British Cattle Conference

Organised by

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British Cattle Breeders Club

DIGEST 77

'A Breath of Fresh Air'

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Annual Conference Papers
25th January 2022

British Cattle Conference

Organised by

The British Cattle Breeders Club

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Message from the Chair

‘A Breath of Fresh Air’

Our ambition from the outset was to deliver a factual, positive, forward-looking British Cattle Breeders Conference after the ongoing difficulties posed by the COVID-19 pandemic and to provide ‘A Breath of Fresh Air’ towards the challenges continually facing our hard-working and resilient agricultural industry.

We were moved to tears, bombarded with great science, blessed with inspirational speakers, and given practical advice on how we can improve our businesses and move forward in these ever-changing times.

Former Rugby Union referee and beef farmer Nigel Owens opened the Conference by explaining that asking for help is not a sign of weakness, it’s a sign of great strength. It’s important to understand the value of mental health not just for individuals, but families and the wider industry – we must support one another.

We have some of the best animal welfare conditions in the world and we can farm in environmentally friendly ways that should ensure that the UK industry is at the forefront of sourcing decisions. Farmers have a real opportunity to embrace change to the benefit of their business and to the UK consumer, were key messages from speaker Steve McLean of Marks & Spencers.

Closing the Conference was the Sir John Hammond Award recipient for 2021, Professor Jude Capper, who highlighted the importance of considering economic viability and social accessibility as well as environmental responsibility within discussions on sustainability.

Several of our speakers across the day emphasised how UK Agriculture can be part of the climate solution but that it will take a concerted effort from the livestock sector to influence climate policy and there is still more that can be done.

It has been a great honour and privilege to Chair the British Cattle Breeders Club and to play a very small part in the Club’s rich history. I would like to thank all our sponsors for their support, which enabled us to continue to deliver a conference, and those people who have supported me as we faced a continually changing world. Many thanks to my Vice Chair, Amy Hughes, our Club Treasurer Andy Dodd and our amazing (and incredibly patient) Secretary, Heidi, without whom this Conference could not have taken place.

The BCBC provides a brilliant networking platform for farmers, scientists, vets, students and industry influencers and the Conference enables the latest developments to be aired in a friendly and informative forum. The need to progress British cattle breeding and genetics by utilising sound R & D and embracing new technologies and innovation has never been more important, with margins getting ever tighter and the input costs rising still further.

I wish Amy, Ben and the BCBC Committee all the very best in the coming year and in planning the 2023 Conference and 75th Anniversary of the British Cattle Breeders Club. I am really looking forward to seeing you all there!

Dr Karen Wonnacott

The British Cattle Breeders Club

CLUB PRESIDENTS

1956	Joint Presidents: Sir John Hammond CBE, FRS
	Mr George Odlam
1965	Professor Alan Robertson OBE, FRS (retired 1987)
1988	Dr Tim Rowson OBE FRS (died 1989)
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 OBE (retired 2017)
2017	Professor Mike Coffey

CHAIRMEN

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

1949–1951 R. H. Howard
1952 B. H. Theobald
1953 Mrs D. M. Wainwright
1954–1956 Peter Redfern
1957 C. B. Cooper
1958–1959 Major C. Wheaton-Smith
1960–1961 Brevit-Colonel S. V. Misa
1962 E. J. Boston
1963 M. O. K. Day
1964 F. J. Coney
1965 E. J. Wynter
1966 Miss J. H. Barry
1967 H. N. Haldin
1968 H. N. Haldin/P. Dixon-Smith
1969 P. Dixon-Smith
1970 Miss M. Macrae
1971 R. G. Galling
1972 N. J. D. Nickalls
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1974 Mrs S. Thompson-Coon
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1976 T. A. Varnham
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1985 Richard Linnell
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1988 Peter G. Padfield
1989 Malcolm J. Peasnall
1990 Mike Trevena
1991 Chris Bourchier
1992 Barrie Audis
1993 Dr Geoff Simm
1994 Geoff Spiby
1995 Tom Brooksbank
1996 Miss Sybil Edwards
1997 Keith Cook
1998 Tony Blackburn
1999 Chris Watson
2000 Henry Lewis
2001 John Downing
2002 Christopher Norton
2003 Mark Roberts
2004 Philip Kirkham
2005 David Hewitt
2006 Dr Duncan Pullar
2007 Dr Mike Coffey
2008 Paul Westaway
2009 Rob Wills
2010 Miss Lucy Andrews
2011 Duncan Sinclair
2012 Philip Halhead
2013 Neil Darwent
2014 Dr Philip Hadley
2015 Roger Trewhella
2016 Iain Kerr
2017 Andy Dodd
2018 Mrs Anya Westland
2019 Laurence Loxam
2020 Clive Brown
2021 Dr Karen Wonnacott
2022 Mrs Amy Hughes

SECRETARIES

1949	R H Holmes
1950–1956	Edward Rumens
1957–1959	Miss H. Craig-Kelly
1960–1961	Rex Evans
1962–1993	Colin R. Stains
1994–1998	Malcolm Peasnall
1999–2000	Janet Padfield
2000–2015	Lesley Lewin
2015 *onwards*	Heidi Bradbury

Building mental resilience for a positive farming future

Nigel Owens MBE
Former International Rugby Union Referee and Beef Farmer

A Summary of Nigel's presentation at the BCBC Conference 2022

'*The mind is a powerful tool that can be positive and helpful, as well as negative and destructive*.'

Nigel Owens MBE, the world's most capped rugby union referee spoke openly about his struggles with mental health and coming to terms with his own sexuality.

Nigel was born and bred on a council estate in Mynyddcerrig in Carmarthenshire, Wales and left school at 16. He worked on farms as part of a youth training scheme, however his career path soon led him to the world of rugby, which turned into an extremely successful career as a referee until his retirement in December 2020. He officiated his first international game in 2005 between Ireland and Japan in Osaka and made his World Cup debut in 2007 in France. He has received many awards for his work on and off the pitch in rugby, equality, inclusiveness and mental health.

Nigel has struggled with his own demons in the past, and became extremely depressed during his late teens and early 20's. He shared the story of attempted suicide and the impact that this had on his family. It is something he will regret for the rest of his life, and that he will never forgive himself for. 'But when you are in a dark place you believe that the people you care about the most will be better off without you, and don't think about it as being a selfish thing to do. The reality is that it's the complete opposite.'

He strongly encouraged anyone struggling with depression to try and get to the route of their problem and why they are feeling so stressed. 'Once you have accepted the issues that are affecting you, you can move on to the next stage, and try and talk to people, whether that be friends, family or professional help. It's important to ask for help, it is not a sign of weakness. We need to create an environment where people feel that they can talk about their problems and that it's actually a sign of great strength to open up.'

'Mental health issues are so prevalent in agriculture, and it is time to turn the tide by sharing and understanding people's problems. We are always keen to learn from the people who are doing well, but we should also be learning from those that don't. We must remember to never underestimate the influence that we all have on others around us. Look out for our family, friends, neighbours and colleagues, and if you've not seen someone for a while give them a call and check they are okay.'

For Nigel accepting himself and his sexuality was the biggest challenge of his life. He was referee of the World Cup between Australia and New Zealand in 2015, the biggest game in world rugby which happens once every four years and the pressure of this was huge for him. But Nigel explained that that challenge was nothing compared to accepting who he truly was.

Since retiring from refereeing, Nigel has been able to fulfil his dream of becoming a farmer. He now runs 60-head of pedigree Hereford cattle, called The Mairwen Herd, after his late mother. In 2020 Nigel was elected President of the National Federation of Young Farmers Clubs.

He urged everyone to remember, that asking for help is not a sign of weakness but a sign of great strength.

If you are struggling or know someone who needs help the following organisations can provide support:

- Farming Community Network offers practical and pastoral support to those in the farming community both in-person via its network of regional volunteers and its national helpline and ehelpline. For more information visit https://fcn.org.uk
- The RABI recently partnered with Kooth to offer emotional support and online counselling to those in the farming community. Visit https://explore.kooth.com/rabi/

Nigel's talk was kindly sponsored by CRV.

Adapting to change in order to succeed . . .

Steve McLean
Head of Agriculture and Fisheries Sourcing, M&S Food

There is no doubt that the agricultural industry is facing a period of huge change. We've seen significant cost price inflation, the disruption from Covid-19, new trade agreements and the post-Brexit re-focusing of UK agricultural support. Against all this, we are also continuing to see increasing focus from consumers on where food comes from and how it is produced. This manifests itself through interest in animal welfare and, increasingly, in the environmental impact of the food we eat.

As many will know, Marks & Spencer is well established in the UK, starting back in 1884, and recognised for high quality products. Today we operate in the UK and 62 other countries and have 44 different websites globally, selling a range of food, clothing and homeware. When it comes to our food business, we have around 700 UK food stores as well as our joint venture, Ocado, which has given us a strong online grocery presence. We are growing our market share through our focus on innovation and quality.

When it comes to agriculture, M&S is a long-term supporter of British farmers. We work with around 7,000 UK M&S Select Farmers that we know and trust, all of whom work to our Select Farm standards, which cover food safety, traceability, animal welfare and environmental stewardship.

The focus on animal welfare and the environment isn't new for Marks & Spencer. We launched our eco- and ethical plan, Plan A, way back in 2007, because the leadership in the business at the time had the foresight to understand that the challenges that society was facing meant that customers and investors would have great expectation on leading brands such as M&S. We were very clear about the need to demonstrate leadership on social and environmental issues, and we've had several successes in these areas over time. However, late last year, we recognised the need to reset our Plan A strategy, with a real focus on climate change so that we can limit global temperature rise to below 1.5°C. We set an ambitious target of net zero by 2040 across our entire supply chain value chain.

To be clear, that includes the agricultural supply chains that serve M&S. Whether we like it or not, farming is a major contributor to carbon yet the opportunity that agriculture has is that it is also uniquely placed to be part of the solution through carbon sequestration. What we need to ensure, however, is that any work in this area is science-based, but I genuinely believe that farmers have a real opportunity in this space if they embrace change.

It is easy to be sceptical about the real impact of agriculture, with so many different points of view on the subject. But what I can share is that an independent end-to-end assessment of our own value chain – from farm to consumer – showed that 72 per cent of our total carbon emissions came from primary agriculture and 47 per cent of that came from the meat, fish, dairy and deli categories. As such, it is essential that we work together with our farmers, and particularly our livestock farmers, to address the carbon challenges we face. But, of course, we haven't just got that to deal with now, with inflation, global conflict, Brexit and COVID-19 all impacting on how we operate today, and with significant uncertainty and change ahead.

That inevitably shapes everyone's thinking and dealing with so much uncertainty is difficult from a personal perspective and when trying to run a farming business. But the most important thing is to recognise the opportunities that come with change, and part of that is about closer supply chain relationships and better understanding of consumer needs.

We know from our research that our customers are very clear about what they expect from us, both at store and product level. Unsurprisingly, when visiting a store, they want great quality and taste, they want value for money, they want competitive prices, and they want a good range of products. These dynamics haven't really changed. But increasingly, customers also want to know that we're offering food that is both healthy, sourced from livestock that are reared in high animal welfare conditions and coming from farms that are environmentally friendly. Now, you could take those last three as either a threat or an opportunity. Personally, I think there are real opportunity for UK farmers. We have some of the best animal welfare conditions in the world. And we can farm in environmentally friendly ways that should ensure that the UK industry is at the forefront of sourcing decisions.

What's interesting is if you dive deeper into customers' understanding of what sustainability means, consumers are confused but they do see it as a shortcut to quality and I think that's important.

We see that more than a quarter of adult customers always seek out ethical or sustainable products and research has shown that three quarters of adults in the UK are concerned about climate change.

This is a challenge in one way, but a huge opportunity for the UK farming sector to really demonstrate the advantages it has over other industries and over food chains in other countries.

What's also important to realise is that these trends towards transparency and interest in sustainability and animal welfare are not just consumer trends. Major brands like M&S are increasingly under scrutiny from ethical investors, who make decisions based on the sourcing principles of organisations, so this is becoming embedded in business. When it comes to carbon, it is also government-led. The climate crisis is urgent and needs urgent and co-ordinated action. It's not something we've just dreamt up and it's not based on a carbon account principle that we've created. Yes, we have a net zero target, and that includes so-called Scope 3, which is all the emissions that we don't directly control. What that means is that effectively all farmers in our supply chain, and indeed most other supply chains, have a net zero target too by default.

We've seen red meat and dairy in the spotlight for carbon. There are several public perceptions that the industry must deal with relating to ruminant livestock, which is unfortunately seen as a problem rather than part of the solution. There are numerous calls to reduce consumption. The underlying trend towards vegan eating and the perceptions around environmental health and environmental benefits are a risk to the industry. But they're not new. And, if we're fact-based, and if we can demonstrate that we are acting on the issues that face us, then I think there is great opportunity. But we do need to change, and we do need to think differently.

One thing I want to stress is that at M&S we are huge supporters of British meat and British dairy we believe that both play a valuable role in a balanced diet. Whilst others are talking of reducing meat and dairy sales to address climate change, we have a very clear strategy to grow sales in both categories, so we want to sell more British meat and dairy than we do today. But we do need to focus on high quality, high welfare and carbon reduction so that we can ensure that the consumer comes to us for a great offer.

Change brings opportunities and the whole issue of carbon and carbon sequestration, and carbon trading will be an opportunity for the farming community when we understand better the platforms around trade in place. We also need to change the way we look at production methods and supply chain relationships. I've continually talked about how we should be looking at ways of shortening the supply chain, being more collaborative in our approaches and I really do think that that is an opportunity for us all. We should be thinking about differentiation in everything that we do. It shouldn't be about commodity production. And I think greater collaboration along the supply chain will help us identify opportunities to differentiate products. There needs to be greater alignment, more transparency, more collaboration, and more of a common view around how we address some of the issues that have been identified.

One of the areas that I'm sure will play a part is integrating supply chains. If you were going to categorise our beef supply chain, we enjoy supply from a range of different farms – from feeder finishers, to store finishers and integrated dairy models. The reality is we want to find ways working collaboratively with all our suppliers. We want to be clear on the specifications that we need. We need to be clear on the opportunities to demonstrate improved carbon efficiency and improve quality.

One of the areas that we've been investing in of late is a new approach for beef production models. Our pathway farming model is a unique supply chain to Marks and Spencer and it's a model that we can point at any one of our M&S-approved abattoirs.

Pathway has purpose-built calf rearing facilities in Surrey, Yorkshire, East Sussex and Devon. It is about developing a system that builds on some of the learnings from the more intensive pig and poultry industries and applying them to free range, less intensive systems. We've built in a requirement that cattle graze, as we know that's important to customers, and then has a bespoke approach to the finishing period in a dedicated facility. It also uses the very best quality genetics that we can source, and we enjoy a great partnership with ST Genetics and Cogent, and we're very much focused currently on Aberdeen Angus. But that focus on Angus isn't just about breed. It's about feed efficiency. It's about eating quality. And it's very much about delivering a consistent product that our consumers and our processors can enjoy.

