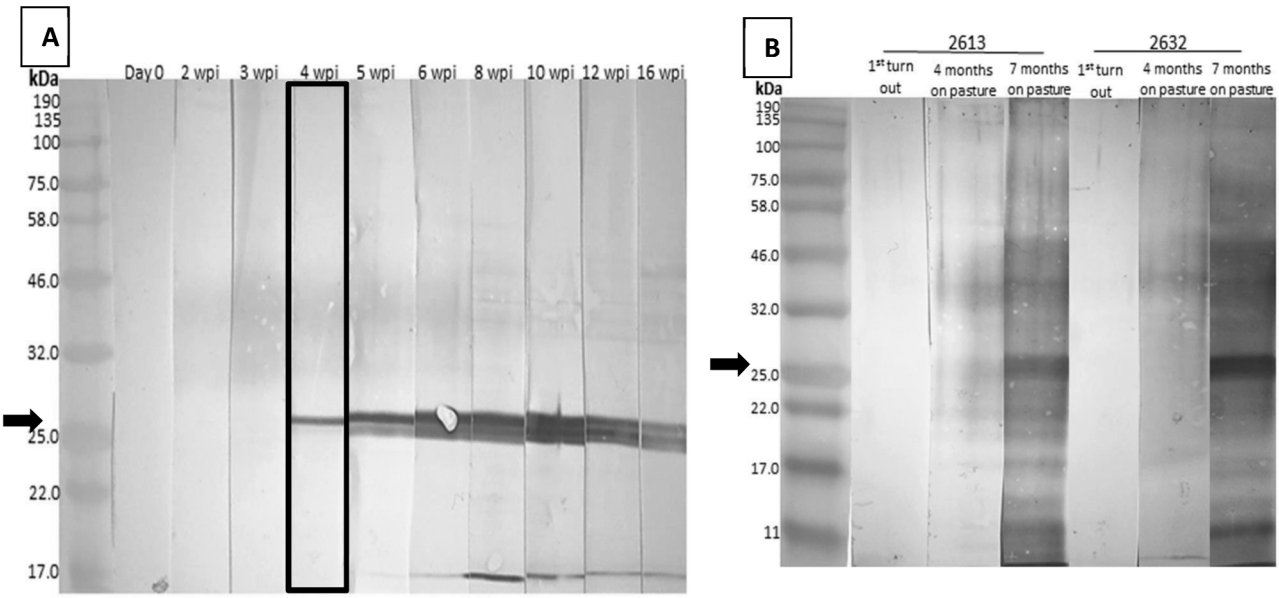


Figure 2: (A) shows the increase in antibody response over the course of a 16 week infection in an experimentally infected sheep. Host antibody response is detectable at 4 weeks post infection, and the main target for this antibody response is CL1, as highlighted by the arrow. (B) shows the same increase in antibody response to liver fluke infection in two naturally infected calves over the course of their first grazing season. The arrow again highlights that CL1 is the main target of the host antibody response.



CL1 that we aim to detect with our diagnostic test. This test will therefore work in a similar way to laboratory antibody detection tests; however this test will aim to provide results much faster. Figure 2a shows the increase in the antibody response to liver fluke infection in an experimentally infected sheep over a 16 week period. It also shows that CL1 is one of the main targets for this host response. Figure 2a also shows that host antibodies against fluke infection can be detectable as early as 4 weeks post infection. Figure 2b shows that the same response can be detected in calves naturally infected over the course of their first year grazing season.

Lateral flow immunoassays (LIFAs) (Figure 3) are used in a wide variety of settings and are rapidly gaining popularity for use as a diagnostic technology. The first tests commercially produced were for detection of human pregnancy and now kits are commercially available for the monitoring of ovulation, detecting infectious disease, such as viruses, bacteria and parasitic infections, analysing drug abuse etc. LIFAs can have several different designs, and some can be made to qualitative (presence or absence of disease), semi quantitative or occasionally fully quantitative (intensity of infection). Currently, no such test exists for the monitoring of liver fluke infection in livestock.

In order to design the LIFA, we require large amounts of the target molecule, CL1. The second aim of the project this year has to isolate or clone the gene for the CL1 enzyme and then put it into yeast. The yeast cells can be stimulated to produce the fluke CL1 enzyme, which is then known as a recombinant protein (Figure 4). The recombinant protein will be identical every time it is produced and therefore will provide good uniformity in the pen-side test.

Figure 3: A diagram showing the design of a lateral flow strip assay. A sample is added to the sample pad, and begins to migrate along the test strip. Results are interpreted by the presence or absence of the test lines (O'Farrell, 2013).

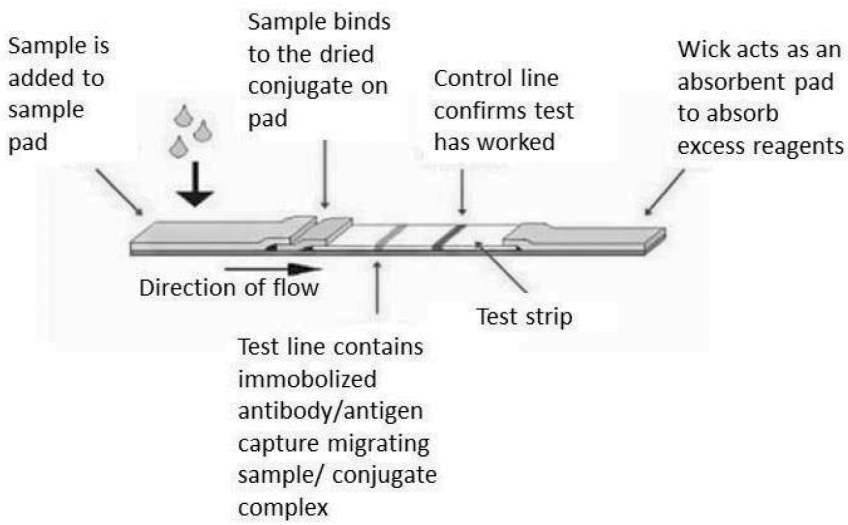
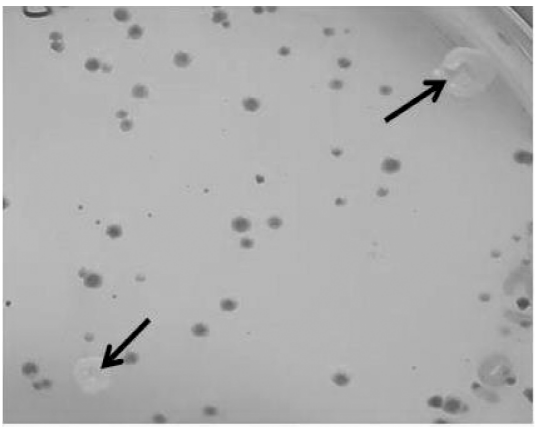


Figure 4: This figure shows successfully transformed yeast colonies containing the CL1 gene, as highlighted by the arrows. These cells can now produce the CL1 fluke enzyme, known as a recombinant protein, which is identical each time it is produced.



Conclusions

A LIFA will provide a much quicker and simpler method for detecting individual animals infected with liver fluke on farm. This will aid in the target treatment of animals reducing the reliance on blanket drug treatments of whole herds or flocks and therefore not only improve health and welfare of infected individuals but also aid in slowing the rapid increase in resistance seen in liver fluke populations.

The next steps for the test will involve designing the remaining molecular components of the test, and then the actual test itself. For this we will probably contact a local biotechnology company to help, and once we have the final product, we will validate our LIFA against other currently available diagnostic tests for fluke infections.

Improving carcase and eating quality through breeding and management

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The objectives of rearing cattle for beef include producing as much meat as possible of the highest possible quality, sustainably (which includes profitably).

Improving carcase quality

Beef carcase quality in GB is assessed by the EUROP system, which is an indirect indicator of meat yield from the carcase. Tables 1 and 2 show that there has been some improvement in the carcase quality of beef cattle over the ten years to 2014, with carcases generally becoming leaner and of better conformation. This may reflect better selection for slaughter. Nevertheless in 2014 only 55% of prime cattle slaughtered in Britain met the target of E, U or R for conformation and 1, 2, 3 or 4L for fat class.

One means of improving carcase quality is to breed cattle for better carcase characteristics, improving the genetic attributes for carcase traits. Currently this is being done indirectly through measuring growth rate and associated carcase traits on the live pedigree animal – fat depth and muscle depth/area using ultrasound. We know the value of this to be £4.9 million per annum (Amer et al., 2015). It may be possible, however to breed directly for the traits measured in the abattoir.

Abattoir data for genetic evaluation

When combined with other national databases, abattoir data are suitable

Table 1: Percentage of prime beef by fat classes in GB, 2004–2014.

	Fat class						Target fat classes
	1&2	3	4L	4H	5L	5H	1 to 4L
2004	8.3	28.2	46.4	15.8	1.0	0.1	82.9
2005	8.8	27.1	46.1	16.6	1.3	0.2	82.0
2006	10.3	27.7	45.8	15.0	1.0	0.1	83.8
2007	11.3	28.7	44.5	14.4	1.0	0.1	84.5
2008	13.4	31.1	43.8	11.0	0.6	0.1	88.3
2009	12.1	30.8	44.0	12.1	0.9	0.1	86.9
2010	11.8	30.6	44.1	12.4	1.0	0.2	86.5
2011	12.5	31.8	42.2	12.4	0.9	0.2	86.5
2012	12.7	32.7	41.3	12.2	0.9	0.1	86.7
2013	13.1	33.2	41.8	11.0	0.8	0.1	88.1
2014	10.7	32.2	42.8	13.3	1.0	0.1	85.7

Table 2: Percentage of prime beef by conformation classes in GB, 2004–2014.

	Conformation class							Target conformation classes
	E	U+	−U	R	O+	−O	P	E, U, R
2004	0.1	1.5	11.3	45.4	27.3	12.5	2.0	58.3
2005	0.2	1.5	12.0	44.7	26.1	13.5	2.0	58.4
2006	0.3	1.7	13.4	44.9	25.4	11.9	2.4	60.3
2007	0.3	2.0	13.6	44.3	26.3	11.7	1.8	60.2
2008	0.3	1.8	12.3	43.8	28.5	11.3	2.0	58.2
2009	0.4	2.3	13.0	44.2	26.6	11.5	2.1	59.9
2010	0.5	2.3	13.1	42.2	25.5	14.0	2.4	58.1
2011	0.7	2.9	13.7	41.1	23.8	15.4	2.4	58.4
2012	0.8	3.8	14.6	41.4	22.5	14.5	2.4	60.6
2013	1.0	4.6	16.5	41.4	21.7	12.5	2.1	63.5
2014	0.9	5.0	17.7	41.1	21.3	11.8	2.2	64.7

for producing national beef genetic evaluations for the traits farmers are paid for. This project being undertaken by Scotland's Rural College (SRUC) is a follow on from an AHDB funded feasibility study which showed the data could be collected, validated and merged. The focus of the project is on producing genetic parameters and genetic evaluations for carcase weight, conformation and fat class for those breeds with sufficient data in the BCMS database. Unfortunately some breeds do not have sufficient data because they are numerically small or the sire has not been recorded on the passport for enough animals.

The project, funded by AHDB (Beef & Lamb and Dairy) and Hybu Cig Cymru (Meat Promotion Wales) is now nearing completion. Nearly 4 million carcase records have been assembled and matched with BCMS records and other data sources to assemble the best possible 'super-pedigree' file.

From this set of data a smaller set was extracted for the calculation of genetic parameters (heritability values and genetic correlations). The analysis so far has resulted in the development of genetic parameters for carcase traits (fat class, weight (in relation to age) and conformation). Heritabilities (within breed) are mainly in the range of 0.2 to 0.4 which is very encouraging – indicating the breeding for these traits using commercial carcase data is not only possible, but also likely to result in good rates of progress.

A larger subset of the data has been used to produce EBVs for 2,416,966 animals (those with a 3 generation pedigree) for the carcase traits. Table 3 shows a summary of these EBVs for the UK population. These EBVs have been rebased to 2010 born animals so an average of 0 is not expected, and EBVs can be interpreted as a comparison to the average 2010 born animals, i.e. a carcase weight EBV of +2kg has the genetics to produce 2kg more than the average 2010 born animal.

Table 3: Summary of EBVs for sires with 10+ progeny (n=14,829).

Trait	Avg	St. Dev	Min	Max
Slaughter Age (days)	−2.897	16.487	−135.700	134.660
Carcase Weight (kg)	0.998	12.491	−63.262	64.210
Conformation (class)	0.689	1.549	−7.201	7.998
Fat (class)	0.058	2.085	−9.930	8.201
ADCG (average daily carcase gain) (kg/day)	0.004	0.022	−0.135	0.127

The most extreme animals were checked for each EBV to confirm the result. In most cases these were animals for which slaughter data were available and they showed an extreme, but valid phenotype. Given they had directly measured data, these animals also tend to have generally high accuracies and even if restricted to those that have 10+ progeny we still see a wide range in EBVs reported. This variation also means that good rates of genetic progress are likely.

Simple correlations were also undertaken between the raw phenotypes and the resulting EBV. Generally, correlations suggest a strong relationship between observed phenotype and the underlying genetics but this relationship was weakest for slaughter age, suggesting a strong effect of management/environment which is unsurprising. The relationship was strongest for conformation, suggesting a very strong genetic component, again unsurprising.

Table 4: Correlation between the raw unadjusted phenotype and EBV for each trait for the UK all breed population.

Slaughter Age	0.22
Net weight	0.50
Conformation	0.71
Fat	0.55
ADCG	0.36

The project team are now preparing to examine the EBVs for a sample of animals by breed and discuss the use of the new carcase trait EBVs with the breed societies.

Improving eating quality

A wide range of factors can influence the eating quality of beef available to consumers. Delivering optimum quality relies on the adoption of a whole chain approach. Individual retailers, however, adopt differing specifications to suit their business needs and the practices intended to improve meat quality, operated in isolation, may not be fully effective. In 2011, AHDB Beef & Lamb (EBLEX) conducted a retail beef survey following concerns that there was an undesirable and avoidable degree of variation in the toughness of English beef at retail. Sirloin steaks and topsides from six major retailers were shear force tested for tenderness over a three month period and the findings reported.

This was repeated in 2015, although the sample was expanded to include the increasingly prominent discount retailers. This has enabled assessment of changes in the tenderness of beef at retail. The results from sirloin steaks suggest an improvement in quality. This is thought to be partly due to changes in packaging methods, from high oxygen modified atmosphere packs to vacuum packs and vacuum skin packs.

Animal age and meat quality

Despite improved attention to processing and packaging practices to improve eating quality, there remains uncertainty about the attention being given to live-animal factors. In particular there has been relaxation of rules regarding the maximum age of cattle sourced for quality beef specifications. The correct age limit for quality beef production from steers and heifers is

Table 5: Shear force values (maximum force in kg) for steaks assess in 2011 and 2015.

	2011	2015
Overall Average	4.9	3.6
Overall Minimum (most tender)	2.5	1.9
Overall Maximum (most tough)	10.0	6.6
Average for retailer with lowest value	3.9	2.9
Average for retailer with highest value	5.8	4.0

often debated. With some prime beef cattle not being ready for slaughter until 30–36 months of age there is a need to know if meat from these older cattle is tougher. A project, being undertaken at SRUC (funded by AHDB), has been established to examine the effects of alternative lifetime growth paths on animal performance, carcase characteristics and meat eating quality parameters.

The first phase of the project was to assemble Limousin cross finishing cattle at the SRUC Beef Research Centre. These cattle have been finished according to three target growth paths:

- Short duration growth path: 12–16 months of age
- Medium duration growth path: 18–26 months of age
- Long duration growth path: 28–36 months of age

Both steers and heifers were allocated to alternative growth path groups taking individual sire into account so that no one sire dominated within any one group for either steers or heifers.

All 24 animals from the short-term finishing growth path group completed their finishing phase and were slaughtered in 3 batches in the summer of 2013. All 24 animals from the medium term finishing growth path group were slaughtered in 3 batches in autumn 2013 – spring 2014. The long term group were slaughtered in the 2015/16 winter. This long-duration group had a pattern of growth typical on many commercial systems with periods of growth interrupted by periods of little or no growth.

Once slaughtered, bone-in loin joints of beef were recovered from all carcases and dispatched to the University of Bristol for subsequent assessment and eating quality analysis. This includes assessment of the composition, including thickness and weight of gristle and intramuscular fat content, and finally trained sensory panel assessment of eating quality. These analyses are not yet complete, but the results of the gristle weight indicate that whilst the weight of gristle increased with each growth phase, in the short and medium periods, the gristle as a proportion of both the joint and the loin weight did not differ. However, in those animals that had been subject to a growth check, and hence longer growth period, the gristle had increased disproportionally to the joint growth.

The results of this work will help inform guidance to supply chains on the appropriate age of cattle at slaughter to ensure quality prime beef production.

Conclusion

While improvements have been made in both the carcase and eating quality of beef in England, further research underway will help deliver further improvements to ensure that the customer receives the quality they require.

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Driving beef profitability using maternal composite genetics

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The biggest risk facing the UK beef industry is reduced per capita consumption due to competition from cheaper, more efficiently produced meats like chicken and pork. To counteract this, as an industry we must ruthlessly improve the efficiency of beef production rather than constantly demanding higher farm gate prices and subsidies. There are many useful lessons that can be learnt from our competitor industries – mainly the use of specialist hybrid maternal genetics.

Two Facts:

- The biggest profit driver in suckler beef production is total kilos of calves weaned per hectare, and the biggest influence on this is cow type.
- Approx 2/3 of the cost of producing a kilo of suckler beef is the cost of keeping the cow.

Taking these together it is clear that suckler farms need to use cows which cost less to keep and have a higher relative output, ie efficient cows.

Various trials, including on our own farm, have demonstrated that using the best maternal genetics alone can improve total kilos weaned per hectare by up to 30% and net profit per cow by up to £300.

If we get cow type right, we can use which ever terminal sire which suits our farm system. If we get cow type wrong, it is virtually impossible to make money.

Maternal Profit Drivers

- Fertility – Our farm has moved from 10% empty in 12 weeks to 3% empty in 9 weeks.
- Calving Interval – 400 days to 361 days
- Birth Assistance – 25% to 3%
- Birth Mortality – 5% to 2%

The combination of these factors has seen calves weaned per 100 cows put to bull rise from 83 to 95 and calving move from indoor with 24 hr supervision to outdoor checked twice daily with subsequent improvement in family life.

When considered alongside temperament and structural correctness (udders and feet), this increases longevity and reduces replacement costs.

Cow Size/Weight – Bigger, heavier cows do not wean bigger heavier calves. Eblex, DARD and Teagasc figures all show that 600kg cows wean the same weight of calves as 800kg cows. More of the smaller cows can be kept on the same land area at minimal extra cost, resulting in substantially more kilos weaned per hectare. This is expressed in the Cow Efficiency Percentage defined as:

Total kilos of calves weaned at 200 days
÷
Total kilos of cows put to the bull

UK average is below 40%. US Agri-economists say that 50% is the figure generally regarded as giving sustainable profit. This is much easier to achieve with smaller cows and increasingly difficult when cow weight exceeds 650kg. The average cow weight in our herd is 620kg.

Two Year Old Calving

Virtually all large-scale beef producing countries of the world calve heifers at 2 years old. Compared to 3 year old calving, this increases net profit by over £40 per cow per year every year of her life. So early puberty-type cows, preferably containing at least 50% native breed influence and good heifer rearing are a necessity.

Net Feed Efficiency

Feed efficiency is usually considered in the context of influencing the profitability of beef finishing. While this is very true, the main financial effect of feed efficiency is in the cost of keeping the cow. Trials carried out in the USA have shown that harnessing this trait will readily reduce the cost of keeping a Cow/Calf unit by £100 per year without reducing output.

Hybrid Vigour

We all know the definition – how much better is a cross-bred offspring compared to the average of its pure-bred parents. In a four way cross, the extra output is 22%. This is one of life's very few "Free Dinners" and it is a no brainer to utilise this. So, cross-bred cows are an essential.

Milk Yield

We generally think – milky cow = heavy weaned calf. This is true,

however, if an excessively milky cow eg Holstein X is kept on inadequate grazing like marginal hill, then body condition and conception rates will fall. This has a greater negative financial effect than the benefit of the extra calf weight. So for maximum profit, milk yield potential must be matched to the nutritional potential of the farm.

Conclusion

Efficiency of suckler beef production and consequent farm profit will be massively improved by using specialist maternal genetics. Basically cows should be cross-bred, fertile, easily calved, easily fleshed, adequately milky, preferably polled, under 650kg and able to wean over 50% of their own weight.

On our farm, after much experimentation, we have achieved this by using American Stabilisers, which is a scientifically developed 4 breed maternal composite based on the pig/poultry model.

In effect – a chicken with a rumen.

Breeding for TB resistance – the 'TB advantage'

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Summary

The important contribution of genetics to the long term advancement of the national dairy herd is well accepted. Improving trends, as a consequence, in a wide range of traits such as milk production, conformation and several fitness traits is further evidence of this. It would be unimaginable that as part of a national progress strategy, genetics could be ignored, despite other important and on-going management enhancements. Now, with the knowledge that bovine tuberculosis (bTB) is similarly affected by an underlying degree of genetic resistance, the availability of the TB Advantage is expected to contribute to long term improvements in the national TB situation, if used alongside other important industry TB control measures.

Introduction

Over the centuries breeders have successfully capitalised on the fact that on farm animal Performance is a combination of Genetics and Environment (P=G+E). Simply by selecting animals with favourable genetic merit for a variety of production and fitness traits, breeders have been able to make both permanent and cumulative changes to the performance of their herd in a cost effective way.

With the availability of this information, the dairy breeding goal changed over time from being mostly output driven (i.e. production), to a much stronger emphasis on reducing input cost (i.e. improved health, fertility and longevity) leading to a modern balanced breeding goal.

An example of how the availability and use of genetic information can drive industry performance for an economically important trait is Somatic Cell Count (SCC); the first health related trait to be made available to the UK dairy industry. Because SCC is heritable, we have been able to calculate Predicted Transmitting Abilities (PTA) for bulls, which have been used in selection since 1998 (1). Based on the shifts in genetic trends, it was predicted that we should observe a gradual improvement for the national herd average SCC values from 2008 onwards (2). Today, we now know this prediction to be true, with year on year SCC levels reducing since its peak in 2008 (Figure 1) despite continued increases in yield.

Today, PTAs are available for many traits and their application for non-production traits is becoming increasingly important, with now over 67% of the UK Profitable Lifetime Index (£PLI) being directed towards fitness (cost) traits (Figure 2).

Genetic evaluations for bovine tuberculosis

Premiered at the BCBC 2016 Conference, from 19th January 2016 Holstein breeders have a new genetic index to help them make more informed breeding selections. The

Figure 1: Average SCC by Year of Production (Source: AHDB Datum; 2016).

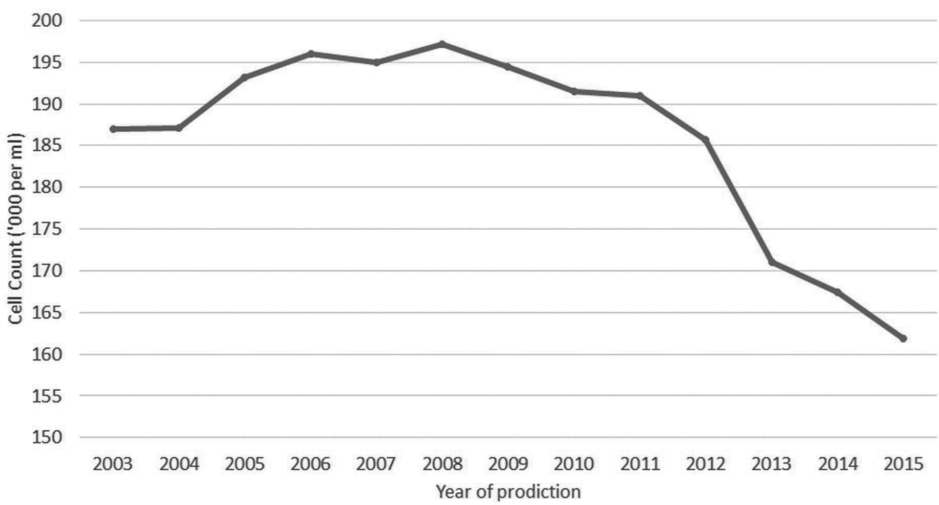
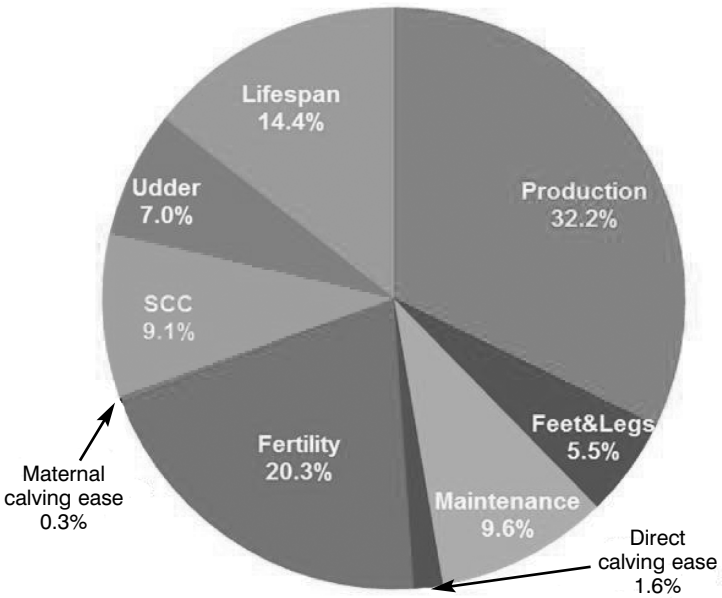


Figure 2: Relative weighting of traits within £PLI.



new PTA published by AHDB Dairy, named the TB Advantage, can be added to existing selection criteria, to help breed dairy cows with better resistance to bovine tuberculosis (bTB).

Although no one in the industry is claiming the TB Advantage will be a cure-all for bTB, it certainly has the scope to improve an animal's resistance to the disease and, like all genetic improvement, benefits will accumulate over the generations.

The index has been developed following extensive research undertaken by the University of Edinburgh, Roslin Institute and Scotland's Rural College (SRUC) and supported by Defra, the Welsh Government and the Agriculture and Horticulture Development Board (AHDB) (3, 4, 5, 6).

By using data from the APHA (Animal and Plant Health Agency) from animals which react to the official bTB skin test and are sent to slaughter, we have been able to identify patterns of resistance amongst different bloodlines.

This knowledge forms the basis of the genetic index, which is the first genetic index for bovine TB to be used in the world. The number of animals included in the evaluation released in January 2016 exceeds 650,000.

The introduction of the TB Advantage continues a long tradition of innovation in genetic indexes in the UK, and the industry has become accustomed to using genetic indexes for health and fertility, and has seen significant genetic improvement in the traits which have been targeted.

The heritability of bTB resistance is about nine percent, which means that of all the variation we can detect in the trait, about nine per cent is due to genetics. This is on a par with some other health traits, including Somatic Cell Count, which as shown earlier, breeders have been improving through genetic selection for a number of years and consequently are now seeing the benefit in improved performance on farm.

All of this gives us confidence that the TB Advantage will be an effective tool in the fight against bTB, but it does not detract from the other control measures which must continue to be taken as part of the broader disease eradication plan. Continuing with the usual measures of biosecurity, the protection of cattle against infected wildlife and the routine monitoring of cattle for the disease, remain core components of the strategy to eliminate TB from the national herd.

Using the TB Advantage

The TB Advantage provides an indication of the degree of resistance to bTB a bull is predicted to pass on to his offspring and, like all genetic indexes used by breeders, it is a Predicted Transmitting Ability (PTA). It is expressed on a scale which typically runs from −4 to +4, with the majority of bulls ranking between −2 and +2, and a positive index is desirable.

For every point of a bull's TB Advantage, it is expected that one per cent fewer daughters become infected during a TB breakdown. Therefore, the difference between daughters of the best (approx +3 TB Advantage) and the worst (approx −3 TB Advantage) bulls is therefore around six percent, which mean that six fewer cases of bTB could be expected per 100 cows in just one generation if the best bulls are chosen over the worst. And as with all genetic improvement, the benefits are cumulative, building up over the generations.

Analyses have shown that the correlations between TB Advantage and other trait PTAs of interest for selection are generally small, but favourable. This is good news, as this means that breeders do not have to make strong compromises if they wish to incorporate the index in their breeding plan (Table 1). The strongest and most favourable correlations is with the £PLI, which may not be surprising given that this already incorporates a high proportion of 'fitness'.

It is important to note that the TB Advantage should form only part of a broader breeding strategy. Breeders already know that too much emphasis on any one area in breeding can detract from others, so it is advised to continue to select service sires on the basis of all traits important to a business.

There are many factors which should influence whether to add the TB Advantage to a breeder's breeding

Table 1: Correlations between the TB Advantage and other traits.

Trait	No. sires	Correlation
Milk kg	9,835	0.03
Fat kg	9,835	0.04
Protein kg	9,835	0.05
Fat %	9,835	0.01
Protein %	9,835	0.03
SCC	9,813	−0.05
Lifespan	9,727	0.08
Fertility index	7,274	0.06
Calving ease (direct)	4,494	0.07
Calving ease (maternal)	4,754	0.07
Maintenance	5,904	−0.05
Profitable Lifetime Index (£PLI)	9,835	0.11

criteria; these are likely to include whether a herd is within or close to a bTB affected area or whether it is felt that having progeny by a bull with a better TB Advantage will give some commercial benefit, such as when selling livestock.

However, if all other traits are equal, it would definitely be preferable to use a bull with a positive TB Advantage and using bulls with an extremely negative TB Advantage is inadvisable as it is likely to increase the susceptibility of a herd to bTB.

Like all genetic improvement, this is a step-by-step approach, but by taking those steps in the right direction, breeders are undoubtedly helping to stack the odds in their favour.

Which animals will have a TB Advantage?

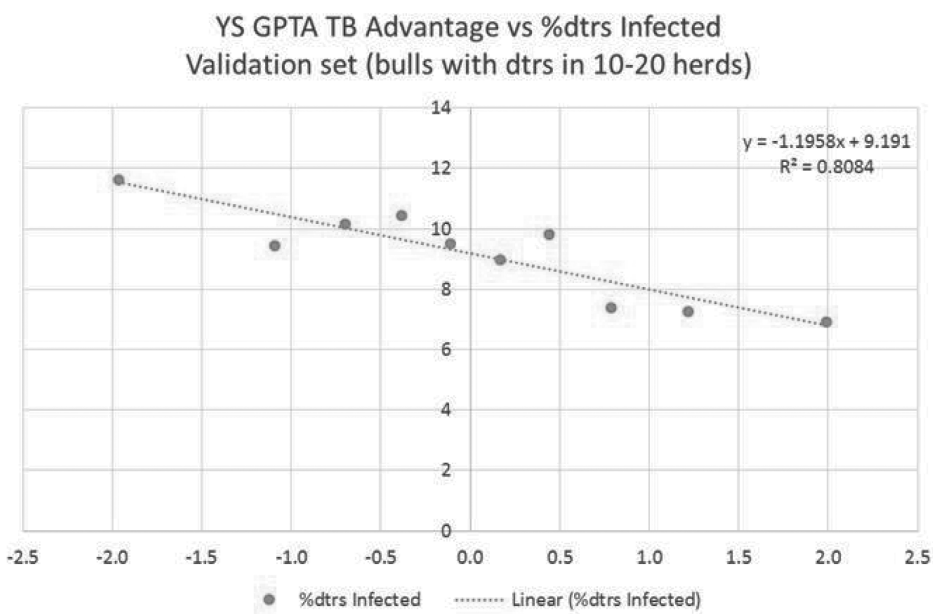
Initially, only Holsteins will have a TB Advantage because there's considerably more data available for the Holstein than for any other breed. The index will be calculated for bulls which either have daughters milking in the UK (daughter-proven bulls) or have had their genotype taken (genomic bulls). In effect, this means there will be very few commercially available Holstein bulls which don't have a figure calculated for TB Advantage. However, breeders should note that some bulls which have obtained their progeny indexes outside the UK will have a larger genomic contribution to their TB Advantage than for other components of their genetic index due to the lack of bTB information from international sources. Longer term, this information may be available from other countries such as Ireland. Any breeder obtaining a UK genomic index for females in their herd will also now obtain a score for TB Advantage.

How reliable is the TB Advantage?

Genetic indexes are published with a reliability figure which gives an indication of how likely the index is to change as more information is added. The reliability for the TB Advantage ranges from 20 to 99 per cent, with an average reliability of 65 per cent for bulls with UK daughters, and 45 per cent for those with a genomic index only. Although the reliability of genomic predictions for the TB Advantage is currently less than for some other indexes, it can still be used as part of a herd's breeding strategy and has shown to be valuable in predicting future performance. Also, as more data is added over time all PTA's will rise in reliability.

An analysis was conducted whereby genomic predictions were made for bulls which had daughter information for TB in 10 to 20 herds (n=450 bulls). Their genomic prediction, which excluded daughter information, was subsequently compared against the proportion of their daughters that were culled for bTB. Figure 3 shows the relationship between the genomic prediction for TB advantage and the number of daughters culled. The 450 bulls in the analysis were grouped in 10 percentile groups, ranging from the worst 10% on genomic TB Advantage prediction to the best 10%. This figure clearly demonstrates, that despite the lower reliability, the genomic

Figure 3: Relationship between genomic predictions for TB Advantage (YS GPTA – x axis) vs future percentage of daughters infected with bTB (y-axis) (grouped in 10 percentile groups).



predictions can serve as a useful guide for future performance of the bull's offspring.

When and where is the TB Advantage published?

The TB Advantage is published by AHDB Dairy as part of the routine dairy cattle genetic evaluations service, computed in collaboration with EGENES at SRUC. Indexes are published three times a year in April, August and December. They are always available on the AHDB Dairy website at: dairy.ahdb.org.uk

Acknowledgement

Co-workers in the project team responsible for the implementation of the TB Advantage; Prof. Georgios Banos (SRUC/Roslin Institute), Prof. Mike Coffey and Prof. Raphael Mrode (SRUC/Edinburgh Genetic Evaluation Services), Prof. John Woolliams and Prof. Steve Bishop (Roslin Institute)

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TB – what a vet would do

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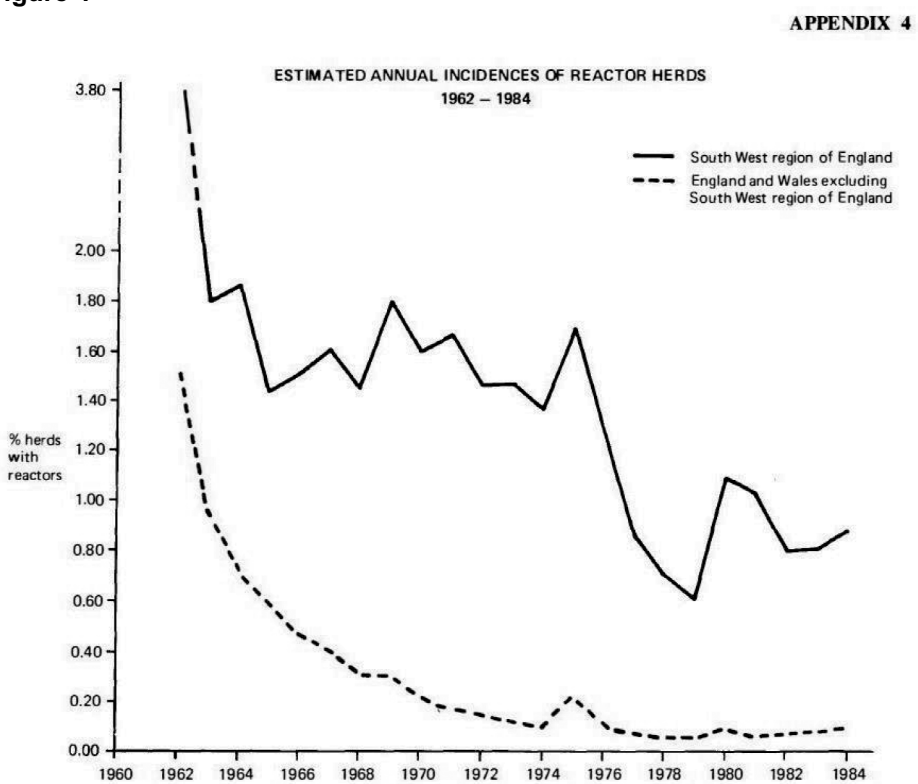
Cattle TB history

Tuberculosis of cattle in the UK was relatively rapidly controlled following the decision to become officially TB free (99.8% of herds and 99.9% of cattle testing free of disease) in the middle of the last century, which saw the introduction of attestation. This involved testing, culling and restricting movement of infected cattle herds, which is the model across the entire developed world for control of bovine TB. However it was noted in the 1960's that cattle TB was persisting in some areas of the South West of England, whereas the rest of the UK saw TB virtually completely eradicated in cattle.