We want to deliver beef with the lowest environmental footprint and better eating experience and improved performance year in year out. We also take account of both the market and cost of production dynamics, so that farmers working with us through this model get a fair return for their work.

This is a great example of new thinking that delivers for everyone in the supply chain. It relies on communication but provides our customers with great quality, consistent meat, great performance at a farm level, fair returns and good environmental performance, as we work closely with the farmers involved on biodiversity, improving soil health and water quality and on carbon reduction. It also makes the whole supply chain more efficient financially and environmentally and, whilst we still have a lot to do in terms of the environment and carbon, we believe this will be one of the lowest carbon beef supply chains in the country. We are at the start of this process, but we are working collaboratively and driving change which not only benefits the environment but also improves the bottom line for all involved and delivers a better product for consumers.

So yes, we face huge change and that brings uncertainty. As we look forward, we don't know how we'll address some of the challenges we face, particularly around carbon. Uncertainty can be scary, and the danger is that it can result in paralysis at farm level whilst we wait for clarity that may not come in time to react to it. We've probably never seen a period of change quite like this for British agriculture. But change isn't necessarily negative – it also brings opportunities. We all need to think differently, and we all need to be more joined up and collaborative than ever before.

At M&S we are willing to be collaborative, and we do recognise that we will only achieve our objectives if we work together. We welcome conversations with any of our Select Farms on what we could do to be more supportive. We all need to recognise that consumers still want great quality, taste and value as well as the other deliverables around climate change.

This needs a new mindset and approach. We are proud to continue to support British agriculture and we want to work in partnership with British farmers to help address the challenges ahead. We look forward to working with you.

Drive carbon reduction through the use of improved genetics and management practices

Seth Wareing
Business Manager, Stabiliser Cattle Company,
The Barn, Southburn, Driffield

A combination of management and genetic changes can reduce the carbon footprint of an individual UK suckler unit by up to 40% while contributing to beef production efficiencies.

The UK suckler industry is under immense pressure to reduce its carbon footprint while still feeding a growing population in a financially feasible way. While the strength of the suckler industry is converting grassland unsuitable for growing crops into a high-quality protein for human consumption, there is room to do this more efficiently from both an environmental and financial stand-point.

By benchmarking 12 different suckler herd system scenarios using industry performance from AHDB's Stocktake report, we have calculated carbon savings from alternative management changes that could be made between each modelled system scenario using Alltech E-CO2's (Carbon Trust approved) life cycle analysis model.

A life cycle analysis approach gives us the true picture of a farm's environmental footprint by considering the balance of emissions across the entire production system. This is done by examining all inputs, processes and outputs of a system – from obtaining raw materials to products leaving the farm gate.

Modelling each farm as a 100 cow suckler herd to finishing system on a predominately forage diet, inputs such as synthetic fertilizer and manure application, straw, farm fuel and feed were kept constant as the life cycle model calculated the emission outputs between different management changes. These changes included such things as, leaving bulls intact for finishing, reducing cow size, calving heifers at two and improving feed efficiency.

What we found is that significant carbon savings were easily and quickly achievable by improving many things incrementally rather than one thing 100%. This is because when one small component is made more efficient, that efficiency will resonate in the supply chain and enable reductions across the entire life cycle.

When combining improvements seen across the 12 modelled systems, a full steer finishing system had a carbon saving of 31% and the bull finishing system had a carbon saving of 40%.

The full system, which includes improved fertility, growth rate and feed efficiency, reducing cow size, calving at two, all forage-fed cows – all of these management and genetic factors when taken together encompass what the Stabiliser breed offers the UK suckler industry. The tools and knowledge to make radical long-term reductions to the carbon footprint are already available whilst also enhancing the opportunity for profit.

This information gives beef producers and supply chains the opportunity to select management practices and genetics that can reduce the carbon footprint of the suckler supply chain. The drive for efficiency on farm not only reduces carbon footprint but it improves the bottom line for farmers, and the quality and consistency for the consumer. It can be a big win for the entire beef supply chain.

Maternal Traits

Trait	Info	Carbon Saving
Smaller cow size	Reduce cow size from 750kgs average to 600kg average	7.3%
Calving at 2	Reduced age at calving from 3 to 2	3.8%
Smaller calf	Reduced birth weight from 47 kgs to 37 kgs	4.1%
Nine week bulling with improved fertility	Reduced bulling from 15 weeks to 9 weeks and improved fertility of 65% conception from 35%	4.6%
Reduced replacement rate	Reduced replacement rate from 16% to 12%	2.0%
Only forage fed cows	No concentrate feed for breeding females after 15 months old, UK average 130kgs per animal per year	3.6%

YOUNGSTOCK TRAITS

Trait	Info	Carbon Saving
Improved growth rates – Steers	Reduced age at slaughter for steers from 23.1 months to 18 months, and heifers from 24.8 to 20 months	10.1%
Improved growth rates – Bulls	Reduced age at slaughter for bulls from 23.1 months to 13 months, and heifers from 24.8 to 20 months	16.3%
Improved feed efficiency	Improved feed efficiency by 12%. There is 12% less feed needed for the same growth rates	7.3%

SYSTEM RESULTS

Trait	Info	Carbon Saving
Full Stabiliser system – Steers	All of the cow and youngstock efficiencies, with all male offspring slaughtered as steers	31.7%
Full Stabiliser system – Bulls	All of the cow and youngstock efficiencies, with all male offspring slaughtered as bulls	39.7%

Advanced carcase grading technology – what benefits can it bring to UK producers?

Desi Cicale
Founder and CEO, Meat Imaging USA

Meat Imaging Mobile Camera: A Robust commercial grading tool ideal for the full range of Marble Score Variation

From the first time I took my carcass captures, I knew I needed to bring this technology to the United States. With the rise in popularity and demand of Above Prime meat, we were beginning to face a crisis. The Wagyu meat industry was entering a new phase, with a market yearning for the taste and quality that Wagyu has to offer, but one that did not understand how to interpret their above prime meat quality and understandably higher prices at market. We breeders struggled to demonstrate the advantages of carcasses that yielded higher marbling scores and knew there had to be a better way than the aging grading system that was developed almost a century ago in the United States. With this new technology, the MIJ Mobile Carcass Camera, we could not just assess Marble Score Variation, but also full carcass quality while helping guide genetics.

Meat Imaging Japan (MIJ) is recognized the world over for their advanced digital analysis systems and cutting-edge technology for measuring carcass merit. And through stringent testing, Dr Kuchida found that the MIJ Cameras not only mirrored the results collected traditionally but provided more comprehensive and accurate measurements of the carcass. The first partnership of MIJ was with Australia to expand their testing, while also helping a country that was seeking to improve their above prime grading system. Now Australia has outfitted multiple processing plants with the technology.

After learning all this and observing the grading process myself in Japan, I immediately started my campaign to introduce the MIJ grading system and get it certified by the US Department of Agriculture. Years later I can proudly say that not only have many US breeders and processors adopted this grading system, but many other countries are also jumping on board using this state-of-the-art technology in their own processing systems. Together we are poised on a precipice that will launch us into a significantly more effective future where we have the power to improve all our programs.

Meat Imaging is far from just another application; it has the technology to bring your program to the next level, unite the Wagyu breed, and one day the entire beef industry as we know it, with consistent, objective analysis precisely creating a uniform grading system.

Over the years, through meticulous research and rigorous testing Japan has crafted an invaluable tool that now comes with upgrades to make the process even easier. MIJ Mobile has added a Beak Attachment enabling you to get MIJ-30 quality images for less than a tenth of the cost, and a Fast Capture that makes it perfect for capturing images on a fast-moving line, easily handling 200 carcasses per hour. With the new advances in software, no cell service is required to capture and transmit data. Only WiFi is needed; and even if no WiFi is available, you can capture and store your data to upload at your convenience.

As we enter this new era, using our carcass data to better our meat and herds. Many processors use a Carcass Information Tracking Barcode. The MIJ Mobile system also allows you to create your own barcodes. MIUSA can show you how to create these barcodes to track your data. This helps you pair your images with your bloodlines, to track trends both positive and negative and adjust the quality of carcasses you produce.

The MIJ Carcass Camera data provides the user with 2 pages of information with each carcass capture. The knowledge that users gain from their carcasses is the key to better production and higher return. It is allowing breeders to fine tune their genetics in record time by helping track scientifically proven heritable carcass traits.

Meat Imaging's goals for each user are three-fold. First, it is making grading and defining the merits of your carcass accessible to every level breeder, whether you are a small family run farm or an industrial business. Secondly, it's correcting the delay of having to wait for your testing results until after your carcass has been processed. MIJ Mobile Camera allows for Real-Time carcass data that can immediately give you accurate carcass insight, thereby improving your genetics and maximizing the performance of your herd. And last but certainly not least, to help bring awareness to the importance of Marbling Fineness. Dr Kuchida, one of the main Japanese researchers for MIJ Imaging, has proven that not only is marbling fineness a heritable trait, but it also directly correlates to tenderness, taste, palatability, and visual value!

MIUSA's continuing research at leading universities throughout the United States over the last 5 years have observed a direct correlation between Marbling Fineness scores and the tenderness results of the Warner-Bratzler Shear Force Analysis and Fatty Acid Profile results. These findings combined with high marbling Wagyu IMF's were so compelling that last year the USDA (United States Department of Agriculture) was present to observe the most recent testing.

MIUSA now using MIJ technology has the means to make the Wagyu industry a global competitive powerhouse. The MIJ Mobile Camera system is making it possible for more beef producers and processors to capture real-time objective data across a wider range of processing facilities. We no longer need to be in the dark waiting for results to come in but can have the results within seconds of taking one image.

We owe it to the breeders and the expectant public, anxiously waiting to learn and experience better quality meat, to take this singular, yet momentous step into the future, and leave behind the antiquated systems of the past. It's time to get paid for the grade.

New developments in advanced breeding technologies and phenotyping: SemenRate in UK and Canada

J. M. E. Statham[1,2,3], M. W. Spilman[3] and K. L. Burton[1]

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[2] Harper and Keele Veterinary School, Keele University and Harper Adams University, Staffordshire, UK

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Background

Advanced breeding technologies have revolutionised livestock food production. Genetic improvement has facilitated enormous productivity gains in farming. However, genetic potential remains a promise until genuine phenotypic progress is made. Many factors affect conception success and despite representing half of the reproductive equation, male factors can remain unmeasured or unknown. A single bull is often used to mate multiple females and in the case of artificial insemination (AI) where semen is collected, processed and frozen, potentially thousands of females worldwide (Statham et al., 2018, 2019).

Where semen or embryo quality falls below optimal, genetic promise can go unfulfilled. The use of sub-fertile bulls (those failing the pre-breeding soundness examination) or AI semen that has been damaged in processing, transport, storage, or handling is a contributing factor to this. The use of genomics offers specific opportunities for innovation in breeding low emission, net zero dairy and beef animals, but only if breeding is successful (Statham et al., 2017, 2020).

RAFT Solutions Ltd (RAFT) are a veterinary-led business based in North Yorkshire, sitting in a position to bridge the gap between industry and research to enable applied solutions to sustainable health and welfare in livestock animals. Alongside the research and advanced breeding aspect of the business, RAFT provide vet and farmer training as well as consultancy services.

RAFT's involvement in advanced breeding technologies has led to the establishment of an independent semen analysis service, SemenRate, with previous funding from InnovateUK. This service provides a multi-parametric assessment of both frozen and fresh semen using kinematic parameters from computer assisted semen analysis (CASA) alongside flow cytometry assays (Vincent et al., 2012; Sellem et al., 2015; Spilman et al., 2017). Many different factors affect conception success, including health and nutrition, so genetic promise may be unfulfilled if semen/embryo quality falls below optimal to achieve breeding targets.

Breeding for Sustainable Beef

A normal fertile bull is expected to impregnate 90 per cent of 50 normal, cycling, disease-free females within nine weeks, and impregnate 60 per cent of these in the first three weeks. Bulls of high fertility can achieve the same or better results. However, in a study of 319 bulls in the southeast of Scotland 33.4 per cent were found to be sub-fertile; reasons included lameness, poor scrotal circumference, scrotal enlargement, poor semen quality (motility or morphology) and poor serving ability (Eppink, 2005).

Before the service period, the pre-breeding evaluation of the bull should be performed by a veterinary surgeon who has undertaken and passed specific British Cattle Veterinary Association (BCVA) training in bull breeding soundness examinations. It allows a proactive approach to screening for sub-fertile bulls and includes the following:

- History and disease status
- Physical examination (including palpation of testes and measurement of scrotal circumference)
- Semen collection (artificial vagina or electro-ejaculator) and examination of motility and morphology of semen
- Serving assessment (synchronised heifers or farmer observation before visit)
- Special diagnostics (e.g. testicular ultrasound)

With only 65–85% of bulls being classed as satisfactory potential breeders at breeding soundness examinations, it is essential that bulls used in natural service are evaluated as thoroughly as possible prior to use with respect to natural service. Bulls should be capable of depositing high quality semen in the correct place. The BCVA bull pre-breeding soundness evaluation includes measurements such as scrotal circumference and percentage of morphologically normal sperm that have been shown to be correlated with fertility (Statham et al., 2019). The other components of the BCVA semen evaluation include assessment of mass motility (on a scale of 1–5) and individual progressive motility percentage.

Therefore, the use of validated, objective and repeatable measurement of semen motility and morphology such as CASA and flow cytometry should be considered as it is a powerful tool in objective measurements of semen motility (Vincent et al., 2012). Similarly using flow cytometry to determine morphologic differences offers objective analysis (Sellem et al., 2015). Increasing use of AI, embryo transfer, as well as ovum pick-up and in-vitro production of embryos, and especially the opportunity for sustainable breeding offered by sexed semen is a key driver for high quality genetics and checking semen quality. Being able to submit samples to a central independent semen laboratory, offering specialist referral support, may provide a solution to repeatable and objective semen motility evaluation, especially in proactively screening semen quality ahead of breeding programmes. The combination of CASA, flow cytometry and experienced referral laboratory support is the basis of the SemenRate service and central data hubs at the heart of this UK–Canada project described below.

Optimising reproductive success in beef cattle will also reduce greenhouse gas (GHG) emission intensity for beef. Good fertility performance is the cornerstone of a profitable and sustainable livestock business. Fertility drives productivity and in turn mitigates GHG emissions through reduced waste and optimising unproductive replacement youngstock inventories (Statham et al., 2017, 2020). Advanced breeding technologies offer a huge opportunity to achieve 'Net Zero' climate change targets in the beef industry.

UKRI: UK–Canada Breeding Project

UK Research and Innovation (UKRI) has pledged over £2.2m to seven agri-tech firms with Canadian partners to fund the development of new agricultural techniques that will help both countries meet their Net Zero emission targets. One of seven winning UK companies was RAFT alongside their Canadian partner Bow Valley Genetics, other UK technology partners and XL Vets groups in both countries.

RAFT have won funding for a 2-year project to further advance the already established SemenRate laboratory within the UK as well as setting up a new satellite laboratory in the west of Canada and a further site in the east to follow. Alongside the laboratory expansion is the development of new technologies to support the evolution of sustainable dairy and beef breeding.