Veterinary surgeons at the time hypothesised that a reservoir of infection must exist and consequently many wildlife species were examined, particularly in the TB hotspots. It was determined in the 1970's that the badger was a significant reservoir of infection and also that there were high sett densities and badger disease prevalence in the areas where cattle measures were failing to eradicate the disease in cattle. In areas where cattle TB was successfully controlled badger disease was very low or non-existent, based on studies of many thousands of road killed badgers. Other than deer, most other species did not appear to have sufficient disease susceptibility to act as reservoir hosts for TB.

Figure 1



From the Dunnet report 1986 (Appendix 4) showing the period where vets noticed a difference between geographical areas for TB persistence in cattle, which prompted a search for a reservoir of infection in wildlife

During the 1970's various badger culling exercises were undertaken in an attempt to control the disease, predominantly in the South West of England. Repeated gassing of setts was the most effective culling method, but this was banned in 1982 (it was deemed inhumane) and was followed by various less effective strategies involving trapping and shooting. It's important to understand that gassing of setts (mainly with hydrogen cyanide) had been commonplace around the UK and was considered a normal part of the management of wildlife. Consequently the badger population was kept relatively low compared to today. Other factors such as maize silage (anecdotally) may have contributed to the subsequent rise in the badger population too.

The badger had been protected to a degree in 1973 in an Act that was aimed at preventing cruel practices known as 'badger baiting'. However, farmers and countrymen did use other legal methods to control the badger population before and after this Act. In 1992 the Protection of Badgers Act

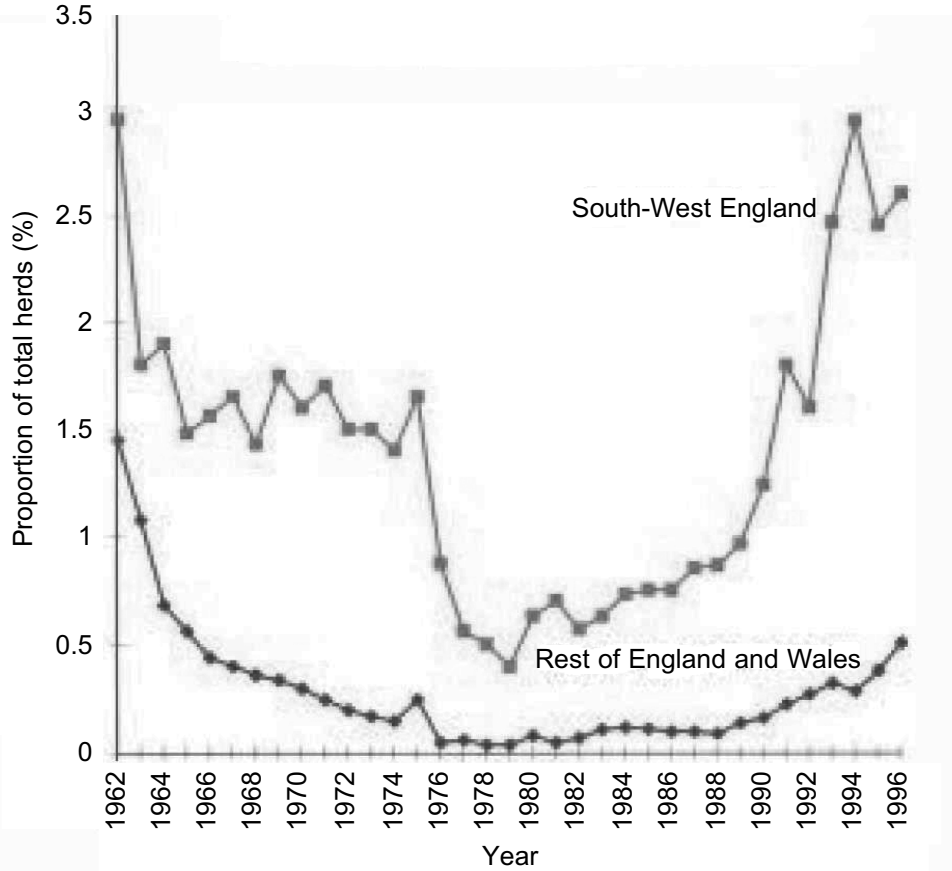
came into force which fully prevented any interference with badgers or their setts. Although the potential for licensing to cull to prevent livestock disease is in the act, these were generally not awarded, other than for a handful of now very paltry government attempts to control remaining TB hotspot areas.

In the mid 1990's TB rose sharply, particularly in the South West of England. Despite the fact that every *effectively* delivered badger cull always reduced cattle TB the whole issue of badger culling became highly politicised and in 1996 Professor Krebs was invited to report on the history to date and include recommendations to government for the future.

Although the more aggressive/ effective badger cull efforts pre 1996 were acknowledged by Prof Krebs to have been highly effective against TB in cattle, he decided that they hadn't been conducted as a true scientific controlled experiment. They were also the subject of much public controversy and hence he advised the government to conduct a large 5 year multi-site randomised controlled study into the effectiveness of badger culling on the incidence of cattle TB, rather than to revert to an aggressive badger removal strategy there and then before things escalated further.

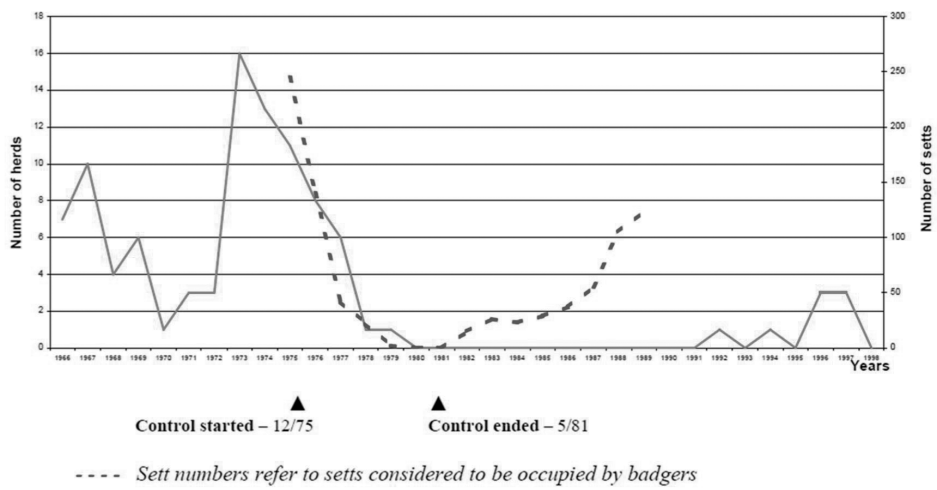
Many academics deny the relevance of the outcomes of extensive badger cull operations such as Thornbury, where cattle TB reduced to zero for ten years following complete badger removal of the area. In fact they refer to them as 'non-scientific'. It is not uncommon for academics to conclude 'More research is needed . . .' despite what appears to the onlooker as common sense. It would be interesting to see the total spend by government on TB research since the Krebs report.

Figure 2: Proportion of total herds with reactors (both confirmed and unconfirmed) 1962 to 1996.



From the Krebs report, 1997, showing the start of the exponential rise in TB in the UK, which began in 1982 and coincided with the banning of gassing badger setts, and then rose again post the 1992 Protection of Badgers Act

Figure 3: The Thornbury study area – badger removal trial. Cattle herds with confirmed TB and badger sett numbers.



The Randomised Badger Culling Trial (RBCT)

The Independent Scientific Group (ISG) were formed and chaired by Prof John Bourne in 1998 to design and implement the trial, known as the Randomised Badger Culling Trial or RBCT. The trial consisted of 11 areas split into 3 groups of behaviours: proactive culling, reactive culling and no culling (as a control area). Reactive culling was abandoned early as this was felt to be causing increased TB.

Although the initial trial design (ISG first report 1998) described proactive cull areas as:

'The target would be to cull as large a proportion of badgers resident within the treatment area as possible, and to prevent recolonization by further culling on a regular basis'.

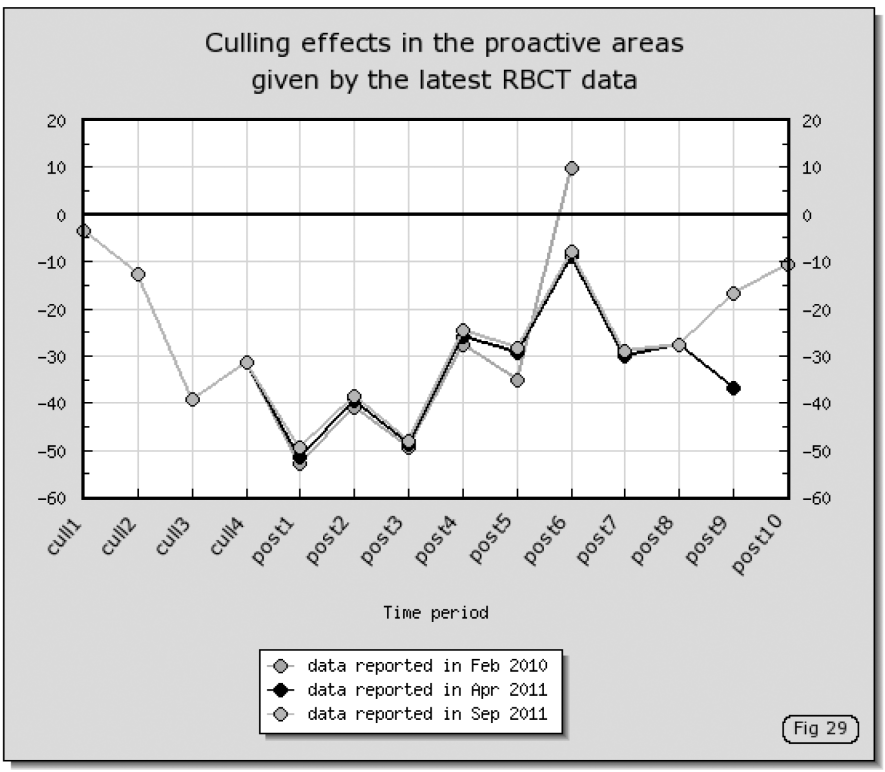
This was watered down by the new Labour government ministers, who used an interpretation of the Bern convention to set a maximum cull effort of 70% of the population in the area, thus compromising the effectiveness of the cull, even if performed maximally to meet this new 70% target. There were many critics of the cull effectiveness of the RBCT, which was also hampered by an outbreak of Foot and Mouth Disease in 2001, and continually disrupted by animal rights activists.

The ISG drew their conclusions relatively early from a long term disease control point of view and stated in 2007 that '. . . badger culling cannot meaningfully contribute to the future control of cattle TB in Britain'. However this should have read '. . . badger culling, as performed in the RBCT, cannot . . .'. This conclusion was reached before the true long term effects of the cull had had chance to fully materialise, which takes several years.

One of the main reasons behind their conclusion was the finding of what has been called 'the perturbation effect' which they claim to be due to infected badgers dispersing from cull areas, and general social group disruption, that results in spread outward of TB in the badger population creating a detrimental effect (rise in cattle TB) immediately outside the cull zone. However within the RBCT proactive cull zones, despite the relatively poor cull effort, TB in cattle reduced for at least 10 years post culling.

The perturbation effect itself has been the subject of some controversy partly because the effect of human relocation of badgers during the RBCT could not be measured with any certainty. It was admitted during Parliamentary Questions by Mr Bradshaw that there was a high rate of trap disruption and/or theft (around two thirds of traps) during the cull operations. It seems likely that this would involve some level of badger removal/relocation by the saboteurs. The perturbation effect from culling is yet to be observed anywhere outside of the RBCT in other badger cull zones, to my knowledge.

Figure 4



Full references for this graph are on www.bovinetb.info

Current government policy on badger culling

Although the RBCT was designed to end the controversy surrounding badger culling it seems to have increased it. Having had time to review the longer term effects of the RBCT and to consider methods to reduce the perturbation effect, the current stance of the government is to grant licenses for badger culling when very strict criteria can be met regarding efficiency, safety and humaneness of culling method. The license conditions contain measures to reduce the possibility of any perturbation effects by using large areas, hard boundaries and high culling rates.

Two pilot study areas to assess a methodology of conducting badger culling using controlled shooting were set up with a view to satisfying the license criteria from these three important aspects. More importantly this level of detailed approach would be required to counter the certain Judicial Review that would be demanded by the Badger Trust to attempt to prevent any culling taking place. Without the risk of this Judicial Review, licensed culling may well have gone on with much less cost and delay. The government appointed an Independent Expert Panel to oversee and assess year 1 of the pilot studies, whose conclusion was that the culls had failed to meet the targets set. An extension was granted in year 1 to allow the cull operators to increase the effectiveness of the cull (and consequently reduce the risk of disease) and recommendations from the IEP were carried forward to subsequent years to improve the performance of the cull effort.

These pilots were subjected to heavy disruption from protesters but it was shown that using a combination of controlled shooting and cage trapping that this methodology could be used to the satisfaction of the Chief Veterinary Officer and Natural England, particularly where interference with the cull effort was policed effectively.

The pilots were deemed to be very costly, but the overwhelming element of the cost was not related directly to the culling of badgers per se. It was heavily weighted to the policing to control protesters and to actually design and study what was going on rather than the cost of simply undertaking it. It is rare for these costs to be publicly broken down accurately. The government are now keen to encourage more areas of the UK to apply for licenses to create cull zones, albeit with sufficient professionalism to satisfy Natural England's licensing criteria. This will require farmers to work together to create their own zones that meet the relevant license criteria.

Figure 6: Geographical distribution of TB breakdowns 1986, 1996 and 2006.

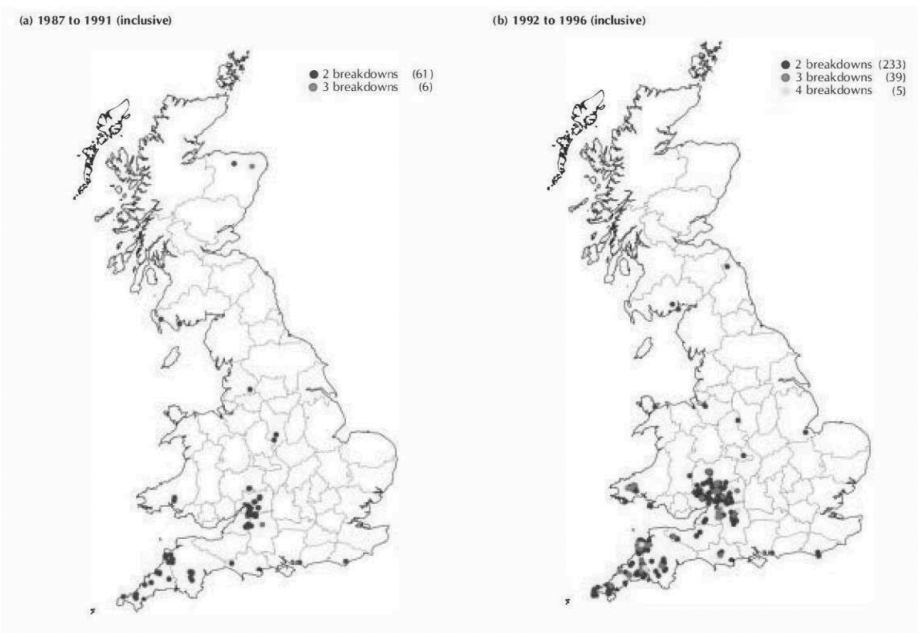
From the ISG report 2007

Geography of TB in England

Figure 5 from the Krebs report shows how few persistent TB breakdown cattle farms there were in the decade before 1997, but also how persistent repeat infection on farms was starting to increase in the known infected areas of the UK, particularly following the Protection of Badgers Act (1992).

Figure 6 from the ISG report shows how TB has radiated from original hotspots very slowly, rather than being spread universally across the UK.

Figure 5: Herds with more than one breakdown.



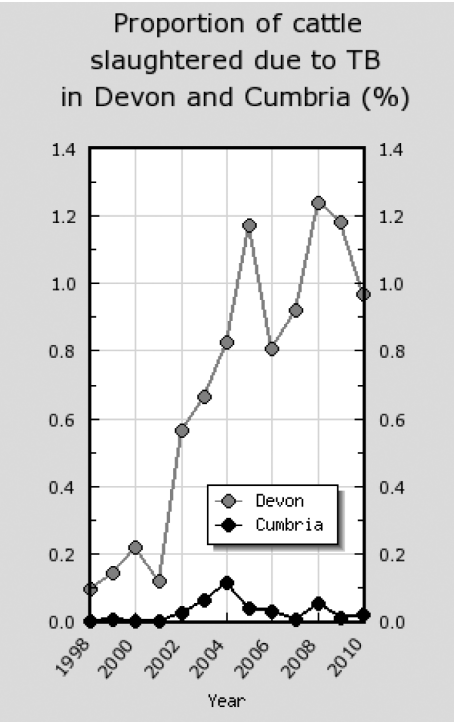
From Krebs report, 1997, showing the number of herds with repeat TB breakdowns at the relative times. Repeat breakdowns are now much more commonplace sadly.

Today England is split into 3 regions, known as the high risk area (HRA), low risk area (LRA) and the Edge area. In the LRA persistent recurring TB outbreaks on farm are extremely rare. This phenomenon predominantly occurs in the HRA. Following the FMD 2001 outbreak Cumbria (in the LRA) had bovine TB seeded in cattle farms due to repopulation from TB infected cattle areas. Devon (in the HRA), similarly struck by FMD, also had post-FMD repopulation and also had TB infection in cattle. However, standard cattle control measures applied in Cumbria reduced TB in that county rapidly such that despite its high cattle population and movements it still today has very low TB incidence in cattle. Figure 7 shows a post-FMD comparison of the two counties. There are far more stringent cattle measures occurring in Devon, due to the TB levels, than Cumbria, but to no good effect.

Figure 8 shows the steady rise of TB in each of the areas of the UK according to their current allocation to HRA, LRA etc.

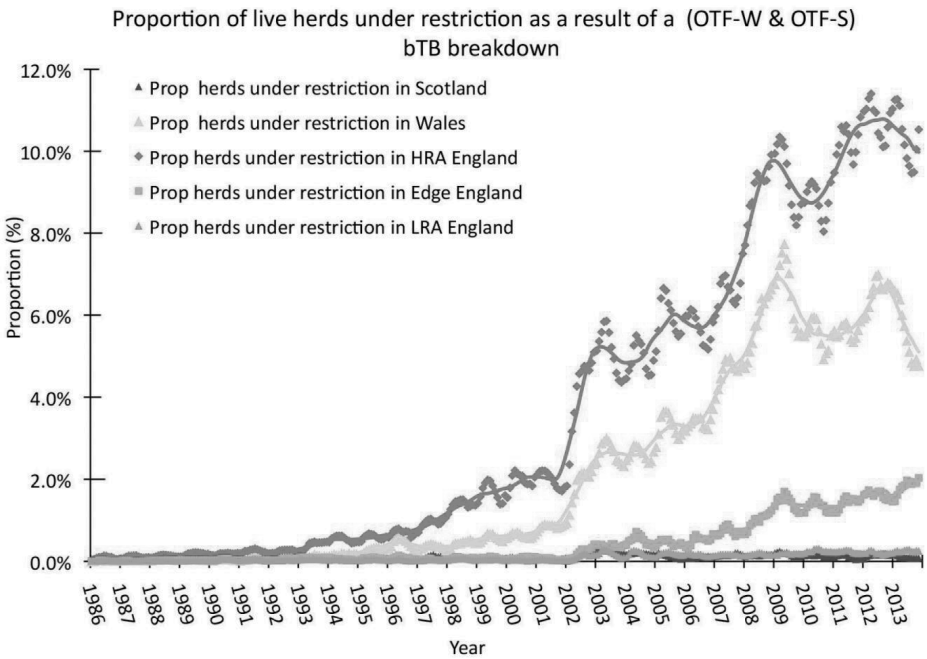
Interestingly the more highly infected areas (particularly HRA and Wales), when viewed in this long term way, show parallelism to rises and falls of cattle infection, despite being geographically distinct. It suggests a common background reason for the infection rates to rise and fall together over the years in these areas for reasons unrelated to their individual

Figure 7



From www.bovinetb.info where it is fully referenced.

Figure 8



TB policy. It may be that this parallel fluctuating rise and fall of cattle TB reflects the level of infection or the population dynamics of the badger, which may itself relate to the severity of winters or other such factors.

These slow multi-year fluctuations also show the danger in analysing alterations in TB infection status of geographical areas over short timescales (less than 10 years). TB fluctuates up and down from year to year, but in highly infected areas steadily rises through the decades. In areas with minimal wildlife infection (Scotland and the LRA) TB is controlled perfectly adequately (as shown above) using relatively ordinary cattle measures akin to most of the rest of the developed world, where wildlife infections and/or population densities of these reservoir species are controlled. The risk to these low risk areas of the UK increases constantly as we allow the infection in the HRA to increase unabated, as this increases the opportunity of trans-locating infection into the LRA through cattle movements. The LRA is also at risk because nothing appropriate is being done to stop the steady outward radiation of background wildlife infection. Currently trans-located, cattle movement based infections in the LRA rarely result in long term breakdowns as seen in the HRA. This is likely to be because LRA badgers are currently relatively uninfected and/or have lower population densities, which means cattle measures (test/cull/restrict movement etc.) are able to work.

Cheshire is in the so-called 'edge area'. In 2014, 102 road kill badgers from Cheshire were examined by Liverpool University laboratories, and a quarter of them were found to be positive for TB. This is around a 100-fold increase in the prevalence of badger TB compared to the last major study of Cheshire badgers.

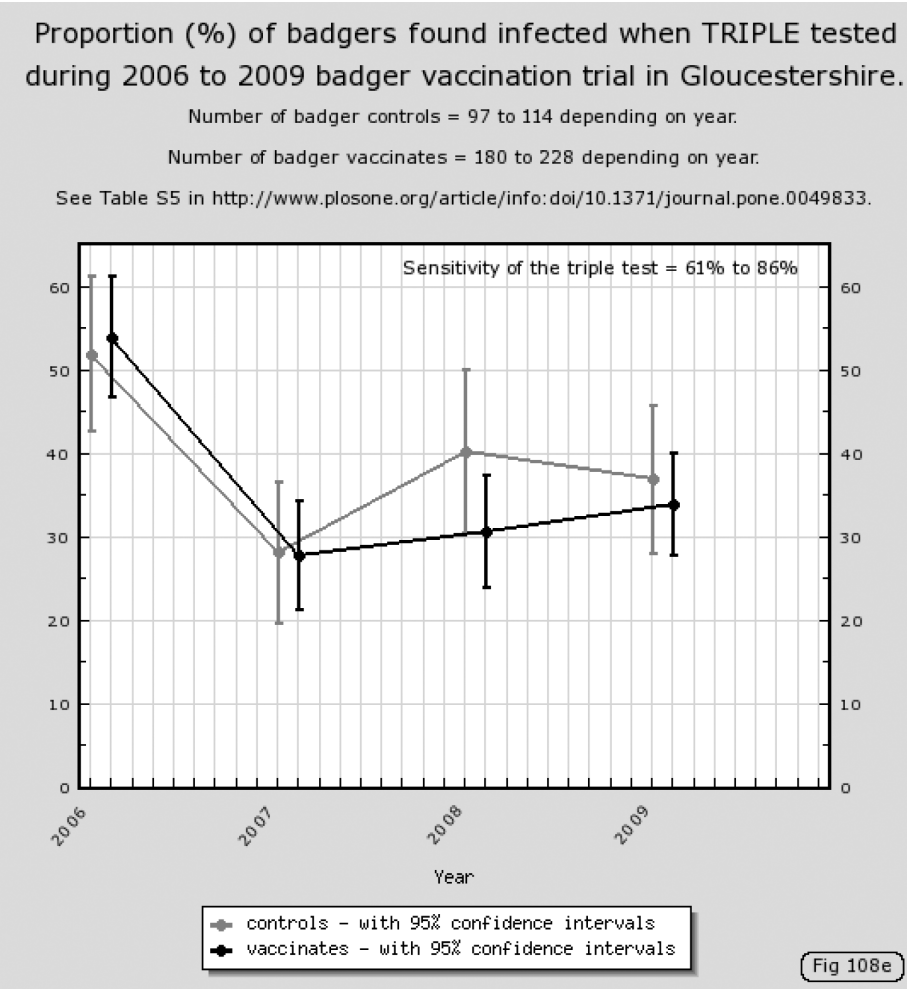
Badger vaccination

All the studies into badger vaccination have shown that the vaccine is unable to prevent all vaccinated badgers from becoming infected. It also has shown that it fails to reduce the prevalence of TB infection in vaccinated badgers when compared to unvaccinated, as detailed in Figure 9. Note also the high proportion of infected badgers in this study of wild UK badgers both at the start and end of the study period, as detailed in this graph, displaying data from the largest published study of vaccination of wild badgers (Carter et al, 2012).

It has been shown that BCG vaccination can reduce the severity of TB in badgers and slow the progression of disease, but nevertheless they still become infected. Consequently it is likely that following the cessation of any vaccination program in infected badger populations, residual infection will remain and result in the future population becoming more infected again. This is exacerbated by the fact that we are only able to vaccinate around 70% of the targeted population with current methods and it is unclear if there would be sufficient manpower or vaccine to roll this out more widely. It is also unclear when, if ever, it would be appropriate to stop vaccinating if this option was deemed to be beneficial.

Wales has an area known as the Intensive Action Area (IAA) where badger vaccination is the method of choice for control of wildlife infection. This was to be a 5 year plan, and 4 years have been completed. The cost of vaccinating this area, which is

Figure 9



Taken from www.bovinetb.info which references the source of the data from Carter et al, 2012 Table S5

1.4% of Wales, is just under £1m per year, but the delivery of the vaccination effort has been highly effective in relative terms (>70%). Given the constraints of BCG mentioned above there will be residual infected badgers at the end of the 5 years, and newly born unvaccinated cubs arriving every year following the cessation of this program. Therefore it is highly unlikely that this short term program will result in any long term benefit to badgers or cows, albeit we may learn something of the feasibility of badger vaccine as a component of TB control in wildlife and/or cattle.

In the IAA there are also much more stringent cattle measures and general attempts in terms of biosecurity on farms aimed at controlling TB. This is not dissimilar to historical efforts (albeit not well documented) that occurred in the South West of England, and in Ireland, that completely failed because of the wildlife reservoir of infection that resulted in the persistence of disease as noted in all of the government reports on the subject since 1980. In Ireland the badger population density and TB infection rate is much lower following their culling program, and they are more hopeful, because of this, that badger vaccination will have a better chance of being a feasible component of TB control.

Throughout the UK there is likely to be illegal culling of badgers at some level, and this complicates the entire interpretation of the outcomes of policy, as it is not measured by anybody. The evidence does suggest that piecemeal small scale efforts at badger culling will make TB worse. This should be discouraged in favour of appropriately delivered, legal and effective licensed culling if we want to make progress against TB in the UK. Farmers need to work with the government to make sure the best outcomes are achieved for both our livestock and wildlife. We owe it to the future UK badger population to reduce their disease levels, even if this means we manage a healthier population dynamic for the species, through controlling population density and targeted removal of diseased social groups, as is the case with many TB reservoir host species around the world.

Summary

In the absence of wildlife infection existing cattle measures (skin testing, movement restriction and culling of infected cattle etc.) work very well across the world at controlling TB and this includes the non-wildlife-infected areas of the UK.

Cattle measures worked across almost all of the UK during a time when it was permissible to limit the badger population and particularly their interaction with cattle (pre 1992).

Every *effectively* conducted cull of badgers in the UK has resulted in lowered cattle TB, and this lowering of TB rises with the effectiveness of the cull effort (Krebs report, 1997).

Any efforts to control badger populations should be within the law under license and this is correct to reduce the potential risks suggested by the perturbation effect.

In published studies of infected badger populations BCG vaccination has failed to reduce the prevalence of infection in vaccinated badger populations compared to unvaccinated.

If we were in a position to reduce the badger population and its infection level sufficiently then badger vaccination may become more feasible as a part of the control strategy, but only if sufficient vaccine and an appropriate delivery method is available.

Unlawful ineffective badger culling has the potential to increase TB spread.

References

www.bovinetb.info – recommended for well referenced material and the source of some of the graphics used above (with permission).

Key Historical Government reports: 'Badgers, Cattle and Tuberculosis' – (Zuckerman, 1980)

'Badgers and Bovine Tuberculosis – a review of policy' (Dunnet 1986)

'Bovine Tuberculosis in Cattle and Badgers' – (Krebs, 1997)

'Bovine Tuberculosis in Cattle and Badgers' – (King, 2007)

Badger vaccination: BCG Vaccination Reduces Risk of Tuberculosis Infection in Vaccinated Badgers and Unvaccinated Badger Cubs (Carter et al, 2012 – see table S5 available on the online 'plosone' version of the paper for prevalence data)

Wales Intensive Action Area – reports available on the Welsh Government website

Cheshire Badgers – Prof Bennett (unpublished data – 2014 study at Liverpool University)

Making a future in dairy farming?

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We live in challenging times and no real recovery in sight for the dairy market until supply and demand align and stocks are used up. Price is the best 'fertilizer' and we are now paying for the high returns which encouraged investment and increased production over the past few years around the world and a period of sluggish commodity prices seems set to last for some time.

We must therefore adapt both our minds and practice over the coming weeks and months; given the scale of the challenge, nothing less will see us through. Volatility was the most important topic by some distance during our AHDB 'Activity Meetings', where we met and listened to our levy-payers; the scale of challenge to their businesses and what we at AHDB can do to assist.

The danger of volatility is not necessarily the height of the peaks and the depth of the troughs (although the higher and lower they are the more difficult it is), but the length or duration of the periods in question and it is due to the steady fall of milk prices over many months with the prospect of a long period facing us before things improve, that the challenge ahead is so severe.

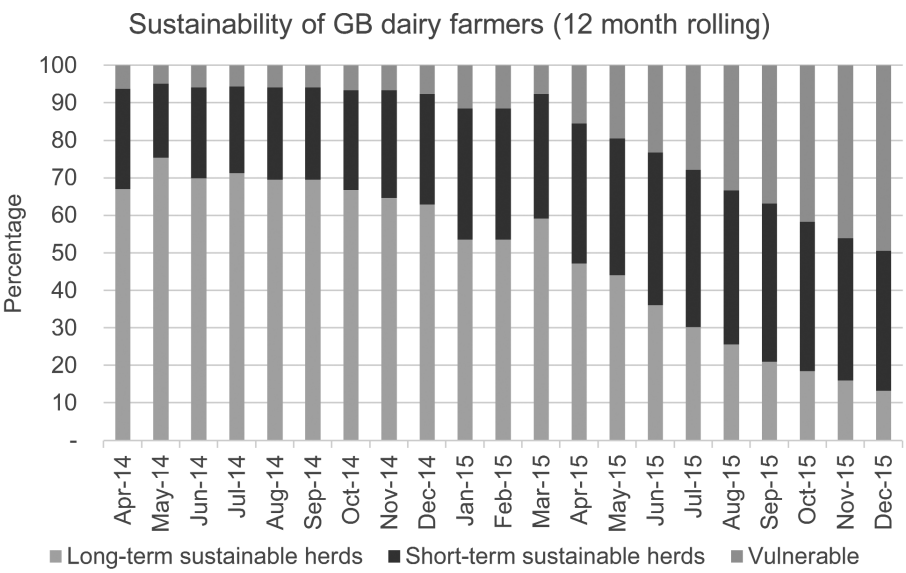
We at AHDB are here to help by providing advice, information, technical data and market information and comment; all of which enables dairy farmers to make better decisions. We have launched our 'Volatility Forum' which will look at all the different ways of mitigating the worst effects of volatility across all sectors, learning from other countries, other volatile markets and experts in this field. As Chairman of this forum I am determined to do what we can in this area, but it will of course be in preparation for the next downturn. It will not provide any solutions for this one.

How sustainable is the UK dairy industry? What makes the difference between profitable operations and less profitable ones? It is of course the combination of milk price, good management practices and cost control. However, the durability or resilience of dairy businesses when facing a long period of low milk price also needs the support of a healthy balance sheet and in many cases the support of the bank. In the case of tenant dairy farmers an understanding and realistic landlord is also important as incomes plummet. Many businesses have invested recently and in future, the timing of large investment will be crucial in volatile markets.

Milk price has reduced significantly quicker than on-farm costs; how long we remain in the trough and how quickly the market recovers will be key factors to determine just how many dairy farmers will survive this period. It is notable in (Figure 1) that the percentage of vulnerable dairy businesses has increased dramatically in the last 12 months and as we head for the spring and even lower prices, it will become more challenging. AHDB analysis shows that there has been a strong correlation between UK milk prices and the fall in UK dairy farmers over previous years (Figure 2), but no real correlation with national production as many cows sold by those exiting the industry are bought and milked by others.

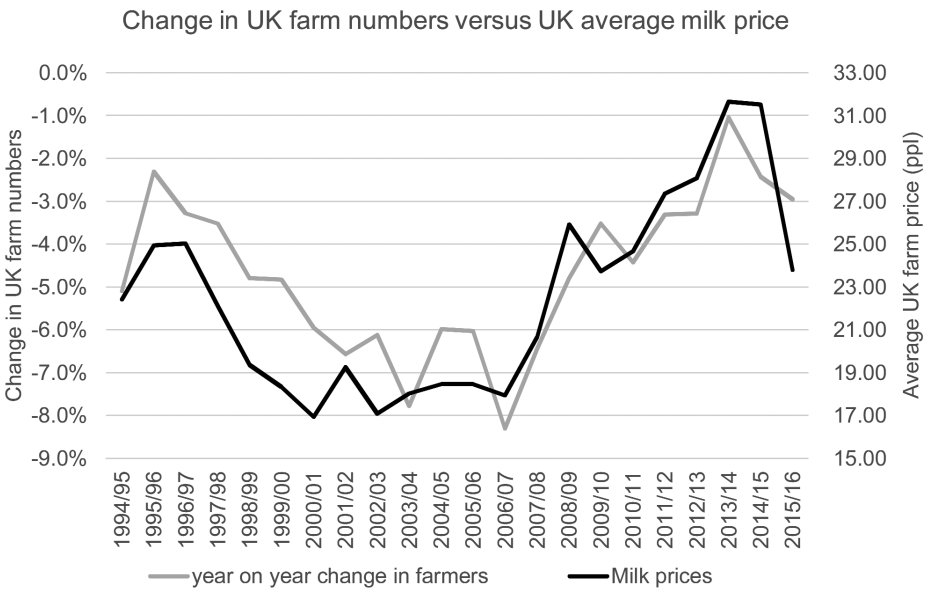
One thing I do know is that we do have some world class dairy farmers in this country, operating different systems to a very high standard.