Over the next two years the project partners will develop a group of advanced breeding technologies alongside a phenotyping database across the UK and Canada. This work will explore the role of germplasm quality and transport as part of achieving sustainable genetic progress and seek to establish phenotyping data across both countries in both sustainable dairy and beef breeding.

The technologies under development within the project include:

- Cytokine development: processing semen for AI removes the natural cytokines from the seminal fluid. These cytokines have been found to be important for fertilisation (Johnson et al., 2017). This work package aims to establish the cytokine profile for cattle, any variance between breeds and develop possible cytokine replacement treatments before or at insemination.
- Novel transport system for germplasm using hydrogels: the unique transport system would allow the movement of semen and embryos in countries where the cold chain has potential for disruption – lack of liquid nitrogen supply, long shipment distances etc.

* An objective, bull side semen analysis system (Jepson et al., 2019): this would provide veterinary surgeons performing pre-breeding soundness examinations with an objective assessment of semen motility and allow for any borderline samples collected to be referred to the established SemenRate laboratories for further analysis.

Each of the technologies will go through an alpha and beta testing phase with SemenRate within the project using the RAFT farm network as well as the XLVet network in both the UK and Canada.

RAFT recently launched a new diagnostics data management company 'VetDx' at the Precision Livestock Farming (PLF) in Practice Conference held in at the York Biotech Centre in November last year. Veterinary Diagnostics Solutions (VetDx) is a joint venture between RAFT Solutions and human diagnostics data software specialists 'Personalised Diagnostics' (PDX) that will manage large scale collection, storage and interpretation of health and breeding information in a usable and flexible manner, protecting the confidentiality of individual data. This approach will be central to the development of the national data hubs at the centre of this project.

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How many calves can 100 cows wean realistically?

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I was brought up on a small, family beef farm in the parish of Harray in the Orkney Islands and from an early age I had a keen interest in cattle, especially beef cows. In 2006 my wife Lorraine and I were fortunate to be offered a farm to buy, and since then have purchased another farm and built the herd up to 100 cows. We farm 330 acres, 230 which are owned and 100 on seasonal lets. We have Simmental and Salers cross cows and sell the calves as stores, and we also grow some spring barley.

In 2012 we were fortunate to become Orkney's first Monitor Farm. At the start of the project a whole farm review was carried out on the business. The whole farm review programme is carried out by someone completely independent to highlight the strengths, weaknesses, opportunities and threats to the business. The review highlighted that our herd was not achieving targets for cows scanned in calf, live calves born, and calves weaned, as recommended by both QMS and SRUC.

Farmers are often told by industry experts how we needed to be more efficient by achieving 96% scanning, 94% live calves and wean 92% from every one hundred cows exposed to the bull, all in a 9 to 12 week breeding period. However, Quality Meat Scotland estimates that only 82% of cows in Scotland are producing a calf each year. So, we are rearing 10% less calves than what we are being told is possible. Either these targets are unrealistic or we as an industry are under achieving. I wanted to find out if these targets were realistic, which prompted two questions that I wanted to answer through my Nuffield Scholarship:

(1) What is a realistic weaning percentage?

(2) How do you achieve this?

My study tour in 2015/16 covered farms in the UK, Canada, Ireland, Norway and Sweden. Visiting farms in the UK and Ireland first, I wanted to know what they were achieving. I asked all the farmers the same 22 questions to find out what breeds, housing, forage type, minerals, feeding method, management and health planning they had. But, most importantly, what was their scanning, calving, weaning and replacement rate.

I have seen very different systems; from Highland cross cows on the hills of Scotland, to pedigree herds on the east coast working well alongside successful arable systems. Cowboys farming thousands of acres on the edge of the Rocky Mountains, to very highly stocked family farms in Ireland. Every farmer I have met is passionate about cows and a lot of them are in the process of expanding cow numbers.

My study tour has reinforced to me the importance of cow type, management, 2-year-old calving and block calving. But I have also noticed that a few of the farms I have visited were weaning calves which are close to 50% of the cow's body weight. At home we are not achieving this and the last time the cows and calves were weighed at weaning they were only 45% average. They varied from 32% to 66%. To try and achieve better and more uniform weights I intend to reduce the average weight of the cows by selling off the biggest cows and culling cows which consistently under perform. I also intend to supplement the cows better before calving to improve the quality of colostrum. I hope this will improve the health of the calves in the first few months of life. Our scanning rate has been 93%. I hope by culling cows which have had calving difficulties, we can achieve 95%.

Only 10% of the farmers I met in the UK were achieving better than the target of 92%. The main focus of my study was to compare the top 10% with the bottom 10% of the farmers which I met, which would represent the average suckler producer in Scotland. My findings have shown that 92% is setting the bar to High. Breed and type of cattle does matter. Continental and native breeds have different strengths and when you combine the two you can have the best of both worlds. Heifers should be calved at two years old unless it is an extensive system using slow maturing, hardy breeds which do live longer. Block calving within 9 or at the most 12 weeks is achievable with the right management and cow type. All the other management practices, services and products are important but can vary greatly between farms.

After visiting farms in different countries which are achieving 92% weaning, I am in no doubt that the industry can improve greatly on what is being achieved at the moment. Farmers have all the tools and information already to achieve this. It is time to get this message across.

View Steven's Nuffield Farming Scholarship Report – *Are benchmarking targets for suckler cows achievable* 2015_UK_Steven-Sandison_Are-Benchmarking-Targets-For-Suckler-Cows-Achievable.pdf (nuffieldscholar.org)

From the first artificial insemination to technologies of the future – what role do genetics play in improving sustainability?

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Sir John Hammond was a true pioneer, without whom we may never have been able to harness the myriad technologies that we now employ within livestock breeding.
If we look back to the characteristic shapes and sizes of cattle, sheep and other animals in the early 20th century, it's clear that considerable genetic changes have occurred over time with the advent of selective breeding. Given the current industry, consumer and policymaker focus on sustainable food production, it's clear that we will have to adopt both existing and new technologies to continue to move forwards, yet it's not always obvious how much of a contribution reproductive technology may play in sustainable systems.

Given the brilliance of Sir John Hammond, and the renown that he has within our industry, there is a certain irony in the fact that if you search for 'John Hammond' on popular internet search engines, the top results relate instead to another reproductive expert. Perhaps coincidentally (although the author suspects not), Michael Crichton, author of many best-selling books, chose the name John Hammond for the geneticist who managed to bring dinosaurs back to life in the book (and film) Jurassic Park. The resulting dinosaur appropriation of the entire theme park, with death and destruction trailing in their wake, was, of course, an entirely unsustainable consequence.

By contrast, the contribution made to the livestock industry by Sir John Hammond CBE FRS PhD, has greatly improved cattle industry sustainability over the past century. Sir John's recognition of the timing of oestrus in cattle; classic studies in embryo survival and authorship of the first authoritative text on artificial insemination (AI) mean that he can truly be considered the father of modern animal physiology. Perhaps most importantly (at least with reference to this conference paper), he founded the British Cattle Breeders Club in 1946 and was an active member of the European Association of Animal Physiology during the early days of its inception in the early 1950s. It is interesting to note that when Sir John conducted his pioneering AI studies the work was considered socially unacceptable and as such, often had to be transferred overseas (Wilmot, 2007). Yet AI has a history that extends further back than we might suppose. For example, the first (albeit anecdotal) incidence of human AI is postulated to have occurred in 1461, through the actions of King Henry IV King of Castile, nicknamed 'the impotent' (Ombelet and Van Robays, 2015). The first documented human AI was undertaken in 1770, followed by successful AI of a springer spaniel in 1784. 150 years later, in the late 1930s, the applicability of AI to UK farming systems was doubted by many, citing concerns relating to livestock standardisation and a future lack of genetic diversity. Nevertheless, in 1943 Sir John headed the first Cattle AI centre based in Cambridge and, a mere eight years later, 20% of UK dairy cattle were served by AI (Wilmot, 2007). By 1958, AI was used in 58% of dairy cows and, almost a century later, AI has become the standard technology in dairy cattle breeding.

These dramatic gains in technology adoption have had considerable benefits to the rate of genetic gain within dairy and other livestock industries, yet we should not assume that we are now in a societal position where all technologies are automatically welcomed by the consumer. Scientific advances in human medicine, telecommunications, transport and other sectors have generally had a positive reception from consumers. However, a small yet insidious perception that technology use within food production, particularly technologies that have the potential to cause pain or distress to livestock, still exists for many consumers, with nostalgic views of farming garnering favourable opinions.

This may be exemplified by the painting 'The Farm' by Alexis Rockman (2000). The artwork depicts changes in farm animal appearance and use from 'traditional' farming through to imagined future animals, including a six-winged, four-legged naked chicken and mouse with a human ear grown on its back. The date by which the future farm animals might have been created is not stated, yet it's interesting to note that the artwork includes an image of an obese pig growing organs for human transplantation. Given recent media reports of a porcine kidney being successfully surgically attached to a human and apparently functioning normally (Roberts, 2021), this future vision may not be as far ahead as originally conceptualised. Concerns over technology use in all food production sectors will therefore remain a significant social sustainability issue going forwards.

Sustainability has become a surprisingly complex issue within food production, as although it appears to be a simple concept, the exact definition varies considerably according to the desires and perceptions of the beholder. To some, sustainable systems may conjure visions of organic, small-scale farms using native breeds; to others it means improving efficiency through large-scale, intensive production and making the best use of by- and co-product feeds. From a scientific perspective, the consensus definition is a balance between economic viability, environmental responsibility and social acceptability (United Nations, 2005), a balance that must be striven for in all livestock systems. One of the greatest sustainability issues that the cattle industry needs to overcome is the gap in knowledge and understanding between the producer and the consumer, which, when hitherto-underknown practices are exposed, may lead to accusations that the farming industry lacks transparency. There is a significant difference between intentional misrepresentation versus failing to communicate every advance in farm management practices, yet communication must be improved for producers to gain the social license to operate in future (Capper, 2020).

Advances in information technology that allow us to find the answer to almost any question in a matter of moments, or to talk with colleagues thousands of miles away, also lead to a greater need to consider consumer views when adopting new or existing farm technologies, with the knowledge that these views may not accede with our own. For example, Pieper et al. (2016) surveyed the attitudes of German consumers to reproductive technologies used in farm animals and reported that the proportion of consumers viewing these practices in a negative light appeared to increase with the artifice or invasiveness of the practice. Consequently, 53% of consumers were opposed to the use of sexed semen, 58% to embryo transfer, 65% to fertility programmes and 81% to cloning. As with any consumer survey and as noted by the researchers, results may be biased by the question formatting. For example, the question 'are you concerned about hormones being injected into dairy cows?' would be expected to yield different answers to 'what are your top 3 concerns about dairy farming?' Nevertheless, the results reported by Pieper et al. (2016), did reveal a general lack of awareness by consumers regarding the reproductive practices used on dairy farms, and therefore the need for improved outreach and education.

Meat labelling, until now, has largely been confined to marketing claims, nutritional information and badges from accreditation schemes, yet it seems likely that, in future, considerably more information will be available. It's conceivable that consumers will be able to access sustainability information on a range of topics and metrics (e.g. carbon footprint, biodiversity, antimicrobial use, production system, etc) through traffic-light style colour codes, numerical indices or QR codes within in the next 5–10 years (Capper, 2020). This will have significant implications for the potential social acceptability of technologies used on farm, yet will also necessitate a greater technology adoption rate with regards to being able to measure, benchmark, compare and prove the effects of farm practices on sustainability metrics.

The focus of many sustainability efforts still remaining strongly upon greenhouse gas (GHG) emissions however, particularly in the wake of COP26. Although GHG emissions vary considerably across the globe, developed livestock industries have tended to reduce their emissions per kg of food produced through improvements in genetics, nutrition, health and management over the past century (Capper et al., 2009; Capper, 2011; Cady et al., 2013; Xin et al., 2013; Legesse et al., 2016; Capper and Cady, 2020; Ottosen et al., 2021). Perhaps the most extreme example in terms of productivity gains may be the USA, in which a whole-scale move towards large-scale farming has conferred reductions in the GHG emissions per kg of milk by 63% between 1944 and 2007 and a further 19% between 2007 and 2017; per kg of beef by 18% between 1977 and 2007; per kg of pork by 35% between 1959 and 2009; and per tonne of eggs by 63% between 1960 and 2010 (Capper et al., 2009; Capper, 2011; Cady et al., 2013; Xin et al., 2013). The magnitudes of these gains could lead to the supposition that future gains may be capped given the biological limits that exist for growth rates, carcass sizes or milk yields and the eventual plateauing of efficiencies of scale. However, given that the USA-based dairy cow that holds the world record for 365-d milk production yielded 35,437 kg, it is clear that further genetic gains may still be available within dairy herds. Indeed, Shook (2006) reported that approximately 55% of the gains made in US dairy productivity between 1980 and 2006 were due to genetics, and it is logical to suppose that, given the highly integrated nature of monogastric production and supply chains, an even higher proportion of global pig and poultry efficiencies may have been conferred by improved genetic merit, as discussed by Ottosen et al. (2020).

Beef production may be considered the exception to the rule, both in the USA and in the UK. Despite differences in scale, the industry structure is largely similar between the two countries, including a relatively limited uptake of reproductive technology compared to the dairy sector, which presents a considerable opportunity going forwards. Increased slaughter weight was one of the major driving factors behind the reductions in GHG emissions per kg HCW beef identified by Capper (2011) between 1977 and 2007, however, trends in UK beef cattle carcass weight reveal that gains have been moderate at best, with an increase of 27 kg between 2003 and 2020 (an average of 1.6 kg/year; Statistica, 2021). This has partly been directed by laudable efforts to reduce suckler cow bodyweight and therefore maintenance nutrient costs and resource use. Given the additional difficulty of processing and marketing larger carcasses to UK consumers, increasing carcass weight is not a sustainable strategy for UK beef production.

The other force behind the US beef industry's environmental improvements over time was increased daily liveweight gain (DLWG) that facilitated cattle being slaughtered at an average of 450 d in 2007 compared to 609 d in 1977. Age at slaughter has already been identified by Kamilaris et al. (2020) as one of the major determinants of production system efficiency in UK production and therefore an opportunity to cut both resource use and economic costs going forwards. At the simplest level, a reduction in slaughter age from, say, 24 mo to 21 mo, saves three months of pasture, water intake and GHG emissions. Given the gains in animal science knowledge over the past half century, it's therefore somewhat surprising that the average slaughter age of UK cattle hovers between 24–26 mo of age. This is partially cultural – the traditional nature of British beef production mean that many producers sell cattle at a fixed point in the year rather than according to liveweight and condition. This was echoed by Barber (2018), who reported that few suckler producers regularly weighed their cattle, relying on sale or deadweight values to estimate performance. Nevertheless, there is a significant opportunity for improvement though cooperative purchasing of weighing equipment between farms, or investment in new digital technologies that will provide image-based estimates of weight and condition score and allow cattle to be sold at the optimum time.