Figure 1.



Source: AHDB

Figure 2.



Source: AHDB, DHI, SEERAD, DARD, DEFRA

At AHDB I see our task as championing this, and whilst celebrating our diversity, the right cow, the right system, on the right farm with the right contract; let's sell that to the customer. However, some systems are easier to operate than others and likely to be more profitable for the majority of dairy farmers and this is an area to look at?

Our markets are under pressure and we need to compete. There is no escape from competition in this new world and it is just as intense in our domestic market as it is for exports. We have many advantages in this country, farm size, farm structure, very favourable climate, and a huge market at home; no other country in Europe has all four. Yet, we import more cheese than we produce in this country and that will not change unless we can compete and attract investment from processors.

I know we can do this and I see great dairy farmers every day. I see my job as Chairman of AHDB Dairy, to assist and encourage dairy farmers to do better and survive the market challenge. The best farmers are always the ones who ask 'How can I improve – how can I do this better?' They will find ways to improve, they will continue to do things better and we are there to assist them and others who wish to do the same.

Given that dairy farmers all over the world, including New Zealand, found that their cost of production went up with the higher milk price over the years, everyone now needs to re-adjust, cut those costs and look again with a fresh pair of eyes on their business? Due to the volatile nature of markets, we need to take a longer period whilst planning our businesses, looking at least three years ahead in order to smooth out the peaks and troughs which gives a more accurate forecast.

One area which seems to be equally important regardless of system is milk from grass and forage and yet we see very low average figures which have fallen over recent years. There is a great deal to do here, starting with the basics. Almost half the grassland in the UK is not corrected for acidity, which means that performance and return from inputs will be low.

Growing grass and forage, utilising it efficiently and turning it into milk is a central plank of dairy farming regardless of system, and failure to do so is hugely costly. We see some farmers growing double the tonnage of maize when compared to others and the difficult question 'should I be growing maize' needs to be asked on many farms? AHDB publish grass growth information on our website and you can sign up to our 'Forage to Knowledge' monthly newsletter.

When it comes to genetics and breeding, a question often asked is 'would the loss of an honest broker in this area matter?' Should we not leave it to the market? Frankly, I think it would matter a great deal, reputational and financial. The robust cow, longevity and welfare are issues that matter to the general public and with genomics AHDB can again make sure that we are covering all the areas not just the immediate commercially advantageous. Genomics opens many doors which dairy farmers will take advantage of, especially disease including bovine TB. Finally, without the 'honest broker'; who safeguards the dairy farmer?

Our published combined data sources shows the national picture on genetics used and this tells us a great deal about the next generation of cattle being bred. Commercial companies were apprehensive about the introduction of the daughter Fertility Index and would have preferred it not to be introduced back in 2005; ironically they were the first to react to the data by selecting better bulls and removing poorer bulls, bringing about improvement.

We have shown that we can improve fertility without sacrificing production traits, in 2008 we predicted that the UK should start seeing a reduction in national somatic cell counts (SCC), based on forward prediction of genetic merit, genetic indexes are delivering. It really is worth the effort and we are proud to be part of this area where we are up there with world leaders in an area where everyone in the dairy industry benefits.

Use of the UK breeding indices within my herds

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I am a partner in a family dairy farming partnership that farms on the edge of the Forest of Dean, Gloucestershire with my brother and our wives. The partnership was started by my brother and I's Grandfather and Father when they purchased the farm in 1952, although my Grandfather had been a farmer in his own right on a smaller farm 10 miles away which he had paid for by working in a factory at night and working on his farm during the day, with the help of my father when he came home after school. We now milk 125 autumn block calved high output Holstein cows through two Lely Astronaut A3 robots installed in 2010. Prior to installing the robots we milked through an 11:22 swing over herringbone parlour installed in 2002. I also manage the dairy unit at Lydney Park Estate for Lord Bledisloe, which now milks 800 Jersey cross cows (expanding to 1,000 cows in 2016) once a day on a low cost grazing based system. This unit has changed radically from the one that I took over, which was a fully housed high output system milking 350 pedigree Holstein three times a day.

The breeding policy for the family partnership never seemed to have any continuity. This in some ways was acceptable when the majority of bulls available were predominantly of Friesian type, but as more extreme Holsteins became available and the black and white breeds became more polarised, it started to become more of an issue. By 1990 we had within a matter of a few years gone from using MMB Sunnylodge Supreme (Holstein) to Crewipool Emperor (British Friesian) to Riverdown Jester (Holstein) to Crocketts Pollux (New Zealand Friesian) and back to another Holstein, Linde Alfred. Each time we change breed and tack it was always for the same reason. The reason being was to breed a more profitable cow. The problem was that we just did not know what the best combination of drivers was for profitability in a cow. We knew it was a combination of type, milk yield, milk quality, fertility and longevity but we just did not know what the best combination was. By the early 1990's we were still struggling with the combination of drivers for the profitable cow but had become more convinced (rightly or wrongly) it lay somewhere in the Holstein breed and became more consistent users of the breed. It was during this period that we started using PIN (Profit index) the forerunner of PLI (Profit lifetime index) to help us make breeding decisions. This we believed was the answer to our breeding conundrum of the correct combination of profitability drivers. (It actually was only the first step in the right direction as several things had been left out of the equation such as conformation and health traits). During this period we used bulls such as Skalsumer Sunny Boy, Jabot, F16 Rocket, Eastland Cash and Etazon Leaf. As this decade progressed and more and more of these high PIN bulls, daughters started to enter the herd, we started to feel that at long last we were starting to move in the correct direction.

In 2001 the herd was unfortunately slaughtered out due to Foot and Mouth (F&M). Obviously this was a particularly bad time to be on the farm, but looking back at it from some distance today, it was a time of good opportunity for the farm and one that we did not miss. During the time without any livestock on the farm we had time to look back at what we had been doing on the farm prior to F&M. Where we were making money and where we were not. Also it gave us the chance to set up the farm in a way that was more family friendly. We needed a farming system that allowed for people to have more time off, and actually take periods away from the farm for holidays. As part of this plan we decided to drop cow numbers back from 155 to 130 but get the same total yield for the herd and calve them all in a late summer (July–mid-October) block. This we realised would be quite a challenge but it was one we were non-negotiable on, because I had a young family that I wanted to spend more time with, my brother had just got married and our father was approaching his 70th birthday.

Just prior to F&M the herd had started to show quite an improvement in yields due to the use of the high PIN genetics. We decided as part of our plan to continue to using high PIN genetics, infact to make sure that we did not fall short of our plan for a more profitable farm with less cows we included in the plan to put together a herd in the top 1% for PLI. So on restocking the farm we made the decision to use PLI (PIN had now change over to PLI) as the sole criteria for the purchase of the entire replacement herd. When we started restocking the farm in the late summer of 2001 there was a large selection of cattle available for purchase, so I was entrusted by my father and brother to source 130 high PLI bulling heifers. The way I did this was slightly radical, in that I did not go and look at the heifers. I would

telephone the vendor and ask them if all bulling heifers were in the top 5% of genetics for PLI (at the time this was above 50 I think). If they said they were and could verify this with the appropriate paperwork, we bought them there and then over the telephone. The 130 bulling heifers were sourced from 6 different farms in England and Wales and a group of 10 were imported from the Netherlands as incalf in May 2002.

We started serving all the heifers to easy calving high PLI Holstein bulls in October 2001 so that we would recommence milking in 2002. This gave us some time to replace the old herringbone parlour and do some other renovation work on the farm buildings that we never seemed to have time to do before.

In November 2002 some 4 months after we had restarted milking, I was approached to take over the management of the dairy unit at Lydney Park Estate. Fortunately with the new simpler system with block calving and not rearing all calves (something we had used to do) it allowed me to take over this unit on a part time basis. At the time this was a fully housed dairy unit of 350 pedigree Holsteins as mentioned earlier. The breeding of this herd had once again been without focus and had mainly been driven by cost of semen and not much else. This I changed once again to be PLI driven but within tight budgetary constraints.

As time went on the owner of the estate Viscount Bledisloe wanted to get a better return for his investment in dairy farming and requested myself and the farms manager Gavin Green to look into ways of making a better return for the dairy unit and the rest of the farm. As part of our research into different options we looked to see what if any advantages our dairy unit had, and being situated in the middle of what could be 335 hectares of grazing, that at the time was mostly in arable rotation, with no roads to cross cows over was by far the most obvious. We therefore went to visit a number of grazing based dairy farms and took some advice from a grazing consultant Mike Bailey in drawing up a detailed budget. After sense checking these budgets with other farms the decision was made in 2007 to change the system from a fully housed dairy unit to a grazing based unit.

It quickly became obvious that the PLI was not quite the correct index to be used for breeding, as the Holstein cows we had were too large and heavy for our heavy clay soils and also lacked the extreme fertility required for a tight spring block calved herd. Being a fan of the PLI index I wondered if there was a version of the index for grazing based systems. The only one available at the time was the BW (Breeding Worth) index used in New Zealand, so we immediately started using this index for our breeding decisions. On a visit to the Moorepark research station in Southern Ireland in 2008 we came across the research that Jersey cross Holsteins were actually the best animal for the grazing dairy system, so from 2008 we started to cross our Holstein cows with Jerseys rather than our original choice of New Zealand Friesian. This was relatively straight forward as the BW index is an across breed index so we could very easily see which bulls would be the best for us to use. We continued to use the BW index until 2011 when I was introduced to the EBI (Economic Breeding Index) from Southern Ireland. This index although very similar to the BW was more appropriate to our system in the UK and where we ourselves at Lydney Park Estate were coming from. Especially the high weighting on fertility, as the Irish had had a problem within their national herd and so had we at Lydney Park Estate plus the values it put on its milk constituents. So in 2011 we started to use the EBI and still use it until today, although this year we will be using it in conjunction with the new SCI (Spring Calving Index) developed by AHDB Dairy. My hope is that over the next few years the few wrinkles that are in the SCI – in that a number of the newer New Zealand and Irish bulls are not listed – so that we at Lydney can make this index that is developed specifically for UK spring block calving herds the only index we use.

Now in 2016 after solely using breeding indexes for breeding decisions at home we have a herd of high yielding Holstein cows that are fertile and easy to manage and only by coincidence as it was never in our plan, the highest PLI herd in the UK. They yield in excess of 10,200 litres of which over 4,700 litres come from forage. Whilst feeding no fancy products such as yeasts, fats or even minerals, (the only minerals are in the concentrate fed in the robots). The herd is block calved from early July until mid-October with an empty rate (cows chosen to breed but failing to get in calf) of between 12% and 15%. Which to a low input spring calving herd would not be a great figure but I believe is more than acceptable for the high yielding system we have. All of these things I believe are hugely important if a dairy farm is to be profitable in these times of volatility.

At Lydney Park Estate we have seen not only the grazing system prove itself but have seen the type of animal we milk rapidly change to the requirements of the low input grazing based system we need in just 3 generations. This being robust, highly fertile cows with a desire to graze in challenging conditions, that produce high percentages of fat and protein in their milk. The conception rates to service have gone from 40% to any service when we first started the grazing system with the Holsteins (31% when they were fully housed) to 59% during the last breeding season and the empty rate has dropped from over 20% to 9% in 2015. Whilst milk yields have dropped considerably over the period (around 10,000 litres when fully housed to just above 4,000 litres) the profitability of the farm has increased dramatically.

So looking back at the decision we made back in 2002 to use breeding indexes as our sole breeding decision maker. I am sure we would not be in the fortunate position we are today with robust, easy care, profitable cows that fit our systems and put us in a strong position for the future years of volatile milk prices, if we had not done so.

Advanced breeding technology advances for cattle farmers

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Introduction

Cattle fertility continues to fall worldwide, and the global human population is rising, accompanied by an ever-increasing need for sustainable protein production. There is therefore a requirement to amplify and exploit existing genetics, and improve cattle production efficiencies.

Background

Embryo transfer was first documented by Walter Heape who, in 1890, introduced two Angora rabbit fertilised ova into a previously mated Belgian hare doe rabbit that carried them to full term along with four of her own offspring (Heape, 1891). The technique was refined and utilised in many species, becoming a commercial breeding tool in cattle by the 1970s; conventional multiple ovulation and embryo transfer technology (MOET) has since then undergone serial improvements (Christie, 2001), such as non surgical recovery and transfer, cryopreservation, sexing, and enhanced regimes for superovulation, and been applied extensively to increase the reproductive rate of cows of high genetic merit.

Since the birth of the first calf after transfer of an embryo produced by in-vitro fertilisation (IVF) was reported (Brackett et al., 1982), advances have been made in the development of relatively simple methods for producing bovine embryos in-vitro as reviewed by Thompson (1996).

The development of a technique known as ovum pick-up (OPU), which facilitated the recovery of pre-ovulatory oocytes from live donors (Pieterse et al., 1988) was largely responsible for the expansion in commercial application of IVF, increasing the number of transfers of IVF embryos carried out worldwide to 41,000 during 2000 (Thibier, 2001).

Since 2000 there has been little change in the number of transfers of in-vivo produced embryos, with numbers having plateaued at around 550,000 per year, while the number of transfers of in-vitro produced embryos has steadily increased to over 630,000 in 2014 (Perry, 2015). This has been largely driven by a steady, steep increase in the number of transfers in South America (especially with *bos indicus* cattle which seem more suited to these techniques) until 2014 when this slowed. While between 2013 and 2014 there has been a sudden 91% increase in the numbers of OPU/IVP embryos in North America, yet there has been little change in the numbers transferred in Europe (Perry, 2015).

Advantages of OPU/IVP

The techniques of Ovum Pickup (OPU) and In-Vitro Embryo Production (IVP) have significant advantages over both traditional breeding programmes or the use of conventional multiple ovulation embryo transfer (MOET);

- The process is non-surgical and requires minimal treatment other than epidural anaesthesia minimising clinical risks and pharmacological interventions
- OPU collections can be performed more frequently, so more oocytes can be collected in a shorter time period
- Oocytes can be collected from both juvenile heifers and pregnant donors during the first trimester, extending the number of potential embryos, which can be produced
- The technique can be used on animals with a range of reproductive disorders which might not otherwise be able to continue breeding
- Less semen is used per fertilisation so multiple donors can be fertilised with a single straw – saving money and utilising limited semen stocks
- A wide range of bulls can be used, due to the frequency of collection, giving greater scope for genetic improvement

IVP to amplify genetic gain

The Food and Agriculture Organization of the United Nations (UN FAO) predicts that by 2050, global demand for animal protein will rise by 85% from the level required in 2008, driven by population growth reaching 9 billion, and increasing affluence in developing countries with a concurrent switch from largely vegetable based diets to meat and dairy products. To achieve this as well as to reduce the impact livestock farming might have on climate

change, greenhouse gas (GHG) emissions and the demand for fresh water, there is a plethora of existing and on-going research. It is imperative that there is a greater amplification and distribution of these outputs. Cattle breeders recognise that it is important to generate as many offspring as possible from genetically superior or important animals, and although the widespread use of artificial insemination has led to very significant improvements in the genetic merit of cattle, there is a need to amplify female genetic lines as well. Efficient OPU/IVP has a role to play in the future.

The potential of IVP

The rate of genetic selection for quantitative traits can be increased by using advanced breeding technologies such as multiple ovulation embryo transfer (MOET) or ovum pickup and in-vitro fertilisation OPU/IVF (Hansen and Block, 2004). This is achieved by improving the accuracy and intensity of selection, in conjunction with reducing the generation interval. Further technological developments are likely to further enhance the technique. With the bovine genome now mapped to over 3 billion base pairs, or 22,000 genes (Larkin, 2011) our current understanding of genotypes will further enhance our ability to select parents to use in IVP programmes, and even of individual embryos prior to transfer.

In most dairy systems, farmers require replacement heifers for their herd of a breeding that they desire, so bull calves are unwanted and wasteful, unless they can be of a cross that will be suitable for fattening. The advances in reliability of sexed semen for conventional artificial insemination (AI) have led to an interest in this being used in IVP systems. Sexing of embryos by biopsy of the 7 day embryo using a micro-blade has been used successfully commercially (Lacaze et al., 2008), usually to select female embryos but is time consuming on farm, and there is wastage of the male embryos. Use of sexed semen means that 98% of all embryos produced are of the desired gender, and hence the number of embryos suitable for transfer is effectively doubled.

With declining pregnancy rates in dairy cattle (Royal et al., 2000, Dobson et al., 2007), any solutions to improve fertility are attractive to farmers, and IVP has been suggested as a means of bypassing, or at least limiting some of the known problems. Although Sartori et al. (2006) found that embryo transfer did not improve overall pregnancy rates compared with artificial insemination in lactating dairy cows there was an apparent benefit of ET when single ovulating follicles were small. Yet (Demetrio et al., 2007) concluded that the transfer of fresh embryos did increase the probability of conception of lactating Holstein cows and suggested it was because ET can bypass the negative effects of increased milk production and low progesterone on the early embryo. This effect was most evident in high-producing cows and is thought to be associated with the increased dry matter intakes associated with higher milk production resulting in lower circulating progesterone, possibly as a result of increased hepatic blood flow and therefore faster metabolic clearance (Vasconcelos et al., 2003). They also demonstrated that high body temperature measured on day 7 had a negative effect on conception rates and embryonic retention. This links to findings of a review paper (Rutledge, 2001) which suggested that a major pathway is in the effects of maternal heat stress on the early cleavage stage embryo. Thus higher pregnancy rates can be obtained with transfer of late cleavage stage embryos.

The IVP technique is also useful in individual infertile cows, where the causes are failure of ovulation or fallopian transport or where the uterine environment will not support a pregnancy (such as low grade endometritis) or in situations of early embryonic death (Hansen, 2006). An essential part of the establishment of pregnancy is the production of interferon τ (IFNT) by the elongating blastocyst. This is the basis behind the technique of implanting 'support' or 'cowstopper' embryos one week after an insemination; part of their effect is to create an additional source of IFNT and therefore improve maternal recognition of pregnancy. IVP embryos can be produced relatively cheaply from abattoir ovaries to act as 'support' embryos – unpublished results (J.S. Mullan, personal communication) suggest that around 70% of calves born assisted by this method are the dam's own, the others either being the implanted 'support' embryo or twins.

Crossbreeding has been widely used in the beef industry for decades and there has been a trend towards more crossbreeding in the dairy herd recently, particularly to avoid dystocia problems with Holstein heifers (Olson et al., 2009). At least 10% heterosis can be expected for total genetic merit, mainly due to increased longevity and improvement of functional traits. There is however some evidence of recombinant loss, and it is critical for long-term crossbreeding that genetic gain within the parental breeds is not reduced (Sorensen et al., 2008). So, IVP is likely to have a place not only in amplifying purebred genetics, but also in creating F1 embryos for crossbreeding programmes.

IVP as a basis for other technologies

Nuclear cloning and transgenesis are possible, but are currently limited largely by societal concerns, which have swung from initial debate about the potential cloning of humans to that of using human embryos to produce stem cells for research (Wadman, 2007) – however these techniques will also benefit from improved IVP technologies, and are likely to become a breeding tool of the future (Campbell et al., 2007).

Intracytoplasmic sperm injection (ICSI) is a technique where a single sperm cell, with acrosome and sperm membrane intact is directly injected into a metaphase II oocyte, and then cultured in-vitro. Although this is a technique now widely used in human assisted reproduction, it yields relatively poor blastocyst numbers

and pregnancy results in livestock. However it may be a technique to be used for genetic salvage, transgenic production, or to improve efficiencies in IVP systems especially when using sexed semen, which is less robust than conventional semen (Garcia-Rosello et al., 2009).

The diagnosis of genetic traits and/or diseases in IVP embryos or preimplantation genetic diagnosis (PGD) has been well established in humans for more than 20. Biopsy of bovine embryos using a laser and micromanipulator to extract between 1 and 10 cells is actively being developed in the UK. Whole genome amplification (WGA) then precedes interrogation with single nucleotide polymorphism arrays (SNP chips). Any 'gaps' in the SNP calls can be 'filled in' by comparison to the genomic DNA of the parents (a technique known as karyomapping). Thus, rather than targeting individual genes for sequence specific detection of traits or diseases, karyomapping uses linkage information to map the inheritance of chromosome specific segments upon which those loci are contained, thus it relies on association with multiple linked markers, rather than identification of causative alleles (Handyside et al., 2010a, Handyside et al., 2010b). Cattle breeders are increasingly making use of SNP chips to assess the genetic merit of animals and these have proven to be more efficient and cheaper than traditional progeny testing, while increasing selection pressure and greatly expediting the introduction of superior genetics into the breeding herd.

Traits targeted using SNP chips include somatic cell count, daughter pregnancy rate, productive life, stillbirth rate and calving difficulty, and this technology has also opened possibilities for increased power to select for lower heritability traits. The advantage of SNP chip use is its multiplicity – it is potentially applicable for any trait; the major disadvantage is the cost (monetary and environmental) of taking pregnancies to term before testing of offspring and subsequent introduction to the breeding programme.

While against a background of increasing dairy cattle disease incidence (NAHMS 2007), Immunity+™ has been developed by Semex. Currently this involves testing sires for two different types of immune response; cell-mediated and antibody-mediated, with those top 10% of responders being designated as Immunity+™ and with a predicted heritability of these traits being 30%. Studies by Thompson-Crispi (2014) have now identified genomic markers associated with these immune responses, and Chromosome 23 has been identified as carrying the genes for the Bovine Histocompatability Complex (BoLA) which is closely associated with regulating immunity in cattle. Most recently it has also been shown that resistance to bovine Tb has a genetic component, and these developments will in the future allow genomic selection for these very beneficial traits.

By genomically interrogating the embryo itself, there will be a reduction in the production and rearing of unwanted offspring, which in turn reduces ethical concerns and decreases the carbon footprint of cattle production. Conversely an artificial insemination (AI) stud bull is worth many thousands of pounds and young candidate sires can be marketed from 2 years old if the SNP chip indicates them to be of sufficient genetic merit. Commercial farmers will more readily be able to select genetics that suit their farm or ambitions, such as disease resistance or health traits.

IVP as an experimental tool

If parameters from within an IVP program such as oocyte collection rates, fertilisation rates, cleavage rates or blastocyst rates, could be correlated with subsequent pregnancy, then in the future these markers of fertility would facilitate smaller and faster studies being undertaken. It is also anticipated that specific genes in the cumulus cells may be markers of oocyte quality and this would give an even quicker assessment of intervention effects. If crossover trials of small groups of animals were to be possible, this would greatly enhance the statistical power of intervention studies.

Conclusion

OPU and IVP are ever more widely used in other parts of the world, and are now available in the UK and Europe. The embryo genomic techniques are at an early stage of development with initial markets being elite breeders, but these are certain to become mainstream breeding tools for all cattle in the future.

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Combining genomics with social media to provide a marketing choice

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Introduction

At the age of 34, my passion for cows and dairy farming is as strong now as it was when I was a young boy. In 2010, it was this passion that drove the relocation of our dairy business and the Cherwell herd of pedigree Holsteins from Oxford to Longmoor Farm in Dorset, a move which allowed us to reassess our business and future goals.

As many of you will know, moving a dairy farm is no mean feat! The move was an internal transfer within The Duchy of Cornwall Estate and we now farm 380 acres, 230 acres of which is ring-fenced. We are currently milking 250 pedigree Holsteins averaging 10,014 litres, calving all year round. The move to Longmoor Farm allowed us to increase cow numbers, and the facilities that we have subsequently developed have resulted in better cow and youngstock facilities compared to the Oxfordshire unit. This is reflected in the improved performance data of our cows since 2010, including increases in milk yield, fertility and youngstock health. Current performance data for the Longmoor herd is summarised in Table 1.

At Longmoor Farm, I farm in partnership with my father and mother. My wife, Helen, is a farm animal vet at Friars Moor Veterinary Clinic Ltd. She is a key member of the team, helping to keep us at the forefront of animal health and welfare. Consultancy is provided by Christine Pedersen and Tim McKendrick of The Dairy Group and both were influential in ensuring that the move to Longmoor Farm was a success.

Marketing and Social Media

Having moved, the decision was made to register all calves born at Longmoor Farm with a new prefix, Longmoor. The main reason for this change was to highlight our new start; whilst Longmoor Farm was a familiar name to many, Longmoor Holsteins was completely new. However, moving to the South West meant that we were no longer a well-known local Holstein breeder. This was something that I was very conscious about, wanting our cows and herd to become recognised within the industry. The desire to establish ourselves both locally and further afield resulted in us creating the Longmoor brand, setting up the website and embracing social media.

When I started engaging on social media, I had no idea how useful it would be, allowing us to reach a worldwide audience. It brings together like minded individuals and allows sharing of knowledge quickly and efficiently. Those with shared goals can form groups on Twitter and Facebook, allowing observation of farms, analysis of breeding goals and critiquing of breeding choices. For example, the group Polled Partners, which was set up a year ago, consists of dairy farmers who all use polled genetics in their herds or supply polled semen. It allows the instant dissemination of information and discussion amongst a relatively small number of members (60) who are invited to join the group if they share the breeding goal of introducing polled genetics into their herd.

Traditionally, promotion of your herd would have occurred in the show ring, but on social media, marketing of your herd can be carried out on a daily basis. It allows cows to be photographed in their 'working clothes', giving an insight into their performance in the herd situation. It has proved to be an extremely powerful tool for us in promoting our new herd, leading to heifer sales and farm visits.

Table 1.

Milk sold/cow (litres)	10,014
Butterfat (%)	4.04
Milk protein (%)	3.16
Milk from forage (litres)	2,815
SCC	93
Daily growth rate for pre-weaned calves (kg/day)	0.86
Average age at first calving (months)	23.5
Overall pregnancy rate (% rolling 12 months)	49
Services/conception (rolling 12 months)	2.3

Farming is an isolated profession and social media provides links with like-minded individuals. You can never underestimate the power of social media and its ability to promote knowledge sharing, spread awareness and provide support. Equally, you have to be aware that everything that you post is in the public domain and is open to scrutiny. By engaging in social media use, you are not only promoting your individual business but are representing the dairy industry.

Genomic Breeding

My father was one of the early adopters of Holstein genetics and has been an incredible guide and mentor in my development as a cow breeder and manager. Having closely followed its introduction to the UK, I chose to embrace genomic breeding relatively early in 2010 to increase the accuracy of breeding decisions. Whilst we were initially cautious, the first heifers that were bred genomically outperformed their conventionally-bred counterparts in both type and production. This gave us the confidence to use genomic semen more extensively and in the past three and a half years we have not bought a proven bull.

I believe that our early adoption of genomic semen makes us an innovator within the UK. I am incredibly confident in the genomic bulls being offered; today's genomic bulls are tomorrow's proven bulls.

Genomic Testing and Breeding Goals

Fitness and health traits have always been my key breeding goals. We are not looking to breed an extreme cow at Longmoor Farm, but a healthy and productive one. Every space in our cubicle shed counts, so filling each cubicle with a productive and profitable cow is key. There are huge hidden costs to retaining heifers that are underperforming herd members and genomic testing provides us with an early means of identifying weaker herd replacements.

Selective genomic testing of heifer calves started at Longmoor in July 2012. Results from genomic testing has reinforced assumptions formed from traditional classification and performance scoring of heifers. More importantly it has also identified high scoring heifer replacements from families that would otherwise have been overlooked.

The test results provide you with extensive information about the genetic potential of a heifer/cow allowing you to make increasingly informed breeding decisions. Ideally, all heifer replacements should be tested. It is easy to form emotional attachments to cow families and convince yourself that a heifer replacement will perform as well or better than her family history. Genomic testing may confirm this attachment or can provide uncomfortable reading! However, the use of genomics increases the rate of genetic improvement and increases herd efficiency by identifying the weaker bloodlines.

Introducing polled genetics to the Longmoor Herd

Recently, my interest in genomic bulls has focused particularly on the incorporation of polled genetics into the Longmoor Herd. Personally, I find that there are not enough hours in a normal day, so the use of polled semen allows us to dedicate the time that would otherwise be spent dehorning to more important tasks. There is also increased pressure from the consumer to eliminate the dehorning process. Don't forget, by opening up our farms on social media all aspects of the farming process are under scrutiny.

Whilst polled bulls have traditionally been viewed as underperformers relative to their horned counterparts, genomics has driven a vast improvement in polled genetics and the selection of bulls available is increasing rapidly.

The polled gene is dominant, allowing genetic gains to be achieved quickly, however, only 1% of the international dairy herd is polled. This is where social media is a vital tool in both promoting its benefits and allow engagement between breeders around the world. Our first polled heifers are entering the herd now and our aim is for every cow to breed a calf with a 50% minimum chance of being polled. At Longmoor Farm, the use of genomic testing to incorporate polled genetics is an opportunity to increase the marketable value of our herd.

Summary

It is a huge privilege to be in a position to breed cows. My focus has always been to improve the health and fitness traits of both the Longmoor Herd and the individual cow. Genomic testing allows me to make more informed breeding decisions to promote rapid genetic gain and improve the productivity of the herd.

Genomics has been hugely influential in improving the availability of polled Holstein bulls, which has allowed us to develop a niche market in the Longmoor Herd alongside improving the quality of the heifers produced. Across the industry it is important that we embrace marketing to advertise such developments to fellow breeders and demonstrate dairy farming's commitment to breeding healthy cattle and rearing them under the highest welfare conditions. With the development of social media, farmers have unprecedented access to the consumer, and the power to reach out and demonstrate that the industry is developing and addressing their concerns.

Social media has provided the Longmoor Herd with the platform to market itself to a worldwide audience. Establishing a brand identity and engaging with new audiences via Twitter and Facebook has been an extremely positive step in developing the future potential of our herd.

The Longmoor prefix is now widely recognised as a herd embracing and sharing the use of genomics to improve the genetic fitness of our dairy cattle.

The role of the digital cushion in dairy cattle lameness

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Introduction

Lameness is a common affliction of dairy cows that causes pain, decreases production and increases likelihood of culling. Many diseases cause lameness, and can be grouped as either infectious (e.g. digital dermatitis) or the non-infectious: the claw horn lesions (most commonly, sole ulcer, sole haemorrhage and white line disease). However, the mechanisms by which the claw horn lesions occur are incompletely understood. Recent and ongoing work at the University of Nottingham, School of Veterinary Medicine and Science, explores the disease process, to help understand why the claw horn lesions occur and what can be done to prevent them. Described here are two studies that summarise our understanding of the claw horn lesions.

The claw horn lesions almost certainly occur through a similar mechanism. This mechanism appears to be through compression of and contusion within the germinal epithelium in the sole of the foot that produces the claw horn. Contusions occur to differing extents and at different locations, which appears to cause the differences between lesion location (e.g. sole versus white line) and severity (e.g. haemorrhage vs ulceration). Two factors are pivotal in the formation of these lesions: greater downward forces exerted by the pedal bone and poorer cushioning of these forces; both result in greater forces exerted on the germinal epithelium and increased likelihood of damage. Many factors such as claw overgrowth, lying times and social competition, underfoot conditions and physiological changes around parturition can increase or prolong the downwards forces exerted through the pedal bone (Newsome et al., 2016, open access). In addition to these, the capacity of the digital cushion in dissipating the forces during foot strike is instrumental to protecting the germinal epithelium of the sole from compression and disruption of growth.

Study 1: The digital cushion

The digital cushion is a connective tissue structure that sits beneath the pedal bone of the foot, and contains large depots of adipose tissue. The fat is high in mono-unsaturated fatty acids and is bound by a connective tissue capsule. It acts as a non-compressible fluid structure that *dissipates* forces during foot strike, transferring the forces to the structures that are designed to absorb shock and bear weight: the wall. This reduces the peak load on the germinal epithelium at any point and protects against claw horn lesion formation.

Epidemiological work has demonstrated that body condition loss preceded lameness events, whether lameness was defined by poor mobility (Randall et al., 2015, Lim et al., 2015) or by the treatment of lesions (Green et al., 2014). Cross-sectional work has also shown that body condition score was associated with digital cushion thickness (Bicalho et al., 2009). The hypothesised reason for body condition loss predisposing lameness is that thinning of the digital cushion leads to poorer cushioning capacity and greater forces on the germinal epithelium of the sole. A thin digital cushion has been shown to increase risk of lesions and lameness (Machado et al., 2011, Toholj et al., 2013), but no work has yet repeatedly measured the digital cushion to assess whether change in thickness occurs with body condition loss, or whether thinning of the digital cushion, rather than absolute thinness, leads to lameness.

The first aim of this study was to determine how the digital cushion changes throughout lactation and with changes in body fat measures. The second aim was to discern whether absolute or changes in digital cushion thickness influence future lameness and lesions.

Study 1: Materials and methods

A longitudinal study monitored 180 cows on 2 high yielding robotic dairy herds (>11,500 litres per 305 day lactation) throughout 1st, 2nd, 3rd and 4th lactations at 5 assessment points: approximately 8 weeks prior to calving and during the 1st, 9th, 17th and 29th week of lactation. The digital cushion and corium were measured using ultrasonography at each assessment point. Additionally, body condition score and back fat thickness (measured ultrasonographically) were recorded. Lesions present on claws were recorded at assessment points, and cows were mobility scored fortnightly throughout the study.

Three statistical models were built to assess:

1. The association between digital cushion thickness and body fat.
2. The effect of a thin digital cushion and low body condition on future lesion formation.
3. The effect of a thin digital cushion and low body condition on future lameness.

Study 1: Results

Firstly, digital cushion thickness was associated with body fat measures. However, this association was obscured at some assessment points by lesion occurrence: the digital cushion was abnormally thickened when a sole ulcer was present, pointing to inflammation in and thickening of the digital cushion. Secondly, the digital cushion was thinnest immediately after calving, before cows had lost condition. Thirdly, the thin digital cushion thickness at *any point* during the study increased the risk of subsequent lesions and lameness. Only *sometimes* was the thin digital cushion related to body condition.

Study 1: Discussion

The results present a novel insight into the role of the digital cushion in lameness. They add to the evidence that body condition loss is a key component of claw horn lesions, and additionally highlight that body condition is only one of many factors that must be addressed in lameness control: many factors could cause a thin digital cushion, such as peri-parturient hormones causing laxity in the suspensory apparatus of the foot (as seen immediately after calving, and all of these have potential implications on lameness.

The work also demonstrates the inflammation present during lesion formation. This strengthens the message that lameness is a manageable disease, that early detection and effective treatment are instrumental in controlling it and that non-steroidal anti-inflammatories are an essential component of treatment (Thomas et al., 2015).

Study 2: Bone development on the pedal bone with repeated lameness (published open access: Newsome et al., 2016, in press)

Study 2: Introduction

A second study looked at chronicity of the claw horn lesions. It has been shown that delayed treatment increases recovery time, occurrence of lesions increases risk of further lesions in subsequent lactations (Hirst et al., 2002) and that the lesions can become chronic, whilst early detection and effective treatment reduces recurrence of lameness (Groenevelt et al., 2014). Untreated lesions could incur damage to the internal anatomy of the foot, including to the flexor tuberosity of the pedal bone, upon which bone development occurs with age (Tsuka et al., 2012). Similar bone development occurs in humans where high load passes around ligament insertions, often as incidental findings with no clinical significance (Benjamin et al., 2000). Our aim was to assess whether bone development at slaughter was associated with poor locomotion and CHL incidence during a cow's life.