The suggestion that DLWG should be increased to finish cattle earlier may be met by resistance and the argument that it is not possible without considerable supplemental feed and therefore increased environmental impacts. Yet, by contrast, a considerable number of producers are already finishing cattle off grass at 24 mo of age. This cannot necessarily be achieved on every operation across the UK and the associated economic viability is dependent on input costs, support payments and system resilience (Kamilaris et al., 2020; Rutherford et al., 2021), however, premiums are being paid by some processors to enable this level of performance. If appropriate breeding goals are identified to ensure that cows and calves can make the best use of the resources available; pasture and feed are managed efficiently and with due regard for optimal production; and livestock health is made a priority to avoid sub-clinical and clinical disease losses; then the national average age at slaughter may be reduced, leading to sustainability gains.

It's rather a cliché to suggest that there are as many beef systems in the UK as there are beef farms, yet this aphorism contains a grain of truth. Debate therefore continues to rage as to the most sustainable breed for UK beef production systems. Although this discussion is likely to continue for decades, it is clear that the most sustainable breed is one that fits the opportunities and limitations of a specific farm and production system (Greenwood, 2021). It may therefore be time to recognise that although it's vital to improve communication and cooperation throughout the UK beef industry, it has essentially become two sectors – based on either suckler cows or dairy beef – and the sustainability goals and outcomes of each system must be assessed accordingly.

Many processors and retailers have come to recognise the reductions in GHG emissions associated with producing beef from dairy calves, given that a considerable proportion of the dam's environmental impacts can be allocated to milk production (Murphy et al., 2017). Dairy beef systems have considerable potential to improve environmental sustainability, especially if animals are reared and finished in either intensive or 24-mo systems, in addition to solving one of the major social acceptability issues of dairy production – the fate of dairy bull calves (Rutherford et al., 2021). Given the preponderance of AI and growing use of sexed semen in the dairy industry, there are also considerable opportunities to have a significant influence on the genetics of the resulting calves, while maintaining important dairy traits (Berry et al., 2019). The potential gains of this approach may be extended further by the use of assisted reproduction techniques and integrated dairy-beef programs similar to those described by Crowe et al. (2021) that make use of oocyte recovery and embryo transfer to ensure that dairy calf crops comprise only high genetic merit dairy heifers plus premium-quality beef calves.

Given the widespread media attention to GHG emissions from beef production, the suckler sector is likely to come under greater scrutiny going forwards and, as such, will need to be proactive in terms of demonstrating their sustainability benefits. As discussed by Wilkinson (2011); Hennessy et al. (2021) and Wilkinson and Lee (2018), both feed efficiency and land use for suckler beef production appears environmentally undesirable compared to cereal beef systems. However, the proportion of the land used for suckler production that could be used to produce human food and fibre crops is extremely low compared to other livestock sectors.

Hence suckler beef has an important sustainability role in making efficient and sustainable use of the 60% of UK land that is unsuitable for anything but pasture (DEFRA, 2020), which should be promoted to the processor, consumer and policy-maker. Nevertheless, this must be done in tandem with efforts to improve productivity through targeted breeding goals that allow producers to meet appropriate KPI (e.g. calves weaned at 50% of maternal bodyweight, high proportion of live calves born per 100 cows bred, pasture utilisation and stocking rates, age at slaughter, antimicrobial use, etc) while meeting processor specifications and maintaining excellent meat quality.

Ultimately, the sustainability of the UK beef industry may be improved by breeding and genetics, but only if three premises hold true. Firstly, appropriate breeding goals must be selected for the relevant systems, with due regard for current and future challenges within both beef and dairy production (Brito et al., 2021; Greenwood, 2021). These include (but are not limited to):

- A focus on feed efficiency to improve productivity, cut methane emissions and make best use of by-product feeds and forages that humans cannot or will not eat
- Meeting and exceeding sector-specific KPI
- Engendering resistance to both endemic diseases and to other health challenges that may occur in future as a consequence of climate variability
- Enhancing meat quality and flavour parameters
- Harnessing the potential to enhance meat's nutritional profile and market as a future functional food
- Accounting for other environmental metrics, e.g. water use, intra- and inter-species biodiversity, air pollution, etc.

Secondly, technology use should be encouraged and improved throughout the beef industry. This encompasses all types of technology, from the relatively prosaic (e.g. weighing cattle), to reproductive and other technologies that have existed for some time but have not been widely adopted (e.g. AI, sexed semen, embryo transfer); to new and innovative practices (e.g. genome editing, molecular breeding values) that are still under development (McFarlane et al., 2019; Terry et al., 2020). Crucially, these must be undertaken in combination with improved data collection, recording and benchmarking. This will be facilitated in future by electronic livestock ID and the development of platforms that allow different apps or services to be linked, thereby reducing both repetitive data inputs and inputting error, but must be initiated now to avoid a lag phase. Concurrent changes in farmer behaviour and on-farm practices may be achieved by greater use of peer-to-peer learning and discussion groups, as described by Morgans et al. (2019) when successfully evoking changes in antimicrobial use on dairy farms. Without clear data showing the gains made over time, it's impossible to demonstrate the beef industry's dedication to improving sustainability and therefore to mount a defence against the myriad challenges that are already building momentum. However, it is also essential that both the benefits of changes in management practice are clearly outlined to the producer. These may involve tangible environmental and economic gains such as described by Quinton et al. (2018) in their assessment of using AI to improve maternal traits in beef cows; may allow access to specific processors and retailers; or simply be associated with improved social acceptability (e.g. dairy bull calves being reared for beef rather than euthanised on farm).

Finally, improved communication both up and down the beef production, processing and supply chain is imperative. Processors and retailers are faced with the challenge of assessing the GHG emissions and other environmental metrics relating to their supply chain, and many will put policies, procedures and tools in place to source these data. These initiatives must be farm-focused, achievable and adoptable in order to be successful, and should be developed in consultation with farmers and allied industry. The ultimate final product is beef that is produced with a low environmental impact and conveys an excellent eating experience to a satisfied consumer. However, this relies upon upstream communication, with improved linkages needing to be formed between the processor or retailer and dairy and producers earlier in the chain. As discussed by Pritchard et al. (2021), data on ultimate end-product quality must therefore be fed back to dairy and suckler producers to allow them to make informed breeding decisions that enhance whole system sustainability.

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Breeding to achieve net zero – the power of genetics

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Better breeding can play a major role in achieving Net Zero, and new genetic indexes, introduced by AHDB in 2021, will help the process gather pace. By focussing on suitable traits in a breeding programme, it has been estimated that the dairy industry can reduce greenhouse gas (GHG) emissions by 20% over the next 20 years, simply by selecting better genetics. This is expected to be one of the most significant single contributors to the farming industry's cut in emissions.

There are various factors behind this confident prediction, ranging from patterns of progress which have been made historically, to the UK's independent research into feed efficiency. This is the most long-running and extensive trial of its kind in the world and has led to the creation of one of the nation's greatest dairy genetics research assets in the form of the largest known independent feed intake database.

Added to this is the fact that genetic changes are permanent and accumulate over the generations. This means a small, positive change made today can be multiplied exponentially across thousands of animals over the years ahead.

Historical context

But despite the promising outlook, dairy farmers have, in fact, been breeding to reduce GHGs since at least the 1990s, when genetic indexes to improve fertility, health and lifespan began to be introduced. This is because every step taken to improve the efficiency of dairy production is a step towards reducing emissions. Almost everything which has a financial implication, such as cutting waste and reducing culling, also has a beneficial environmental impact.

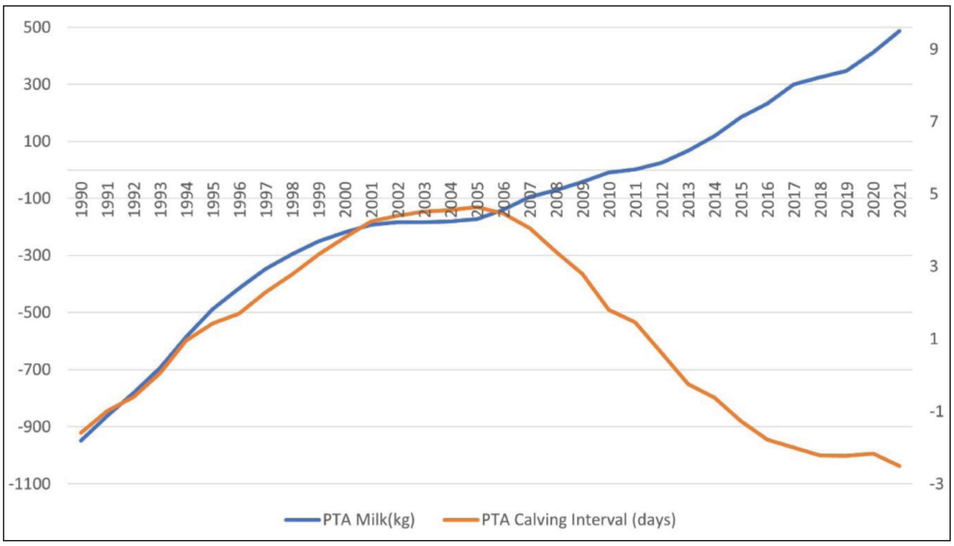
The impact genetics can have is demonstrated by many historical examples, not least in female fertility. This trait seriously declined between 1990 and 2005, when breeders made rapid progress in the genetics of milk production. But production and fertility are inversely related, such that producers were inadvertently selecting against fertility when they bred animals which gave more milk.

But when, in 2005, a female Fertility Index was introduced, the trend began to be reversed. Fertility Index was subsequently added to the UK's national breeding index, Profitable Lifetime Index (£PLI), and the momentum gathered pace. Figure 1 shows how calving interval seriously declined between 1990 and 2005, at which point the genetic trend completely changed direction. This has led to ongoing improvements since 2005 and today, and we now see the genetics of fertility is marginally better than it was in the 1990s and continues to head in a favourable direction. Even more pleasing is the fact that this has occurred while the industry has continued to make significant improvement in the genetics of milk production.

The power of genetics

All of this illustrates the power of genetics to help significantly and

Figure 1: Genetic merit of sires used in the UK, based on insemination data collected by NMR and CIS.



permanently address the dairy industry's challenges. This will be enhanced as new genetic traits come on stream, giving an increasingly favourable outlook for the prospect of cutting carbon emissions.

All dairy cattle breeders need to do is decide upon their direction of travel and make breeding decisions to reflect these goals.

Economic breeding indexes – £PLI, £SCI and £ACI

The dairy industry has supported this endeavour by creating economic selection indexes designed to help producers identify the best bulls and make informed breeding choices.

The UK's main breeding index, tailored for use in a typical, year-round calving herd, is the Profitable Lifetime Index (£PLI). This is formulated for UK market conditions and will help producers – through improvements in a range of its component traits including production, efficiency, health and fertility – to breed more profitable cows.

The Spring Calving Index (£SCI) and Autumn Calving Index (£ACI) do likewise, with slightly different formulae to reflect the breeding needs of spring calving, grazing based and autumn calving, winter-housed herds, respectively.

However, all three of these economic selection indexes, broadly places one third of their emphasis on production and two-thirds on health, fertility, lifespan and efficiency. For this reason above all, they have always ultimately improved the efficiency of milk production which has a knock-on effect on GHG emissions.

New environmental genetic indexes

Today, AHDB has pushed this direction of travel further by formulating some new genetic indexes specifically designed to improve the environmental efficiency of milk production. It has done this in consultation with the Genetics Advisory Forum, an industry body which includes farmers and processors with breed society, milk recording, RSPCA, AI company and veterinary representation. These participants collectively review the genetic progress dairy breeds are making, the long-term market outlook for inputs and output, and they fine-tune the UK's economic indexes as the need arises.

Working with AHDB's service partners, EGENES at SRUC (Scotland's Rural College), they introduced a HealthyCow index in 2021. Through this genetic index, producers can easily identify dairy bulls which will transmit the best overall health to their daughters.

While HealthyCow takes a step towards greater sustainability, this was even more specifically targeted when EnviroCow was launched later that year. This composite genetic index incorporates cow lifespan, milk production, fertility and, most importantly, the brand-new Feed Advantage index. This reflects the fact that the most feed-efficient animals also produce the least methane and makes EnviroCow the first independent genetic index in the world to focus solely on breeding cows for their environmental credentials.

Feed Advantage

The Feed Advantage component of EnviroCow predicts how much feed can be saved while maintaining a cow's milk production. Its calculation is based on around 30 years of feed intake data collected from two lines of cows in the Langhill herd, based at SRUC's Dairy Research and Innovation Centre.

Over this period, feed intakes have been measured from over 5,000 lactations and 2,000 Holstein cows throughout their entire lifetimes. This has created over 750,000 individual dry matter intake records.

Using this information, genotypes have been analysed and genomic predictions calculated such that it is now possible to predict feed intakes for all genomically tested Holsteins. These predictions have been demonstrated to work across the diverse range of genetic background and different feeding and production regimes across UK herds. And because feed intake has been found to be 18% heritable, there is scope to improve it through breeding.

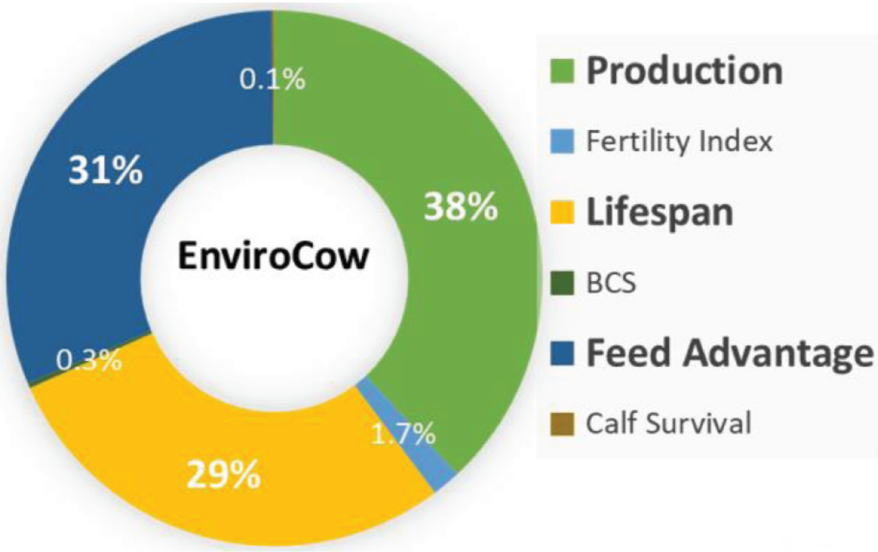
Feed intake information goes on to be used in the calculation of the Feed Advantage, which adds a further dimension to the intake data. By comparing actual feed intake with theoretical feed intake based on the amount of milk solids the cow is giving and the feed she needs for her own maintenance, the Feed Advantage identifies animals which are the most efficient converters. These are the cows which turn a lower intake of feed into more milk solids in the context of the size of the animal itself. Body size itself is another important factor contributing to additional feed intake and so Maintenance index remains an important part of Feed Advantage and reflects the fact that an animal which is efficient at 800 kg liveweight is not as efficient as an efficient animal requiring less feed for maintenance and whose weight is lower, at, say, 600 kg.