Study 2: Materials and methods

A retrospective cohort study imaged 142 hind feet from 72 Holstein-Friesian dairy cows culled from a research herd (SRUC Dairy Research Centre, Dumfries, UK) using computed tomography. Bone development on the pedal bone was measured and tested as the outcome in a linear regression model. Explanatory variables described mobility score, which had been assessed weekly throughout life from first calving, age and occurrence of lesions throughout life.

Study 2: Results

Bone development increased with age, was greater in cows that had experienced a claw horn lesion during life, and was greater with poorer mobility (the mobility score variable tested was 'the proportion of weekly mobility scores at which a cow was lame, during the 12 months preceding slaughter'). The bone development on the *most severely* affected foot was best predicted by lameness history.

Study 2: Discussion

Age explained much variation in bone development. The association between bone development and a previous history of lameness was a novel finding, and bone development appeared to be specific to claw horn lesions.

Several mechanisms for the formation of bone development are plausible. Inflammation occurring at the sole ulcer site during sole ulcers (as seen in Study 1) could elicit bone development on the flexor tuberosity, which then exerts greater forces on and cause further contusions within the germinal epithelium of the sole during foot-strike. Inflammation could also utilise fat depots within the digital cushion for the production of inflammatory mediators and decrease its future cushioning capacity. Both of these mechanisms could precipitate further lameness and could become self-perpetuating. In order to stop irreparable anatomical damage within the foot, early identification of claw horn lesions and effective treatment could be critical, particularly for first lifetime cases of lameness.This further emphasizes the importance of non-steroidal anti-inflammatories in lesion treatment, to resolve inflammation at the sole ulcer site and prevent permanent damage to the surrounding structures.

Conclusions

The claw horn lesions are principally a result of two factors: downward forces on the germinal epithelium of the sole through the pedal bone, and cushioning of forces during foot strike. Many factors, including body condition, can influence the function of the digital cushion. If the digital cushion becomes too thin, lesions and lameness occur. Further, inflammation at the sole ulcer site likely initiates bone development on the pedal bone, which then places greater forces on the germinal epithelium and causes lameness to perpetuate. These studies suggest that managing the risk factors for

lameness, in addition to early detection and effective treatment of lameness, which *includes* non-steroidal anti-inflammatory therapy, are pivotal to lameness control on farm.

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Preparing the next generation of farmers and dairy herd staff

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Bridgwater College started life in 1921 as the Somerset Farm Institute, like many agricultural colleges it was formed following the First World War with the intention of increasing the self sufficiency of food produced in the UK. With Somerset being a strong agricultural county it grew and became nationally renowned particularly for dairying, cheese production and commercial horticulture.

Later it became Cannington College of Agriculture and prospered particularly in the 1950's, 1960's and 1970's. However with a downturn in agriculture and a lack of vision and investment student numbers began to dwindle in the 1980's and 1990's leaving the governors with some difficult choices. By 2004 agricultural student numbers had fallen to 27. The farm was in a poor state of repair and the herd of dairy cows was not one to be proud of.

Like many organisations faced with difficult choices it sought out a larger more financially stable partner, and was fortunate to find one, in the nearby further education college in Bridgwater. Fortunately the senior team could see the strategic advantage of being in agriculture and land-based studies and began to make investments in the farm along with the overall College Estate.

In the past 10 years over £5 million has been invested in the facilities at the college farm which includes a new milking parlour and cow housing, slurry storage, forage clamps, and more recently the innovation centre and bio security building.

This investment linked to the vision, that if we are to have an industry which is able to meet the challenges of the future we need suitably trained and motivated people to rise to the challenge.

Currently the majority of staff employed on dairy farms comprise the sons and daughters of the owners, farm workers who are over 50 years of age, and Eastern Europeans. More and more farming families children are looking outside agriculture for employment as they have seen their parents doing hard physical work all their lives, in many cases for little reward.

According to Landex, land based and environmental industries will require 148,000 more people by 2020, and 447,000 to replace those leaving the sector through retirement.

So how do we attract, educate and retain for the long term, high calibre staff to work in the dairy and livestock sector here in the UK?

Today around 1% of the British work force work directly on farms. Approximately 480,000 people. However if we take the wider food and farming industry is with its allied trades, this accounts for approximately 3.5 million people or 13% of the British workforce. Collectively we produce 63% of the food that is consumed here in Britain, which means we could increase output overall just to supply the home market, without the need to find export markets.

To continually improve skills is a priority for enhancing productivity and performance within the rural sector particularly within Agriculture. However employers in rural areas can face particular constraints in accessing the pool of skills they require due to the remote nature of the business. Businesses in rural areas are more likely than businesses in urban areas to have to outsource work, as a result of skills shortages.

Students from rural areas are more likely to meet expected standards whilst at college, with a higher proportion achieving merit and distinction. The proportion of people working in Agriculture with qualifications at or above degree level, apprenticeships at Level 3 and 4 or equivalent is continuing to grow and there is a direct relationship to productivity and efficiency.

The government is very focused regarding the implementation of a wide-ranging programme of opportunities to improve the skills base and curriculum opportunities to strengthen the quality of the work force in land based careers with particular reference to post-16 skills provision and improving opportunities for young people to progress within the sector through a range of potential career choices.

Several actions are being taken that will improve access to high quality education and training in Agriculture:

- Colleges will respond to the needs of employers, including both large and medium employers.
- To promote skills provision that is responsive to the land based

industry priorities, colleges will invite employers and partners to participate in the reshaping and ongoing review of local post-16 skills provision.

- Both College based and employment based training form part of successful skills systems that have been adopted across the world. They can offer young people in particular high quality, targeted training that allows them to earn while they learn.
- The government is committed to increasing the quantity and quality of agricultural education/ apprenticeships in England. It is introducing a UK-wide levy on larger employers to help fund the increase in apprenticeships training. The government's measures will strengthen apprenticeships in rural areas:
- The government will increase apprenticeships in rural areas including by tripling apprenticeships in food and farming and by helping small tourism businesses to provide more, high quality apprenticeships.
- From April 2016, employers will not have to pay National Insurance contributions for most apprentices under the age of 25.
- Funding reforms, such as the digital apprenticeship voucher, will put control of funding for apprenticeships directly into the hands of employers.

Strong conditions for rural business growth

Enterprise and competition are vital for productivity growth. They drive innovation and efficiency and help ensure that resources flow to their most productive uses. Rural areas are full of enterprise. There are 430 registered businesses per 10,000 of population in predominantly rural areas compared with 400 businesses per 10,000 of population for England as a whole. But businesses need the right conditions to become established with the main ingredient being suitably trained and motivated staff.

Work experience

Students gain invaluable work experience whilst studying at college as it increases their chances of getting part time work and more importantly a job after they have completed their college courses. Not only do they have the opportunity to complete a placement day as part of their course, they also find relevant work in the holidays. This involves working on farms taking part in as many activities as possible and where possible shadowing the farm manager to develop an understanding of farm management. There is also the option of voluntary projects that involve agricultural and environmental work that students can be involved in. Other options that some students get involved in include volunteering abroad on agriculture projects in farms, forests and nature reserves.

The major employment opportunities within agriculture are not just in farm management. Other opportunities exist with commercial ancillary companies both in the UK and abroad. Find information on employers in environment and agriculture, engineering and manufacturing, and other job sectors.

Skills for a CV

Throughout agriculture courses students develop a wide mix of technical skills and knowledge, including land use, farming practice and food production, as well as an understanding of the scientific, ethical and business principles that underpin the agricultural industry.

Students confirm that employers are particularly interested in transferable skills such as:

- numeracy and IT
- initiative
- organisation
- ability to plan and conduct research
- communication, including influencing and leadership
- teamwork
- ability to manage projects

An increasing number of students go onto study at HE level and some progress onto a Masters or other postgraduate qualification in a related area such as crop science and management, animal technology and agricultural technology. Others may go on to a different undergraduate degree course such as veterinary science, there are many different ways to gain a qualification in agriculture.

Generation Y & Z

Has agriculture done enough to understand what generation Y (those born 1977–1994) and even generation Z (born 1995–2012) want in the workplace? During those periods the world has moved from the industrial age to the information age. The expectation of businesses will have to change and recognise that workers are maybe equally as important as customers.

The needs and wants of future generations will be greater than those of past generations. The need to understand what generations Y and Z wants is essential in adapting on farm practices and procedures. It means changing from a protocol culture to a collaborative culture.

For an in-depth study on how to attract and keep staff motivated, do read Andrew Brewers Nuffield farming report, titled 'Who will milk the cows?' which is available free of charge on the Nuffield International website.

http://www.nuffieldinternational.org/rep_pdf/1441530372Andrew-Brewer-report-2013.pdf

If you know a young person considering career choices you could always direct them to the Brightcrop website.

http://www.brightcrop.org.uk

An excellent resource which gives information and may help a young person explore the opportunities within agriculture and acts as a signpost of where to go next.

A European view on the future dairy farmer: will there still be room for emotion?

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Introduction

With a rapidly growing world population, it is estimated that protein production will have to double by 2050 with half of the available resources. Furthermore, it is predicted that rising wealth shall increase the demand for high quality food with optimal nutritional value. Meanwhile, consumers are becoming more involved in food production, and the demand for high quality food is predicted to rise parallel to increasing wealth. It is clear that dairy farmers worldwide are facing a challenge.

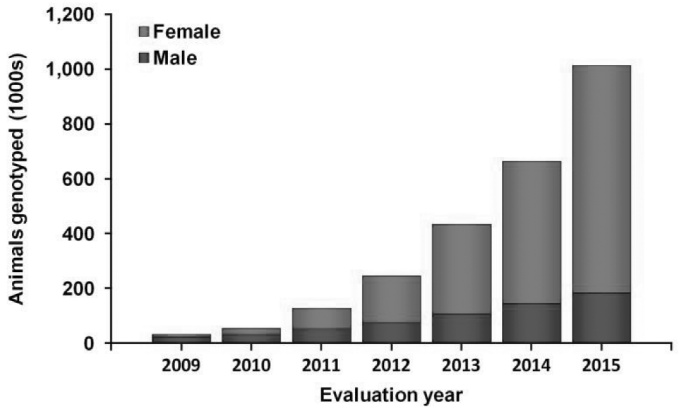
Dutch farmers are already facing the need to farm with optimal efficiency to stay profitable. While continuously striving for continuity as margins on dairy are under threat, current European market developments and new Dutch environmental regulations are squeezing the Dutch dairy farmers into a corner. The number of dairy farms is decreasing but the number of cows in The Netherlands is still growing. 2015 was a particularly challenging year. When the milk quota was removed in April, consequently, herds started to expand. What quickly followed however, were new regulations on phosphate emissions imposed to prevent The Netherlands from exceeding thresholds set in Brussels. Consequently, Dutch dairy farmers now need to justify their phosphate emission by their so-called allocated 'phosphate rights' which in many cases are based on a pre-growth herd size. The seemingly contradictory changes follow up on restrictions on the use of antibiotics that were introduced in 2014. The constant adaptation that is asked of the Dutch dairy farmers is resulting in a sense of insecurity about what is yet to come.

Meanwhile, as technology is rapidly developing, companies are continuously offering new products to dairy farmers as a means to help farm at top efficiency. New terms such as 'smart dairy farming' or 'precision livestock farming' have popped up with increasing frequency in Dutch dairy farming jargon. The trend towards adopting new technology in aid of optimal farming in The Netherlands is well visible in the increased use of the milking robot. Currently, it is estimated that approximately 15% of Dutch dairy farmers are actively milking with one or multiple robots. CRV year statistics for 2015 show that of the top producing 16 dairy farms in The Netherlands this year, 7 are currently automating milk production. The surge of technological development is however producing products that are very novel which often require a considerable investment before showing returns. Although welcomed by a good proportion of Dutch farmers, the lengthy period of acclimation and the sometimes prerequisite change of management that often comes with the new way of farming ensures considerable hesitation as well. When relying on machines that yield large amounts of data and statistics, is there still emotion left in farming?

Genomic Herd Management

When following the trend to higher adoption of technology for more efficient management in the field of cattle breeding, one cannot miss the rise in genomic testing. The active and routine genotyping of heifer calves, have picked up rapidly in the recent 5 years, particularly in The United States of America and France. While the adoption of genomic selection has suffered a lengthy period of skepticism, milking daughters of young genomic bulls are slowly replacing the skepticism with trust. Genomic testing uses genomic selection technology to estimate genomic breeding values for female animals in the exact same manner as it does for bulls. As such, farmers receive information about the genetic merit of their young animals with twice the reliability compared to parent average. This allows for strategic young stock selection and reduces the risk of raising costly cattle which do not contribute to herd profitability when milking. Alongside the genomic breeding values, genomic tests also yield information on any genetic defect or genetic characteristics of the animal. Avoiding carrier matings, for

Figure 1: Number of male and female genotypes entering US national evaluation per year.



example the recently discovered CDH mutation, or carrier matings towards a polled or A2 herd can thereby be made.

Figure 1 shows the exponential growth of the number of low density female genotypes entering the US national breeding value estimation (Cole, 2015). In France, approximately 8% of the dairy farms have actively genotyped in 2014 (Le Mezec et al., 2015). The Netherlands currently counts just over 300 herds which have genotyped their whole herd and use the genomic information for the strategic breeding of their herd, towards individual breeding goals. Data collected on these 300 farms have shown that approximately 10–13% of calves get wrongly assigned to either the complete bottom or top of the list when ranked on their parent average breeding value for milk yield, compared to their ranking based on their estimated genomic breeding value for the same trait. Consequently, selecting the top 75% of animals for breeding the next generation based on genomic merit resulted in an average breeding value for milk in this group of +100kg milk compared to a group selected on parent average (Eaglen et al., 2015). The current value of genomic testing is expected to increase in the next decade, as is the adoption of routine genotyping. CRV expects 50% of Dutch farmers to genotype every newborn animal by 2020. In addition, given the large amount of research on the link between genotype and phenotype currently conducted globally, it is almost impossible not to anticipate that in 10 years' time, much more information on the future performance of an animal shall be extracted from the DNA profile in support of herd management.

Sensor Technology

Alongside genomic technology, a trend towards the use of sensor technology is also visible in The Netherlands. Pedometers that offer aid in heat detection are most commonly used, but farmers also have access to sensors that allows for precise measuring of physical activity, rumination activity, feed intake, temperature and blood concentrations.

Next developing sensors give farmers information on the remote measuring of body condition of an animal through imaging technologies as well as the precise location of an animal in the barn for quick retrieval. Nutrition apps allow precision feeding by listing exact measurements of ingredients for optimal feed mixtures, validated by sensors taking samples of the generated feed. Routine sampling of milk has also been used to great success. Milk sampling results now not only provide fat and protein content but can also partition these in the exact fatty acid and whey vs. casein composition as well indicate an early detection of pregnancy.

A future vision: The Internet of Things and The Connected Cow

Continuous investment into R&D projects ensure that the above listed applications are just the beginning. The International Data Corporation (IDC, www.idc.com) expects that by the end of 2020, 212 billion devices will be globally connected to the internet. This represents 40 times more devices than people. The linkage of devices, and data collected by these devices, via the Internet is referred to as 'The Internet of Things'. Agriculture is expected to not be an exception. When all sensors, apps and genomic information are eventually linked through their connection to WiFi, this will likely lead the dairy industry's version of 'The Internet of Things', or more appropriately: 'The Connected Cow'. A first cooperative project that makes footsteps towards this connection of several novel applications for support in dairy farming is Smart Dairy Farming (www.smartdairyfarming.nl) of which Lely, AgriFirm, CRV, Wageningen University, Utrecht University and Friesland Campina are among the collaborating partners.

Back to the farmer

For the farmer, industry expects that subsequent large amounts of created data, statistics and accompanied advice allows high return on investment, when abided by. Optimal monitoring of all herd management aspects as well as planning out specific breeding strategies to increase the herd's genetic level facilitates management at the required efficiency. However, fully trusting generated data and resulting statistics, without the instinctive need to actually observe the animals as an additional factor in the decision making is not a trivial matter. Assuming the current market circumstances and the future world perspectives for the dairy industry shall remain to allow little space for flexibility in herd management. Dairy farmers are passionate and a large portion of emotion separates a farmer from a general businessman. Hesitation and skepticism to the rapid changes in the industry are therefore

largely present. Will there still be room for future dairy farmers to carry out their profession with the same amount of emotion as their predecessor? Current anecdotal evidence in The Netherlands suggests that despite present reluctance, adoption of varying degrees of technological aids has also unburdened the Dutch dairy farmer, allowing more time with family. Dairy farmers of the future, often having enjoyed higher education, shall likely not experience a reduced passion in dairying but rather a transformed one. Willing to be businessmen and women, they shall likely maintain their passion to make optimal use of all available opportunities for the successful continuation of his or her business. They will be ready for the challenge that faces food producers worldwide, in the decades to come.

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Keeping on track and staying there

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I would like to thank the British Cattle Breeders Club for asking me to give you a presentation.

Metcalfe farms is a partnership consisting of retired parents John and Thora with three sons, David, Brian and Philip, we farm 2,700 acres in the heart of Wensleydale.

Alongside a haulage and contracting businesses we have 900 pedigree Holsteins expanding to 1,300 later on this year depending on milk price.

A 200KW anaerobic digester is on site and we have 900 mules ewes crossed with Texel for fat lambs.

Today I am going to explain how technology is helping us achieve a good performance from the dairy herd, but I do think we can improve further with one or two changes in the pipeline which I will mention later.

A few KPI'S, 10,800 litre milk average, 3.85 Butterfat, 3.25 Protein, 180 Cell Count.

One third of the herd is classified very good or excellent.

The milking parlour is a good place to start, it's a 32:32 Fast Exit that has been used for over 20 years and will soon be replaced by a 72 point rotary. The Fast Exit stall work was regarded as state of the art when we installed it, through puts of 130 cows per hour were being achieved with one person milking without much prep being carried out, this has slowed down now we do full prep. Large swingover parlours probably are as fast, this parlour is very compact though with cows standing square onto pit.