This is important in the context of the average size of animal in the national dairy herd which is now genetically 30 kg larger than in the 1990s. Across the national population, this means we already have to feed 60,000 tonnes of additional cow liveweight, just to maintain their additional body weight. This represents around 90,000 mature Holstein cows, or – in a herd of 200 – equates to 10 extra cows to feed each day.

The difference between the progeny of the most and least efficient Feed Advantage bulls is not insignificant, and the feed saving for one animal can be as much as 500 kg of dry matter per lactation.

By including Feed Advantage within the calculation of EnviroCow, using this index will cut carbon footprint. Methane is by far the most significant contributor to dairy cow emissions, and its production in the rumen is strongly linked to dry matter intake. However, the index is concerned with

Figure 2: Relative contribution of traits to the EnviroCow index.



intensity rather than gross output – in other words, how much methane is produced to create a kilogram of product, and that includes cull cow value as well as milk solids.

Figure 2 shows a breakdown of the EnviroCow index, indicating how the traits which contribute to an animal's environmental credentials are included in its formula.

EnviroCow is published for both bulls and cows, with a higher figure reflecting better environmental credentials. All milk recorded producers can gain access to their own herd's EnviroCow indexes which are available, free of charge, through AHDB in the Herd Genetic Report.

They will also note the strong correlation between £PLI and EnviroCow, confirming that animals which excel financially also tend to have better environmental credentials.

However, if breeders choose to target EnviroCow as their priority index, it is predicted that they'll have scope to reduce their herd's GHG emissions by around 1% per year. This means that over 20 years they can reduce their herd's emissions by 20% through breeding alone.

With an array of choices before them, producers are urged to take control of their futures and define their breeding goals, ensuring they're not a passenger directed by the whims of their breeding company.

Form vs function – how I am using genetics to deliver a cow fit for purpose at Clayhanger

Andrew Rutter
Partner at Clayhanger Farm Partnership and Herd Manager, Cheshire

After several years out in the industry, working with cows and eventually as a sire analyst for Genus for nearly two decades, I had the opportunity to come home and put what I had learnt into practice.

I formulated a breeding plan looking at where we were, where we were heading and where we wanted to go.

We were close to 400 cows with followers. A Holstein stock bull had historically been used but left the farm when I arrived for a combination of health and safety and genetic influence reasons.

The herd was running at 18% Pregnancy rate (Pregnancy rate is simply detection rate x conception rate) vs a national average then of 14%. We were selling just over 8,000 kgs per cow per year.

We were getting decent yields but noticed little response to feed changes in the heifer crop. Replacement rate ran at 18% meaning that we were working with a lot of older, more mature cows within the herd. Type wise, they had a fairly consistent cut, great udders, good balanced cows, but they were big framed cows, which wasn't what my research told me I needed. The sheds were under pressure. We were calving at 25–26 months on average.

Why were cows leaving the herd?

1. Barren
2. Mastitis
3. Lameness

So, not unlike most UK herds. We hadn't culled one for low production which was a concern, or for type, which was great.

As well as looking at why cows left the herd, what did our 'survive and thrivers' have in common? The 75 tonners and above tended to be below average stature within our herd, and usually fairly scarce in the 'notes' department in our uniform programme. The ideal cow here has six entries:

- Calved
- Bred
- Routine trim
- PD
- Routine trim
- Dry off

Was there any sire or sires having an impact? I found a huge raft of third and fourth calvers were sired by one bull. Looking at the data, this bull was running over 20% improved chance of daughters making it to fourth calvers than any other sire we had used at the same time. A PLI, health and management trait outlier in his day he had certainly delivered the goods for us. The cows did not have a flashy cut but were medium sized cows that carried a bit more bone through the hock. Udders are excellent and wearing well but his type trait linear shows mostly strongly negative bars. Form follows function.

We have traditional barns with mattresses and sawdust, and bunker fed cows. I have a relatively new parlour, and I want it to remain fit for purpose, so I need my cows to fit in it easily, along with all those cubicles outside. I was getting too many in the upper quartile for size, which were already starting to push the limits for infrastructure.

Our milk contract rewards lots of clean milk on a level dairy, with little incentive to push for high components. They are paying more attention to welfare and treatments such as antibiotic use of cows, so I need to future proof my cow, for if things change with contract demands or alternative buyers, with care for components, reduced carbon footprint and antibiotic use especially.

Efficiency is something that really interests me. If my cows can produce more, or the same, using the same, or reduced inputs respectively, ultimately producing fewer emissions and impacting the environment less, this is absolutely the way for my herd to go in my mind.

So that was the phenotype. How about the genotype, what did I have to work with for the next generation?

We have run a closed herd, so all our genetic progress really needs to come from within.

I ran a Herd Genetic Report powered by AHDB. It's my report card to how my herd is performing at a genetic level. The first thing that was apparent and quite unique (and not necessarily a good thing) was that my herd was fairly static in terms of genetic progress. That meant it didn't really matter which age group I concentrated on, as all offered the same level of EPTA to the next generation on average. We were sitting in the top 60%tile for PLI, below average for milk and solids, good for cell counts, but poor for fertility and maintenance notably.

My plan was to breed for the traits I needed, for the strengths and shortcomings I had, pushing progress as hard as I could, and let the cow end up looking like she looked like.

After years of watching and observing the rate of 'progress' we have seen in the breed for udder, and type especially has seen more significant progress in this area than any other. We have done more to change how our Holsteins look than how they perform on a health and welfare level and/or production. This is form hoping function follows, and it doesn't appear to be working as well as it could.

The average size of cows continues to trend upwards. The theme out there still suggests we want powerful cows so they can 'withstand the rigours of life and can eat more roughage'. I put it to you that we have skewed the population so far, that we have broken most of these relationships, if indeed some ever existed. My cows are becoming smaller, some of that is down to genetics, and the remainder down to calving earlier, and they are giving more milk, have less problems and producing more of that milk from higher levels of forage.

Clayhanger's Breeding Plan – Margins were really tight back in 2018, and about to get tighter as milk price dropped so I needed to strip costs out of the cow. Profit was my goal, so PLI was the starting point. I needed cows that could produce lots of milk efficiently and have it in them to respond to higher inputs if required, a then limiting point as I'd experienced with our previous crop of milking heifers. I wanted a lot more components within them, so I looked for a heavier weighting on total solids weights.

I wanted to develop a robust cow that could perform despite me, rather than because of me. For me, robustness means vigour and health. I don't need cows to be big to survive, I just need cows that survive. I keep plenty of emphasis at selection for health traits, specifically fertility, longevity and TBadvantage, and a big crank on lameness advantage.

And the elephant in the room, literally, how big my cows were, and how much bigger they could get unchecked. At the initial time for selection, the trait available was maintenance, one I have a lot of time for. We have broken the link between milk and size and so I was aware that I could really push on the traits I wanted to whilst taking overall size out. As soon as Feed Advantage became available, I put the emphasis on this instead, as ultimately my end goal is to be as efficient as possible.

So, those are the traits I concentrated on. I knew the more traits you put in, the more you dilute the ability to make notable improvements, so I limited it to those. Not a type composite or linear troubled my selection policy.

I switch the bulls I use every proof run, typically picking 7–8 bulls a run, and usually supplementing with later releases of a couple of sires during the run that suit my goals. With using purely genomic bulls, I need to spread my risk to best utilise their potential. I try to keep a variety of bloodlines in there, but I am more driven by absolute breeding value for my herd first. The drive for production is obvious but kept in check with profit and it shows a nice trend on feed advantage.

The rankings here really started to jump in the last year as we started getting well into generation two, and as of December 2021, we are now a top 25%tile milking herd, and our youngstock is safely in the top 5% and trending strongly.

So, how are they performing, and what can we put down to management and genetics? It's difficult to isolate either, but I know some things have remained fairly constant, i.e. the infrastructure and pretty much the diet for the milkers.

I think we are improving in transition diets and routinely foot trim all cows at 100 days and drying off which has made a massive difference in incidences of lameness. Fertility has moved with Pregnancy Rate going from 18–30%. There are a lot of things that we can put this down to, but truly it's a combination of me getting better at attention to detail, an RMS team that are on it, improved transition, better legs and feet, and ultimately cows that show much better heats and then hold, and that last bit is definitely genetics.

But what is that actually worth to me? We can assign a financial value to this, taking the herd from 18% to 30% is worth just over £65 per cow per year, or the equivalent to £5.50 per point per year. We can multiply this up to show the herd is more profitable to the tune of over 24k PA based on this improvement in fertility performance alone.

The reason we cull cows has skewed, with Johnes yellow specifically being our number 1 culling reason this year, with fertility and mastitis relegated to second and third. We still haven't culled a cow for poor udders, and certainly not one that's too frail or small, and are now in the position that we make voluntary culling decisions.

We calve our heifers at 23 months now, and they give more milk as 2 year olds than we have experienced before, in fact the whole herd is up on milk sold per year, despite being much younger. Pleasingly there is a noticeable improvement in increased milk from forage and we have experienced improved margins, despite until recently a pretty crippling milk price. Our cows from four years ago performances on today's milk price and cost of production would struggle to be sustainable.

So, my cows are on average a little younger, replacement rate has opened up to 30%, but there are mitigating issues, we sell a lot of milking second calvers, people seem to like the job our cows are doing and keep coming back for them, and we are complimented on the more compact size of our cows.

Crossing back to a point made earlier, how can we tell how much of our improved performance is down to genetics. A recent genetic audit shows strong results, looking at the link between genetics and performance on daughters all on the same system. We can see such a return on investment for production and fertility specifically.

Our girls are on the same management system, same diet, same group and has seen a strong impact on yield we are selling. For every extra litre of milk BV we are putting in, we are seeing 1.2 extra litres in the tank. For every extra kg of fat solids BV we are putting in we are getting over 1.5 kgs in the tank. And despite us already running at a high Pregnancy Rate level, we are seeing instead of the expected 0.5 days open per point of daughter fertility, we are actually seeing 0.8 day open improvement per point.

A quick summary of overall herd performance is seeing strong trends for fertility, milk and solids sold per cow per year. With this we are also seeing a big improvement in yield for forage, maximising what we can produce on farm and a strong trend on margins, which ultimately pays our bills, and this is despite a very challenging time for milk prices.

So, to the future. Are we future proofing our herd? A recent report by Promar found that a point of PLI was worth an extra £1.58 in improved margins over the cows' life.

We can compare where the herd could have been with no emphasis on breeding, and where it is now. The herd is now in the top 25%. The difference between this versus remaining in the top 60% is 104PLI in EPTA, so a Breeding Value (ie how good the cow herself should perform) improvement of 208PLI. Multiply by £1.58 is worth £328 per cow, multiplied by 380 cows should see an improved margin of nearly £125k improved margin for this herd compared to if they had still been a top 60%.

For the youngstock, now safely in the top 5%, again comparing them to a top 60% youngstock is £210epta PLI, or £420 BV. Multiplied by the Promar figure for PLI of £1.58 equals an extra £663 per heifer on average in improved margins over its productive life. That figures out to be over $^{1}/_{4}$ million.

Selecting for profit is paying dividends in the stock we have today and their performance here as well as setting us up to have a strong future. This for me is the ultimate definition of function. And for what it's worth, I think they are an impressive group of cattle to the eye as well as on the balance sheet.

Unlocking the secrets to improving cow fertility genetics

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Key messages

Novel, heritable traits that are measured earlier than current re-calving and mating traits could increase the accuracy of estimated breeding values (BV) for fertility and facilitate faster genetic gain in dairy cattle.

Using a unique research herd, we demonstrated that dairy cows with elite parent average Fertility BV had earlier puberty, shorter anogenital distance (AGD), more condensed calving, less time between calving and first ovulation, stronger and longer heats, earlier submission, and greater pregnancy rates than animals with an inferior parent average Fertility BV.

The suitability of age at puberty, AGD, oestrous traits (timing, heat strength and length), and timing of conception for predicting Fertility BV are now being investigated in a large-scale trial involving 5,000 dairy replacements across 54 herds.

The estimated heritability for age at puberty (about 30%) and its moderate genetic correlation with pregnancy rate during first lactation (about 0.45) support its further investigation as an early predictor trait for genetic improvement of fertility.

Background

Herd reproductive performance is a key determinant of farm productivity in seasonal-calving, pasture-based dairying systems, such as those operated in New Zealand, Australia, and Ireland. In New Zealand, herd reproductive performance is evaluated by the 6-week in-calf rate, defined as the percentage of the herd that conceives during the first 42 days of the seasonal breeding period; however, the national average 6-week in-calf rate of 68% (New Zealand Dairy Statistics 2020–21) is well below the industry target of at least 78%.

Many complex, interacting factors affect reproduction, including genetic merit for fertility. The Fertility Breeding Value (BV) was included in the New Zealand national breeding objective in the early 2000s to halt declining cow fertility, but subsequent genetic gain has been low. This is partially due to the low heritability (i.e.,≈5%) of re-calving and mating traits used to estimate the Fertility BV as well as the fact that sires have already been selected and widely used when daughter fertility phenotypes become available. The Fertility BV reflects the ability of sires to produce daughters that re-calve within the first 42 days of the herd's planned start of seasonal calving (CR42) during second and subsequent lactations. Being presented for mating during the first 21 days of seasonal breeding (PM21) in first and subsequent lactations are also included in the Fertility BV as predictor traits.

A research programme commenced in 2013 to identify novel, more heritable traits that are collected earlier than the current re-calving and mating traits, which will increase the accuracy of the Fertility BV and facilitate a faster rate of genetic improvement in fertility. Firstly, we demonstrated that a superior Fertility BV results in improved reproductive performance, thereby increasing farmer confidence in using genetic selection for fertility. Secondly, we aimed to identify underlying predictors for genetic variation in fertility. The methodology used was to establish a research herd of ~550 Holstein-Friesians with high/positive (POS; +5%) and low/negative (NEG; –5%) parent average Fertility BV (Meier et al., 2021a). To put divergence of these groups into context, the national average Fertility BV was +0.2% (standard deviation (SD)= +2.0%) for all heifers born in 2015 (n=561,675; *www.dairynz.co.nz/animal/animal-evaluation;* accessed 17 Aug 2021). This herd, known as the 'Fertility Animal Model', enabled us to identify key points of difference in the biology underpinning various reproductive measures between cows that are genetically fertile or sub-fertile but otherwise similar in other traits such as live weight and milk production. Thirdly, we selected the most promising earlier-in-life novel traits and tested the practicality of measuring these phenotypes at scale and, moreover, their suitability as genetic predictors of subsequent reproductive success. This work, consisting of the 'Puberty Scale-Up (PSU)' and the 'Fertility Scale-Up (FSU)' trials, is enabling us to provide recommendations on which novel phenotypes to pursue for further investigation as predictor traits in the Fertility BV. Here, we summarise the key findings to date.

Table 1: Heifer reproductive parameters in animals with a POS (+5%) relative to a NEG (–5%) Fertility Breeding Value. PR*x*=pregnancy rate after *x* days of breeding. Adapted from Meier et al. (2021a).