Fifteen years ago the cows were fitted with activity monitors (pedometers) and these helped us a lot catching cows bulling that we had missed, one negative is that it's difficult to tell when is the best time to serve the cow because data is only captured at milking time. We have had a collar system on our maiden heifers which is updated every fifteen minutes, this has worked very well for timing of insemination, and similar collars will be fitted to cows when we start in the new parlour.

Ten years ago we fitted Automatic back flush and teat dipping, after some teething problems this system has proved to be a good investment reducing mastitis and chronic high cell count cows, I would recommend it to anyone, but it must be watched carefully for faults.

Back flush will be fitted to the new rotary but we are either going to manually dip the cows or auto spray, as the parlour is much bigger we feel going back to basics with post dip might be the best option. One of the big selling points of the large rotary is the faster through put, hopefully 400 cows per hour, this will cut cow standing time by up to two hours making a massive difference on eating and resting time for the cows which should help foot health, fertility and hopefully improve yield.

In the future robotics could be fitted to the new parlour but I think it's too early and expensive at the moment to invest in this technology.

On the feeding side we have run a large Keenan for many years, the Pace weigh system is an excellent way to input rations and record what is actually being fed to the cows. We have also invested in a straw grinder to get straw to a consistent length to avoid cows sorting feed which I'm sure you agree they are experts at.

We are looking at a self-propelled feeder wagon because we think it will save time and we will get a more consistent dry matter forage by direct cutting from the face instead of cut out blocks getting rained on.

Automatic scrapers were fitted in the nineties which saved time, but we have learned they are not very good for cow's feet so as they have come to the end of their lives we have gone back to basics and scrape out with a loader three times a day.

We have been using RMS or Green bedding for two years now, we find it a great bedding material with no hock abrasions and very clean cows. The Defra recommendations are sensible and should be followed. This system is saving us 50k in bedding costs.

The Anaerobic Digester has been a success, we didn't fund it, but for providing the site, feed stock(slurry) and running it we are saving about £150 a day in electricity and £40,000 a year in nitrogen through the improved digestate. Also it's offsetting much of the carbon dioxide produced by the cows, but this system only works with having cows housed all the time which won't be for everyone.

With hoof care we have had an automatic footbath for a number of years now which makes it easier to do with water and chemical being piped to it, when we get the new parlour working, a longer 3.5 metre bath has been bought so feet get more dips as the cows go through.

A lameness monitor called Step metrix was evaluated a year ago and

will be fitted on the new parlour, this works by weighing the cow left or right and flagging up any subtle changes, we liked the system and found just a bit of corrective modelling was good enough to cure the slightly lame cow.

With mastitis probably the best thing we have seen results from is using a teat sealant at dry off, since we started ten years ago fewer cows have been getting infection in the dry period, for six months we have tried selective therapy only giving antibiotic tubes to cows over 180 to 200 cells, this again is working well with no increase of infection in the dry period and a big drop in antibiotic usage and money saved.

In the near future when we have more time between milking's we are going to do farm culturing of mastitis cases to see if we can target the case with the correct treatment or even letting the case self-cure again saving antibiotic usage and money.

We have used computerised calf machines for a lot of years now finding them working well, as the herd has grown we have bought extra second hand machines for a quarter of the new price. We have learned that the best results come from keeping calves in individual pens for ten days before introducing to the machine. Also the machine needs to be kept clean with teats and pipes changed after each batch.

With breeding we are using sexed semen on most of the maiden heifers, a beef sire and embryos going onto what I think is the bottom end, all this could change because I think we will end up genomic testing all heifer calves and that will tell us which heifers are the best or worst.

About eighty percent of the semen used is from genomic sires, I believe in this technology because two heifers that we had sampled that have calved are nearly exactly the same as their profile. Some breeding advisors will tell you to use a lot of different sires to spread this risk, this is rubbish because you will lose the uniformity of your herd.

To conclude, if you're thinking of investing in technology ask yourself could the same task be done in a more simple way by organising you or your staff better?

Who will keep an eye on it to see when it breaks down?

What will it be like in a few years' time, will it last?

Learn from other farmers, they are the best consultants!

Leaning on a gate contemplating cattle

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Cattle Early

As a baby, I could peer out of my pram and see cows in the field adjoining our garden. Was it brain-washing?! If so, I'm most grateful! I relish contemplating cattle (Figure 1).

Figure 1: A Cow hiding behind a tree contemplating humans (Uganda)

As a toddler, as soon as I could stand up, I was to be found leaning on a small gate that ran from our Derbyshire garden into the adjoining field full of cows. I spent hours watching them and apparently described them when going in to be milked to my grandmother as '*going de'ords*'. It was my first 'sentence', and I suppose it was 'going forwards', the plodding line falling in behind the boss cow for milking. They were not just any old cows but cattle being traded – even, like foreign stamps for child collectors at the time, being offered 'on approval' by the late Kenneth Beeston of Burley Farm, Allestree, Derbyshire. Many were either Ayrshires, Friesians or Shorthorns but other breeds featured as well, notably Channel Islanders – Jerseys and Guernseys. With Robin Beeston, who was a couple of years older than me, we foraged around the cattle troughs and moved among their chained heads seeking locust (carob) beans, the tastiest ingredients of their rations. It was before the days of rendered offal inclusions! Leaning on that Garden Gate was also rewarded by observing horses, including *Ladybird*, June Beeston's pony, and her father in hunting gear training with his hounds in pursuit around him. But it was the cattle that riveted my attention – and still do.

Cattle Coaching

From the age of 7, I spent part of all school holidays, and some weekends, at my aunt's farm where we originally had two dairy herds of Ayrshires and Shorthorns, subsequently replaced by beef cattle, largely horned Herefords at first, then polled and cross-bred Herefords. I travelled at first by train in the Guard's Van under his charge for the 22 miles down the line from Derby to Tamworth, where I was met by my aunt – frequently with a calf confined in the back of the vehicle in a Hessian sack with only its head peeping out. From the age of 12, I cycled the 30 miles from home to farm, going over some seven level-crossings through Burton-upon-Trent where trains supplied breweries' transport. Much of my cattle moving duties as a child revolved around TT testing, and I gained the impression that this was the full-time occupation of vets! How far we have slipped since the success of that campaign with TB now the scourge that it is among cattle and farming communities. I was early instructed in the points of good beef cattle by Lord (Henry) Plumb's late uncle, Mr Mander, who stressed 'not too much daylight underneath' and 'a leg at each corner'! We suckled our calves on several cows, including old Joanie (an Ayrshire/ Shorthorn cross) – who we had taken to market several times but couldn't bear to part with her despite her unpredictable temperament! My favourite to hand-milk was Gertie the Guernsey. Like the Masai today, with whom I work in Kenya, we shared the same udder for house-milk with suckling calves. And, yes, I caught TB in the form of a very heavy cold probably through milking fresh milk straight into my mouth when thirsty in summer!

My 1st form School Book Prize was Kenneth Russell's version of Fishwick's *Dairy Farming*. However, the only question I can remember from my entire schooldays was one from our Ethics and Civics Master in the VIth form:- **'When did you last lean on a gate and contemplate a cow?'** – Everyone laughed out loud, except me who took the question literally and tried to decide in my mind whether it was Mrs Richardson's Jerseys up in the village, or someone else's Herefords that I had last con-templated over a gate! I have since had many occasions to reflect on how profound was that question . . .

I worked one summer with Nigel at the late John Arnold's Dairy in Shuttington, North Warwickshire. I'm not sure how helpful I proved but he did give me the accolade of downing six successive large mugs of tea faster than anyone he'd ever seen

before! When arriving at the University of Reading to study agriculture in 1965, I met John Arnold, his open brown smock flying either side as he drove his bull down Friar Street in Reading for the Reading Bull Sale; 'What are you doing here lad?' said he. 'Trying to learn something' said I! 'But what are you doing with yon Bull?' It is difficult to imagine driving a bull down Friar Street in the heart of Reading today! One of the memorable early facts I learned in Reading was that it typically takes 400 litres of blood to flow through the udder to produce one litre of milk. Working at Highclere Estate after Reading, I had to count cattle on the hill. 'How many should there be?' I asked. 'I'll tell you when you get back' said the wise farm manager!

Cattle Consolidation

As we contemplate the changes of the past fifty years in cattle breeding and care, with a global perspective, let's try to celebrate the positives and beware the potential negatives. It's good to peer over our shoulders to contemplate cattle worldwide . . .

In my Nuffield Farming Scholarship studies of factors affecting dairy farm survival in seven countries from 1988 (thanks to *The Trehane Trust*), I discovered that the main threat to survival was over-borrowing while the main hope of continuance was diversification to tap into additional income streams, including value-addition to cattle products. During the quarter-century from 1989–2014, the UK, Ireland and France lost over 71% of their dairy farmers, while Spain and Portugal lost some 93% of their dairy farmers.

During FMD, while I was Chairman of FCN (now *Farming Community Network*) many farming families drew comfort in their anguish from Biblical pronouncements about cattle and God's care for them – as the 'Owner of the cattle on a thousand hills' (Psalm 50:10) and as telling Jonah (Ch.4:11) of His care for the 'many cattle' in Nineveh (near modern day Mosul) and His recognition that to lose cattle – 'to have none in the stall' – is a devastating blow to a cattle breeder (Habakkuk 3:17). In FCN today, we are very aware of the particular impacts of TB movement restrictions on cattle breeders, and on farming in general.

Cattle worldwide

Of some 1.4 billion cattle in the world, around 260 million are dairy cows and around 150 million families are engaged in milk production worldwide (FAO, 2014). India is the world's leading milk producer with 16% of the total from some 45M dairy cows, followed by the USA, China, Pakistan and Brazil. While milk production has increased, number of producers has rapidly declined, especially in N. America & Europe. England & Wales lost 7,000 of 17,000 dairy farmers between 2003–2013. However, India has a National Milk Day (November 26th) in honour of the late Dr Verghese Kurien, Father of 'The White Revolution', popularly known as 'the Milkman of India' (John, A., Sathyan, A., Rehman, F. & Marydas, M. (2014) A Day for the Milkman of India. *Indian Currents* XXVI (49) 32–34). India's self-sustaining dairy industry stems from Kurien's belief and practice in nurturing the capabilities of farmers for socio-economic transformation. Kurien's innovative social entre-preneurship driven by his integrity, fearlessness and perseverance, led to establishment of the dairy cooperative movement, starting in Anand and replicated elsewhere as *Amul*. He also founded the Institute of Rural Management Anand (IRMA) to promote equitable and sustainable development. This successful collectivisation led to formation of India's National Dairy Development Board (NDDB) to replicate the *Amul* model nationwide. *Operation Flood* in 1970 was the world's biggest dairy development project and made India a milk self-sufficient country. Kurien was passionate to ensure farmers gained control of primary production, processing and marketing. He deplored political hijacking of some cooperatives, believed in democratic control of autonomous cooperatives freed from government interference with farmer sovereignty over resources managed.

In India, sacred cattle wander everywhere and were said in bygone days to be perhaps the biggest depositors at the Banks! On the international impact of cattle, in 1997 a Japanese Fishing Boat was sunk by a falling Russian Cow! Some cattle had been rustled by Russian soldiers in a transport 'plane but once airborne they moved around, so to avoid crashing they'd jettisoned some cows through the rear door of the 'plane, one of which had sunk the boat. The fishermen were unhurt but were arrested since the boat-owner didn't

Cattle Contemplations

Our British cattle spread worldwide to put their stamp on bovine hide
Until the French connection came by Continental cattle frame –
Late Nineteen-fifties Charollais began the massive rumen fray
Where Breeders chased big guts for maize, with Dairies in a Holstein haze,
And global warming pundits blamed cows' methane-belching habits named
But don't they know that cow-muck makes grass grow much better, and the steaks
From pasture-fed beef taste the best, and pass the global warming test? –
With carbon capture in the soil and oxygen return to foil
Those belching bullocks in feedlots; let's not allow them draw the shots,
Let's not lose wide genetic scope, our biodiverse cattle hope,
With good AI, sexed semen, MOET, with genomics (think we know it?)
But let's heed the bigger vision, not lose cattle breeds' precision
Fitting landscapes, varied systems, heritage of farm-based wisdoms,
Using collars sensitive, to monitor, see how they live,
With markets niche from field-to-plate, our Food Chain sov'reignty of late;
It's good to see Longhorn revival, Aussie imports for survival,
As for me, I'm from South Devon,cattle there are straight from heaven!
Their docile temp'raments a joy; to contemplate them my rest ploy!

believe their story; however, it proved to be true. The Americans said it illustrated the appalling state of Russian air safety, while a German diplomat said it rained 'cats and dogs' in England, so why not cows in Russia?!

Cattle Contemplaters

These have included poets and writers. Thus, William Wordsworth 'The cattle are grazing, their heads never raising; there are forty feeding as one'. While Robert Louis Stevenson wrote in the 19th century, 'The friendly cow all red and white, I love with all my heart: she gives me cream with all her might to eat with apple tart'. Ogden Nash (*The Cow*, 1931) concluded, 'The Cow is of the bovine ilk, one end is moo, the other milk!' For the instruction and perhaps challenge of the more adventurous British Cattle Breeders, Gelett Burgess wrote, 'I never saw a Purple Cow, I never hope to see one, but I can tell you anyhow, I'd rather see than be one!' When asked about his authorship of this ditty, he replied, 'Ah yes, I wrote "The Purple Cow" – I'm sorry now I wrote it, but I can tell you anyhow, I'll kill you if you quote it!' I think we're safe now, Burgess died in 1951! Another farmer using AI wrote, 'The calf was so ugly it should have come without a passport but with an invoice to the AI Company instead!' An anonymous writer, poking fun at Damien Hirst's well-known pickled cow and calf, wrote:- 'A Cow and Calf are cut in half and placed in separate cases; to call it Art, however smart, casts doubt on Art's whole basis!' But in that instance, it's been more profitable than keeping live cows.

Cattle Developments

On the breeding front, we wrestle with the pros and cons of:-

- Cross-breeding to blend productivity with resilience for harsher climes and diets (such as the Jersey x Nguni for KwaZulu-Natal, RSA; and the Jersey-based *Jamaica Hope*)
- AI – 'top of pops' bulls and 'Holsteinisation' as leading breed worldwide
- MOET (Multiple Ovulation and Embryo Transfer) and 'top of pops' dams
- Sexed semen – *Cogent* since 1995 (up to → 93% reliability of female progeny)
- Cloning – the issue is not its safety to consumers *per se* but loss of gene pools tapped and of breeders' selective skills and intergenerational knowledge transfer
- Genomics – and the precision it offers albeit within reduced parameters?
- 'Smart' collars and precision monitoring of all key factors of welfare and productivity

Cattle Farming Viability

Cattle farming is not simply about improved breeding and feeding to maximise production but rather it's about optimising farming systems. Kenya will illustrate what I mean. Kenya has some 2.75 million farmers around 650,000 of whom produce milk. Some 80% of Kenya's milk producers have fewer than 5 cows, and these small ventures (including those started by entrepreneurial youths) have been increasing since the 2003 restructuring of the Kenya Dairy Board and revival of a new KCC (Kenya Co-operative Creamery) together with import/export adjustments. *Send-A-Cow* charity helps. Post-election violence in 2008 disrupted dairying in the Rift Valley. The concentration of milk processing as in other countries has the potential to encourage larger herds leading to displacement of small ones, and this trend could soon outstrip the welcome expansion of dairying in Kenya during the past decade to meet growing population and rising consumer demand for dairy products *in situ* locally. Loss of dairy farmers begs the question, what alternative productive activity can they engage in to contribute to Kenya's real economy rather than boosting unemployment and its community/ geopolitical instability threats? The same question applies to China's current drive to dismantle its legendarily energy-efficient farming systems and consolidate their cattle and other ventures into large, input-hungry industrialised operations . . . Through AFCP (Agri-Food Charities Partnership) in the UK (www.afcp.co.uk), we can help to collate funding for appropriate charitable research and initiatives towards improved cattle systems pioneered here.

Viability of cattle farming is challenged at present product prices by contrast with pricing in other sectors. A farmer who had recently replaced his vehicle decided to get his own back when his car dealer came round to buy a cow from him (Figure 2; US material, adjusted for inflation/exaggeration!).

Figure 2: Cattle Farmer's Guide to Pricing a Cow (Cattle Breeders know this plus zeros!)

BASIC COW	**£1200.99**
Shipping & handling	50.75
Extra Stomachs	179.25
Two-tone Exterior Finish	150.99
Produce Storage Compartment	130.75
Heavy-duty Herbage Chopper	180.99
Four-spigot high output drinks unit	165.25
Automatic Fly-swatter	99.99
Genuine Cowhide upholstery	185.75
Deluxe Dual Horns	85.25
Automatic Fertiliser Attachment	350.99
4x4 Traction Drive Assembly	884.40
Pre-delivery Wash & Comb	75.25
FARMER'S SUGGESTED LIST PRICE	***3740.60***
Additional Dealer Adjustments	400.00
TOTAL PRICE *(Including Options)*	**4140.60**

Conclusions

Contemplating Cattle has at least 7 applications, of which the first is perhaps the most philosophical and applicable for all, while the other 6 are for cattle farming folks:-

- Relaxation & Stress Therapy – cattle metabolise slower than we do; their cudding/rumination can soothe us in an increasingly fast-paced world
- Stockmanship – cattle keepers must regularly observe the behaviour and condition of their cattle for their welfare, beyond the nowadays routine 'condition-scoring'
- Health & Well-being – vital checking for signs of health and early disease detection
- Breeding management – from detailed observation as well as precision-monitoring
- Breeds conservation and retaining farmer/breeder control over their futures
- Reviewing selection criteria for changing circumstances and markets; future-proofing
- Pure Joy – viewing to relish the fruits of one's past breeding or stock-care decisions

There's a strong association between rumination and meditation ('chewing over thoughts') . . . Please take more time to lean on those gates and contemplate cattle for their good and yours!