	POS	*NEG*	*Difference*	*P-value*
Eligible heifers (n)	275	248	+27	–
Age at puberty (d)	358	385	−27	<0.001
Live weight at puberty (d)	274	294	−20	<0.001
% mature live weight at puberty (%)	51	55	−4	<0.001
Pubertal at mating start date (%)	94	82	+12	<0.001
Interval from mating start date to conception (d)	13.0	16.6	−3.6	<0.001
PR21 (%)	75	62	+13	<0.05
PR42 (%)	90	82	+8	<0.05
PR98_final (%)	98	94	+4	<0.05

Fertility Animal Model

In spring 2015, the POS and NEG Fertility BV heifers, born from contract matings in commercial herds, were collected at ~9 days old to establish the research herd. We collected samples and data from these animals as they progressed through the heifer rearing phase (2015–17; Meier et al., 2021a), and during their first (2017–18) and second (2018–19) lactations (Meier et al., 2021b).

Heifer performance

The Fertility BV was associated with differences in the onset of puberty and heifer reproductive performance (Table 1; Meier et al. 2021a). The POS Fertility BV heifers reached puberty earlier and at a lower live weight and percentage of mature live weight than the NEG heifers, which meant that more POS heifers had reached puberty by the start of seasonal breeding. Consequently, the POS heifers conceived, on average, 3.6 days earlier, with a higher pregnancy rate (PR) during their first breeding season. Our results indicated that the timing of puberty and conception in heifers are potential early predictor traits of genetic merit for fertility.

Calving pattern

The earlier puberty onset and conception of the POS heifers advanced the calving pattern during first lactation by an average of 4 days relative to the NEG heifers (Meier et al., 2021b). By lactation 2, the difference was 12 days earlier, with 16% more POS animals re-calved within the first 42 days of the seasonal calving period. Hence, timing of the calving that initiates first lactation is a useful, earlier trait than PM21 or CR42.

Resumption of cycling, submission rates and reproductive treatments

Substantially more POS than NEG cows were submitted during the first 21 and 42 days of artificial breeding during both first and second lactations (Table 2; Meier et al., 2021b). The extremely poor submission rates for NEG Fertility BV cows were due to the large percentage of NEG cows still anoestrous after 42 days of breeding, which required CIDR hormonal interventions (Table 2). Furthermore, the NEG Fertility BV cows that cycled spontaneously postpartum (i.e., without interventions) still had a 9 day longer anoestrous interval in both lactations. The ability to resume oestrous cyclicity postpartum is a key driver of reproduction and is captured in the current PM21 and CR42 traits included in the Fertility BV. Nevertheless, the inclusion of additional measures, such as timing of first heat postpartum, pre-mating cycling rate or accounting for hormonal interventions may result in more accurate Fertility BV.

Timing of conception and pregnancy rates

On average, the POS Fertility BV cows conceived 12 d earlier (relative to the mating start date) than the NEG Fertility BV cows (Table 2; Meier et al., 2021b). Differences in PR in both lactations 1 and 2 were similar, with approximately 30% more POS cows pregnant by 42 days of breeding compared with NEG. The superior reproductive performance of the POS cows was driven by their greater ability to resume cycling post-calving, which could not be explained by differences in milk production or metabolic status. Furthermore, the high percentage of NEG cows that failed to get in calf resulted in high culling rates and, therefore, poor survival rates between lactations. There is an opportunity to use foetal-aged pregnancy diagnosis records, which are now routinely collected on 2 million cows annually, and are available earlier than calving records, to improve the accuracy of the Fertility BV.

Table 2: First and second lactation reproductive parameters in animals with either a POS (+5%) or NEG (−5%) Fertility Breeding Value. SR*x*=submission rate after *x* days of breeding; PR*x*=pregnancy rate after *x* days of breeding. All data are corrected for calving season day relative to 1st June each year. Final PR are corrected for use of CIDR hormonal treatments for anoestrus after 42 days of breeding. Adapted from Meier et al. (2021b).

	POS	*NEG*	*Difference*	*P-value*
1st lactation				
Cows (n)	249	216	+33	–
SR21 (%)	87	49	+38	<0.001
SR42 (%)	95	55	+40	<0.001
PR21 (%)	54	26	+28	<0.001
PR42 (%)	67	34	+33	<0.001
PR98_final (%)	78	68	+10	0.294
Conception rate to 1st service (%)	57	52	+5	0.499
CIDRs after 42 days (%)	5	46	−41	<0.001
Interval from mating start date to conception (d)	20	31	−11	<0.05
2nd lactation				
Cows (n)	204	121	+83	–
SR21 (%)	88	63	+25	<0.001
SR42 (%)	94	73	+21	<0.001
PR21 (%)	45	29	+16	0.245
PR42 (%)	74	44	+30	0.132
PR76_final (%)	86	72	+14	0.238
Conception rate to 1st service (%)	54	51	+3	0.4814
CIDRs after 42 days (%)	6	30	−24	<0.001
Interval from mating start date to conception (d)	22	34	−12	<0.005

Oestrous activity characteristics

Oestrous strength and duration, measured using activity monitoring devices, are candidate traits worthy of further investigation. Cows with POS Fertility BV had longer (~1 h), more active oestrous events than NEG cows, but the inter-oestrous interval was similar between the two groups (Reed et al., 2022). These stronger, longer heat events may support easier heat detection, enabling more animals to be bred at the correct time. Similar differences in oestrous activity between the POS and NEG animals were evident as maiden heifers (Reed et al. unpublished data).

Anogenital distance

The POS cows had a shorter anogenital distance (AGD; the distance between the anus and the genitals) than NEG cows when measured at about 29 months old during first lactation (Grala et al., 2021). Furthermore, reproductive performance of both POS and NEG heifers was substantially less in those with longer AGD (Grala et al., 2021), indicating that AGD is a promising trait for improving accuracy of Fertility BV.

Puberty/Fertility Scale-Up Trials

We are currently testing novel fertility traits in a 2018-born population of 5,000 Holstein-Friesian and Holstein-Friesian x Jersey crossbred animals across 54 herds. Our first objective is to determine the phenotypic variability and heritability of our measures of age at puberty, AGD, and oestrous characteristics. Our second objective is to determine if these novel, earlier-in-life traits are predictive of reproductive success during first and second lactation.

Age at puberty and anogenital distance

Herds were visited on three occasions to collect blood samples when the average (±SD) ages of the heifers in each herd were 299±15 days old (visit 1; V1), 327±15 days (V2) and 355±15 days (V3). The visits were timed to capture variation in puberty onset between animals. Age at puberty was defined as the age of the animal at the visit when their blood progesterone concentration reached a threshold of ≥1 ng/mL for the first time, or their age at V3 plus 31 days if they did not exceed this threshold in any collected samples. Live weight, stature (height and length) and AGD were measured at V2.

The average age at puberty was 352±35 d, with 20% of heifers having attained puberty by V1, 39% by V2 and 56% by V3. We observed a large variation in the rates of puberty among herds at each visit as well as in the age at puberty among individual heifers, which were phenotypically associated with body measures (i.e., a younger age at puberty was detected in animals with a heavier live weight, both absolute and as a % mature live weight, and a larger stature at V2). Furthermore, heifers with a greater % Jersey reached puberty earlier, whereas those with a greater % overseas Holstein ancestry reached puberty later, indicating that routine phenotyping strategies will need to consider these breed differences.

Using our scalable measure of puberty onset, a moderate heritability of age at puberty of about 30% was estimated from pedigree or genomic data. This is considerably larger than the ~5% heritability of either PM21 or CR42. Furthermore, our results demonstrate that just two, or even one, herd visits to obtain blood progesterone tests could provide sufficient data to rank animals accurately for age at puberty, which has important implications for routine data collection. Likewise, AGD is about 25% heritable. Reasonably rapid gain can, therefore, be made through genetic selection for these traits.

Pregnancy during first lactation and its correlation with heifer traits

Foetal-aged pregnancy diagnosis was undertaken between 11 to 14 weeks after the herd's start of mating during the first lactation. Several different traits defining reproductive outcomes were investigated with PR42 (a binary PR trait indicating the ability to conceive during the first 42 days of breeding) being the most robust for genetic parameterisation purposes. Current analyses indicate that the genetic correlation between age at puberty and PR42 is about 0.45, with a credibility interval of about 0.25 to 0.60. This moderate genetic relationship indicates that around 20% of the genetic variance in PR42 can be explained by age at puberty. We are now following PSU/FSU trial animals through their second lactation to determine how these relationships hold with successive parities.

Oestrous activity derived traits

A subset of 2,000 animals across 17 herds had activity monitoring devices attached to a hind leg during the PSU trial and again during the FSU trial from 2–3 weeks before calving until pregnancy diagnoses. These data are being analysed to derive oestrous activity traits, including age at first detected oestrus as a proxy for age at puberty, interval from calving to first heat, pre-mating cycling rate, and oestrous strength and duration. Wearable devices offer opportunities to collect fertility phenotypes across large numbers of animals.

Conclusion

Overall, the POS relative to NEG Fertility BV was associated with earlier puberty, shorter AGD, more condensed calving, reduced time between calving and first ovulation, stronger and longer heats, earlier submission, and greater PR. Our results should increase farmer confidence that selection for cow fertility will lead to tangible improvements in herd reproductive performance and have supported a revision of the Fertility BV, launched December 2021, to better reflect the timing of calving from first lactation onwards. Importantly, we have determined biological differences controlling reproduction that could be used to develop novel, early-in-life traits to accelerate genetic gain enabling faster improvements in a herd's inherent fertility. Measures related to age at puberty, AGD, oestrous traits (timing, heat strength and length) and timing of conception are now being tested at scale. Preliminary results suggest age at puberty is a suitable early predictor trait of reproductive success for genetic evaluations.

Acknowledgements

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Ovum pick up (OPU) – a veterinary perspective

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Ovum Pick Up (OPU) is a non-invasive technique for recovering oocytes or egg cells from the follicles of live cows. OPU is done by needle-guided, trans-vaginal ultrasound that recovers the oocytes using vacuum suction. The oocytes are washed, sorted, and graded. The oocytes are then In-Vitro fertilized, cultured, and finally frozen in individual straws. The frozen straws are returned to the dairy to be transferred into the uteri of recipient cattle.

The OPU process was originally developed to assist with human infertility.[1] It was performed in cattle for the first time in 1988 by Dutch researchers at Utrecht University.[2] The oocytes recovered using OPU are turned into embryos using a process called In-Vitro Fertilization (IVF). IVF of cattle was first performed in 1981.[3] In other words, OPU and IVF are mature technologies that are several decades old.

If OPU and IVF are so great, why has it taken so long for them to catch on? In my opinion, interest in OPU/IVF has increased in recent years because of the arrival of two other technologies: Genomics and sex-sorted semen. Clarifide is a genomic test marketed by Zoetis that provides Genomic Predicted Transmitting Abilities (GPTA's) that are significantly more reliable than traditional parent average/pedigree index values. Thanks to the arrival of a low-cost, reliable genomic test, OPU/IVF has the ability to accelerate genetic progress in cattle at an unprecedented rate. The ability to use sex-sorted semen doubles the amount of female offspring that can be produced by IVF.

The advantages of OPU/IVF:

- decreased generation interval
- acceleration of genetic progress by leveraging female as well as male genetics
- generates more pregnancies from a single dose of semen
- generates more pregnancies per donor
- ability to rapidly multiply valuable or rare genes

Genetic progress per year can be expressed with the following formula:

$$\text{Genetic Progress / Year} = \frac{\text{Genetic Variation x Accuracy x Intensity}}{\text{Generation Interval}}$$

Genetic Variation measures how variable the trait is in the population and is the one factor in this equation that breeders do not control.

Accuracy is the correlation between the real genetic value and the estimated genetic value. Historically, progeny or pedigree records were used to calculate Predicted Transmitting Abilities (PTA's). PTA's or more recently GPTA's are often used as the estimate of the genetic value.

Intensity measures the difference between the parents and the population average. If the parents are close to the average, the Intensity is small. If there is a big difference between the parents and the average, the Intensity is large. In other words, the selection Intensity reflects whether the parents are from the top 25%, 5%, 1%, etc. of the population (i.e. percentile rank).

Generation Interval (GI) is the amount of time between birth of an individual and birth of its replacement. Because GI is the lone term in the denominator of the genetic change equation, it has the largest impact on Genetic Progress per year.

Historically, Accuracy and GI are tied together. To increase Accuracy we needed older bulls with more progeny records and older cows with more production records, thus GI increased.[4] Thanks to genomic data we can use GPTA's to identify the best bulls in the breed and the best heifers in the herd within months after birth. Genomics help alleviate this negative relationship between Accuracy and Genetic Interval.

Moreover, in intensive breeding programs younger animals often have superior genetic merit compared to older animals, thus using young animals increases the selection Intensity. Genomics allow us to increase Accuracy and Intensity while simultaneously decreasing Genetic Interval. Artificial Insemination (AI) studs have been using this Genomic technology since it was introduced.

Everyone that uses commercially available semen from AI studs has benefitted from this increase in Genetic Progress per year on the bull side of the genetic equation. However, Genomics can also give the same benefits on the cow side of the genetic equation if dairies utilize it in their heifers.

OPU can also be used to decrease Generation Interval even further. OPU can be performed on heifers as young as 6 months of age. We routinely start heifers as young as 7 or 8 months in our lab in Idaho. If the Generation Interval in heifers is 22 months, by using OPU we can decrease the GI by 6 months. That is a 28% decrease in GI. This decrease in GI and the advantage of increased Intensity and Accuracy by using genomics to select breeding stock in heifers has the potential to accelerate Genetic Progress per year tremendously in your herd in particular and the Holstein breed in general.

When OPU is done on a heifer, her oocytes are washed, graded, and are placed in a micro-centrifuge tube full of maturation media (MAT tube). After the oocytes have been placed in the MAT tubes they are placed in an incubator at 37.5° C and transported to the IVF lab.

The IVF process has an average production rate of 30%, thus meaning that 30% of all oocytes fertilized will develop into viable embryos. Historically, the oocytes from each heifer are fertilized separately. Fertilization is one of the most expensive parts of the process as it includes the cost of the semen and the cost of the actual IVF procedure. The cost per embryo is lower for donors who produce large amounts of oocytes compared to donors who produce less. This custom of fertilizing each donor's oocytes in a different fertilization group puts the price per embryo very high and makes it less attractive to commercial dairies. However, by pooling donors into fertilization groups, we can maximize the amount of oocytes that are fertilized in one fertilization group and lower costs significantly.

The average number of oocytes collected is about 15 per donor per OPU session. There is a large range of variability in the amount of oocytes collected between donors. Some donors give 30 oocytes, some only give 5. However, donors are usually very consistent in the amount of oocytes they produce. For example, a heifer that gives a large amount of oocytes can usually be depended upon to always give a large amount of oocytes. The opposite is also true, heifers that start out giving only a few oocytes can always be depended on to disappoint.

Fertilization groups can contain 40–60 oocytes. For example, if we take 4 donors who produce 15 oocytes a piece and pool them into one fertilization group of 60 oocytes we will reduce our fertilization expenses by 75%, when compared to fertilizing each of the four donors separately. Also, fertilizing 60 oocytes with one dose of semen is a very efficient use of semen.

Although there is great variability in oocyte production, it is possible for a heifer to produce over 50 calves per year.[5] This is remarkable when you consider that without OPU, the typical cow produces only one calf per year. If sex-sorted semen is used, it almost doubles the amount of females that are produced when compared to conventional semen. Using sex-sorted semen in OPU avoids spending valuable resources to produce bulls that will not contribute to the herd. This ability to rapidly multiply genes can be particularly useful when the desired traits are valuable or rare. Examples are animals with genes for: polled, A2 beta-casein, Net Merit $, disease resistance.

OPU has the advantage that it can be performed without giving donors any hormones prior to the OPU session. However, many veterinarians recommend a series of Follicle Stimulating Hormone (FSH) to increase follicle size. FSH does not increase the number of follicles only their size. In an internal study run by Trans Ova Genetics, FSH was found to increase the number and quality of viable embryos per OPU. Additionally, FSH in dairy animals adds about 2.4 embryos or about 51% more viable embryos per OPU.[6] While a series of FSH injections is expensive, the increase in viable embryos actually decreases the cost per embryo. FSH also increases the ratio of Grade 1 to Grade 2 embryos. This increase in embryo quality results in higher transfer rates when transferred into recipients.

The OPU process is performed by a veterinarian and an embryologist. The Veterinarian uses an ultrasound with a micro-convex probe encased in a probe holder. The probe holder encases a needle guide. The author prefers the short needle system developed by the Brazilians. The needle is connected to a vacuum pump that provides suction to aspirate the oocytes. Oocytes are collected in 50ml conical vial. Warmers for the collection vials are essential in order to keep the oocytes at the correct temperature. Once oocytes are collected the embryologist takes over and washes, sorts, and grades them. The embryologist then places them in maturation media and puts the oocytes in a battery powered incubator suitable for transport. Oocytes are overnighted to the IVF lab. The Lab fertilizes, cultures them for 7 days, and then freezes the embryos. Embryos are returned in liquid nitrogen to the dairy where they are stored until they are transferred into recipients using a specialized technique similar to AI.

Veterinarians interested in adding OPU to the list of services they offer should undergo training in the procedure. I received my training from Trans Ova Genetics. They were kind enough to train me how to perform the OPU procedure. I also went and observed other veterinarians who offered OPU services. Trans Ova Genetics also trained my embryologist as well. The cost of training for both me and my embryologist was about £2,500 and didn't include travel expenses. I spent several months practicing on cows before our first OPU session. At first, everything went very slow. We did about 10 heifers every session and that took all day. As we developed competency, we were able to speed up and OPU more heifers. Currently we OPU between 20–40 heifers per OPU session. We average about 6 donors an hour.

The equipment needed will be:

- Micro convex ultrasound console with good resolution
- Vacuum pump with a tube warmer, boost button, and pedal
- Probe holder
- Battery operated warmer for 50ml conical tube
- Battery powered incubator
- Cryo-tank to hold frozen embryos
- Tokai Hit Glass Heated Stage Warmer
- Olympus SZ61 Stereo-Microscope with LED base
- Slide Warmer
- Water Bath
- Pelican travel cases for transport of equipment

When I purchased the equipment in 2017, the cost was approximately £30,000. WTA and Trans Ova Genetics have proven to be valuable resources for advice on purchasing equipment.

In conclusion, OPU is a mature technology that when combined with IVF, genomics, and sex-sorted semen can accelerate genetic progress. Once out of reach of commercial dairies, strategies like pooling donors are putting OPU within their grasp.

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Using genomic data along with OPU and IVF to accelerate genetic progress

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Our family owns and operates a 2,000 Holstein cow dairy with about 3,000 replacements and beef crosses in southwest Idaho. We also farm about 3,500 acres raising corn, corn silage, alfalfa, and cereal grain forage to feed the herd. My parents bought the 100 acres that the dairy sits on in 1960 and began to milk about 40 Guernsey cows. They transitioned to Holsteins in the 1970's, adding cows and land when the opportunity arose.

In the last 30 years many large dairies have moved into our area which has put pressure on both the cost of labor and feed. These dairies are much larger, many thousands, even 10's of thousands of dairy cows and they can achieve an economy of scale that I don't have with only 2,000 cows.

Consequently, we were searching for an effective way to be competitive and stay in business. About five years ago one of the vets that works with us, Dr. Garth Millard, proposed the idea of building a better cow utilizing Ovarian Pick Up (OPU) and In-vitro Fertilization (IVF) in conjunction with the recently developed genetic test for Holstein cows. I had some experience with the genomic test when it first came out because I had too many replacement heifers due to our successful use of female-sorted semen. We tested 1,500 Holstein heifers and used an index value, Lifetime Cheese Merit Dollars (CM$), to cull the bottom 20–25% before they freshened. Zoetis, the company that developed the genomic test, tracked the cows through their productive lifetime analyzing milk production, disease incidence, reproductive performance, and productive life. Table 1 is from a presentation that Dr. Mark Kirkpatrick from Zoetis put together using those heifers tested back in 2011 and 2012. They divided the animals that calved into quartiles based on an index metric called Dairy Wellness Profit Dollars. Females from the top quartile generate much more income than the bottom two quartiles. How do we get all of our animals into that top quartile? OPU and IVF give us the ability to greatly accelerate genetic advancement.

Table 1: How does DWP$ impact the milk check?

n=1253, YB=2011–2012	*ECM*	*ECM income*
76–100% (Best) DWP$	72,011 lbs	$12,967
51–75% DWP$	67,907 lbs	$12,015
26–50% DWP$	64,139 lbs	$11,286
0–25% DWP$	59,878 lbs	$10,561
Difference = Top 25% – Bottom 25%	**12,133 lbs**	**$2,406**

Each cow in the Best DWP$ group generated **$12,967** in income due to production
$12,967 × 312 cows = **$4,045,647** income for entire group

Each cow in the Worst DWP$ group generated $10,561 in income due to production
$10,561 × 310 cows = **$3,274,006** income for entire group

Difference = **$771,641**

Milk price = $2.63 × fat lb + $2.80 × protein lb + $0.26 × other solids – $0.0072 × milk lbs
–$0.0072 is hauling and check off costs

After we visited an OPU lab in Washington State, we consulted with the IVF lab that we wanted to use and worked with Drs. Andy and Garth to develop a plan. The veterinary clinic invested in training and equipment needed to perform the OPU procedure and we decided to begin testing the top third of our heifers based on parent average to identify donors and building a facility dedicated to OPU. As you might imagine, there were a few setbacks and surprises along the way, but the veterinarians and our management were committed to the process. Once we finally had the facility built and were producing frozen embryos, the next challenge was finding someone competent to transfer them. Fortunately, an artificial insemination (AI) company we were working with helped us train our current AI technicians and one of them became very adept at embryo transfer (ET) to embryo recipients.

Our next challenge was to get the cost of the frozen embryo as low as possible. Table 2 on page 36 is a snapshot of the spreadsheet that we use to monitor the ongoing costs for us to produce a frozen embryo. For

Table 2

Date	# Heifers	Ova Found	Avg	Ova Developed	#G1	#G2	%G1	%G2	Avg	EDR	# Pools	$OPU	Semen	$FsH	$ Fees	TOG Fee	Total	Avg Per Session	Avg per Embryo	Total Generated
6.07	29	289	10.0	116	82	34	71%	29%	4.0	40%	6	$ 3,480	$ 250	$ 1,364	$ 2,100	$ 4,640	$ 11,834	$ 102.02	$ 113.84	6219
6.21	20	134	6.7	46	35	11	76%	24%	2.3	34%	3	$ 2,400	$ 250	$ 941	$ 1,050	$ 1,840	$ 6,481	$ 140.89	$ 114.03	6265
7.05	17	132	7.8	38	25	13	66%	34%	2.2	29%	3	$ 2,040	$ 250	$ 800	$ 1,050	$ 1,520	$ 5,660	$ 148.94	$ 114.24	6303
7.19	17	162	9.5	58	51	7	88%	12%	3.4	36%	4	$ 2,040	$ 270	$ 800	$ 1,400	$ 2,320	$ 6,830	$ 117.76	$ 114.28	6361
8.02	18	244	13.6	65	51	14	78%	22%	3.6	27%	5	$ 2,160	$ 250	$ 847	$ 1,750	$ 2,600	$ 7,607	$ 117.03	$ 114.30	6426
8.16	19	201	10.6	66	47	19	71%	29%	3.5	33%	5	$ 2,280	$ 250	$ 894	$ 1,750	$ 2,640	$ 7,814	$ 118.39	$ 114.35	6492
8.30	19	212	11.2	51	41	10	80%	20%	2.7	24%	5	$ 2,280	$ 250	$ 894	$ 1,750	$ 2,040	$ 7,214	$ 141.45	$ 114.56	6543
9.13	19	245	12.9	91	64	27	70%	30%	4.8	37%	5	$ 2,280	$ 150	$ 894	$ 1,750	$ 3,640	$ 8,714	$ 95.76	$ 114.30	6634
9.27	16	200	12.5	82	57	25	70%	30%	5.1	41%	4	$ 1,920	$ 190	$ 753	$ 1,400	$ 3,280	$ 7,543	$ 91.99	$ 114.03	6716
10.11	15	215	14.3	48	34	14	71%	29%	3.2	22%	5	$ 1,800	$ 200	$ 706	$ 1,750	$ 1,920	$ 6,376	$ 132.83	$ 114.16	6764
10.25	16	154	9.6	59	36	23	61%	39%	3.7	38%	3	$ 1,920	$ 80	$ 753	$ 1,050	$ 2,360	$ 6,163	$ 104.45	$ 114.08	6823
11.08	13	152	11.7	49	28	21	57%	43%	3.8	32%	3	$ 1,560	$ 135	$ 612	$ 1,050	$ 1,960	$ 5,317	$ 108.50	$ 114.04	6872
11.22	14	176	12.6	29	9	20	31%	69%	2.1	16%	4	$ 1,680	$ 150	$ 659	$ 1,400	$ 1,160	$ 5,049	$ 174.09	$ 114.29	6901

us, there are three main factors that determine the cost of an embryo:

- How many oocytes each heifer produces
- The percentage of oocytes actually recovered in our lab
- The embryo development rate (the percent of oocytes that develop into embryos)

In Table 2, the first blue column is the average number of oocytes found per donor. The next column is the total number that session that develop into embryos. As you can see, recently our average embryo per donor has been between two and five with a development rate between 16 and 40 percent. One of the keys for us to hold down the cost of an embryo is to pool donors; in other words, we will put the oocytes from two to five donors together and use one unit of semen to fertilize the group of oocytes. Therefore, we can use one fertilization for up to 70 oocytes. On the right-hand side of the table, we have the average cost per session per embryo, and the next column shows our average cost per embryo since we started about 4 years ago which is just over $114 USD. Drs. Andy, Garth, and I have spent many hours thinking about and changing the program to reduce the cost of the embryos. $115 USD per frozen embryo is very reasonable, especially considering semen from elite bulls can run over $100 USD per unit, but there is still room for improvement.

An additional factor that determines the cost to get a live calf on the ground is the transfer rate (pregnancies per transfer). By evaluating pregnancy rates (pregnancies per transfer or insemination) in both cows and virgin heifers we found that the grade one frozen embryos perform as well as Holstein semen. Pregnancy rate is reduced with grade two embryos, 15 to 20 points lower in the heifers and five points lower in the cows than grade one embryos. That is why we track the grade 1 to grade 2 ratio in the spreadsheet (Table 2). One downside to the pregnancies created using embryos is the higher abortion rate. In virgin heifers, our abortion rate with semen is 3–5%, with frozen embryos it is nearly 20%. With cows, our abortion rate with semen is 5–7% with frozen embryos it is about 10%. With all these considerations, it costs us about $300 USD more to produce a live calf with an embryo versus artificial insemination. Is this extra expense and risk justified? Referring back to Table 1 we can see that we are able to create more than enough income to justify the extra cost if we move the genetic merit of the offspring from the bottom two quartiles to the top quartile.

Figure 1 shows our genetic progress versus the average cow in the breed using Net Merit dollars (NM$), which is a widely accepted index here in the US. Until we started utilizing OPU and IVF, we were breed average or just slightly above. Now after just 3 or 4 years, you can see our progress has accelerated relative to the breed.

Another way to look at genetic progress is with Figure 2, which is generated from our dairy herd management software. Here we are looking at CM$, which is very similar

Figure 1

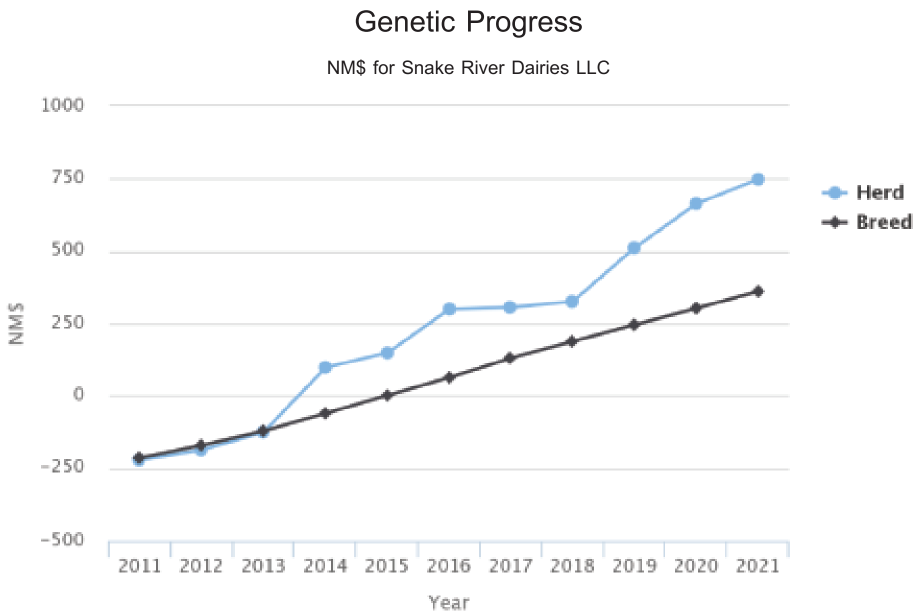
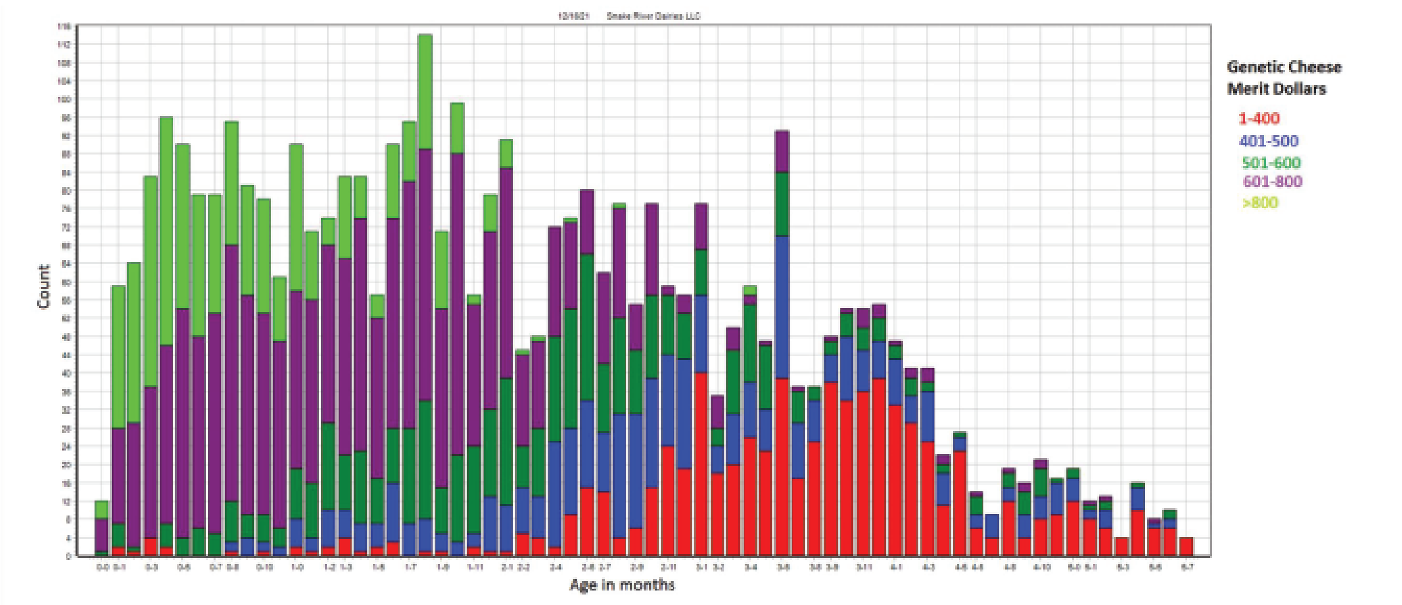


Figure 2



to NM$. Each bar represents a cohort of calves born in the same month with the youngest being on the left. In the space of 3 or 4 years we have gone from most of the animals born having a current CM$ value under 400 to having nearly all above 600. Progress has been accelerated by removing average female genotypes from the genetic pool and replacing them with elite donor alleles.

One of the unexpected consequences of this technology was producing an outlier heifer calf that generated interest from AI studs; we sold her for tens of thousands of dollars to help offset some of the costs of this program. We hope that one day fairly soon we will be able to produce bulls that AI companies will be interested in.

Looking at Figure 2 you might notice a few of the lower CM$ animals, the red color, creeping in again. That is another serendipitous consequence of our adventure with this technology. Because our team has done well transferring embryos and raising the calves, we were noticed by a group of cattle breeders that are making milk cows and bulls for different markets than the commercial market that we are in. They don't necessarily test high on the indexes we use but can be quite valuable in other situations. Those calves have just started hitting the ground, but early indications show that it could be an important source of revenue for our operation.

Does this genetic advancement translate to revenue in a commercial dairy setting? After all, that is why we decided to go to this expense and trouble, to be the most profitable, sustainable, and lowest cost producer making milk for the consumer. Table 1 shows that it is measurable and valid,

Figure 3

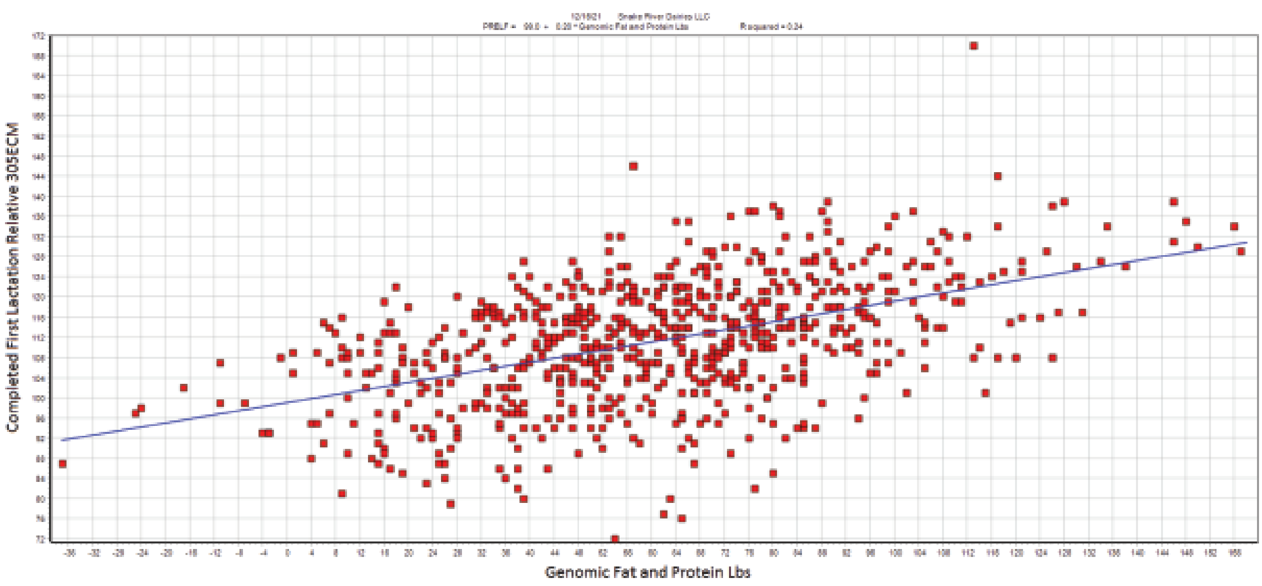
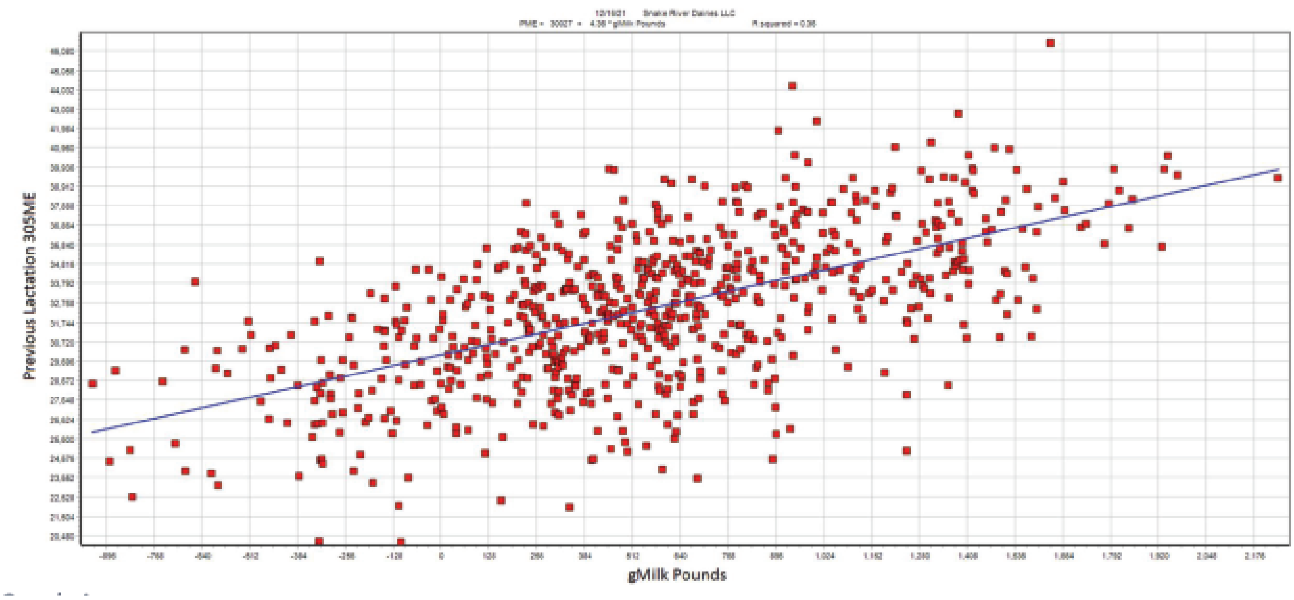


Figure 4



but that data has been compiled and processed by the company that stands to gain from the use of the genetic test. Is there anything I can look at here on the dairy that is simple and straightforward that can tell me if we are on the right path?

Fortunately, there are a few metrics that we can easily and accurately measure here on the dairy that correlate to specific traits from the genomic test. Figures 3 and 4 display two metrics that allow us to evaluate influence of genomic traits on cow performance. Figure 3 shows the relationship between predicted milk production and actual milk production; this scatter-plot graph displays 305 day mature equivalent production from first lactation cows that have a genomic test. Figure 4 is the same population but compares genotype to 305 day mature equivalent energy corrected milk, which adjusts their milk production based on fat and protein percentage.

In addition, daughter pregnancy rate (DPR) genotype is highly correlated with conception rate on the dairy. Cows with DPR values exceeding 1.5 have conception rates 81% higher than those below –1.5. These kinds of results give me confidence that most, if not all, the predictions are accurate.

A few things to consider before travelling down this path:

- Is my calf raising program up to par? When we started IVF-ET our calf program needed some work. We were able to make quite a bit of progress, but it really wasn't as good as it should have been and as a result we lost too many ET calves. Nothing concentrates the mind like losing money because of poor preparation, but with some good advice and direction we were able to get things corrected quickly.
- Is there enough infrastructure, talent and facilities, for me to achieve my goals or will I have to build out or develop some expensive resources? Do I have trusted advisors that will be there to work through the problems that will arise? I was very fortunate on these fronts, especially with the people that were working with me, including family and employees.
- Obviously, the payoff for a commercial operation is several years down the road. Can I wait that long to start recovering my costs?
- One other mistake that I made was not knowing my market. Selection metrics for elite genetic calf sales are not necessarily the same as those for a commercial dairy.

My experience has been with Holsteins, other breeds may be much different as far as oocyte yield, embryo development rate and transfer rate.

Overall, the decision to use OPU and IVF-ET to advance genetic progress has been a good one. Profitability has not yet been achieved since most of the ET animals we have produced are too young to be milking, but I'm confident that our decision to build a better cow is leading to a competitive advantage with greater sustainability.

Stress-free milking for you and your cows

James Duke, ADF Milking
James Lywood, Dairy Farmer

James Duke and James Lywood spoke to Karen Wonnacott during the lunchtime workshop at the BCBC Conference, where they introduced the concept of 'intelligent venting' to help combat the adverse effects of high vacuum levels on teat health, utilising the new ADF InVent milking system. A breath of fresh air for stress-free milking – literally!

ADF Milking recently launched their new technology, InVent, building upon the proven results of their automated dipping and flushing technology. ADF InVent now raises the bar further with the integration of intelligent teat-by-teat liner venting – in a lightweight, reliable cluster. The new ADF InVent milking cluster continuously controls vacuum levels on each teat individually – resulting in calmer cows, less teat damage, higher yields and faster milk let down – bringing you the ultimate in cow comfort and unrivalled precision.

James Lywood manages an 18-point Herringbone parlour, milking a herd size of 200. He installed ADF in August 2020 and installed InVent in December 2020. Each milking was taking 3.5 hours. So, adding more cows – two or three more rows – would have pushed this to at least four hours per milking. He was sure the ADF system was a way to milk more cows through the same parlour, with the same number of staff, without taking more time. The cows are milked twice a day by one person. James is pleased with the performance of the automatic cluster flushing and teat dipping – not least because it's shaved 20 minutes off milking time.

The ADF InVent system automates the post-milking hygiene routine to a higher quality and with more reliably consistent results than many other alternative methods – saving time, reducing labour costs and more efficient use of consumables and resources.

James explained that we know we're not compromising udder hygiene or the milking routine and doesn't like things to be complicated. For the majority of milkers, it's a case of spray, wipe and clusters on, with the ADF system doing the rest once milking is complete. The system has given peace of mind and saves time, with the scope to be able to milk more cows and keep within three hours in the parlour. This also means the interval between the two daily milkings will stay the same and we have been able to start milking a little later in the morning, at 4.30am, with the afternoon milking starting at 3.00pm.

The herd's average somatic cell count has always been pretty good, but it's fallen by 15,000 cells/ml since installing the ADF and InVent. Average SCC now stands at 113,000 cells/ml for the herd. Prior to installing the ADF system, only 7% of cows required antibiotic treatment for mastitis. This is now down to just 4% in 12 months. James does see other cases in the herd, but they self-cure with NSAID treatment and a little TLC.

'It didn't take a lot to convince me to install InVent, on the back of the results we'd seen with the ADF. Once I understood the additional benefits the technology offers, which go far beyond quicker and "kinder" milking, it was a no brainer,' said James.

Since the installation of InVent, the milk yields have increased by an extra litre a day per cow, potentially gaining around 300 extra litres per lactation for freshly calved cows. The herd is currently averaging 11,300 litres of milk at 4.6% butterfat and 3.5% protein.

There are teat condition and udder health gains to be made, the cows are being milked out more gently and completely. Stress is also kept to a minimum – for the cows and also, ultimately, the person in the pit.

Reduction seen in kicking, fidgeting and defecating in the parlour, then calmer cows then go back out into the sheds to drink, eat and lie down. There must be other hidden health, fertility, productivity and efficiency benefits to be had here.

'Cows should also, ultimately, complete more lactations in the herd. Only time will tell, but I'm excited to see more benefits become apparent as we move forward,' explained James.

ADF InVent

Every farmer knows it is impossible to select a liner size that works for each cow and every individual teat. In a conventional milking cup, it is this compromised choice of liner sizing that means some teats will suffer from a poorly fitting liner. This in turn leads to several negative effects. With intelligent venting, the risk of congestion and swelling of the teat is significantly reduced because the

ADF InVent milking cluster continuously controls vacuum levels on each teat individually.

ADF InVent introduces clean, filtered air into the liner to pull vacuum levels back into the safe zone enabling milk to flow as fast as possible compared to the conventional milking cup where the teat is congested and impeding milk flow.

'ADF Invent customers are reporting excellent results – all, without exception, said cows were calmer and quieter. Some are getting an extra litre of milk per cow, with one producer seeing yields increase by two litres a cow. And not only are the cows milking out fully, but they're also milking faster and with significantly fewer cases of mastitis and lower SCCs. One producer has seen milking times reduced by 30 minutes – they milk three times a day so that's 1.5 hours a day, or 548 hours in a year – equivalent to 68 eight-hour shifts,' says James Duke.

ADF InVent is available now, to find out more contact ADF Milking directly at 01243 814030. For more product information visit ADFmilking.com.

About ADF Milking

ADF Milking is proud to produce the market leading Automatic Dipping and Flushing system. ADF Milking are committed to improving cow health, with the award-winning product being recognised by dairy industry experts around the world for its innovation and technology. It started with a vision to increase efficiency in post milking hygiene methods. At ADF Milking it is the needs and demands of their clients that drive and inspire them to innovate as a business. From the first prototypes in 2004 to the state-of-the-art system they continue to develop today, they have had a passion for improving cow health as a key driver for increasing farm profitability.

BCBC

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