British Cattle Conference

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The British Cattle Breeders Club

DIGEST 76

‘Our breeding goals learn from the past to focus on the future’

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Annual Conference Papers

26th January 2021

British Cattle Conference

Organised by

The British Cattle Breeders Club

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Message from the Chair

After a day focussed on a computer screen and praying that technology behaved itself, I am able to reflect on a programme packed with a mixture of world class scientists, producers and practical cattle breeding discussion. The 2021 British Cattle Breeders Conference was a significant milestone for the club as we delivered our first ever online conference and brought my year of Chairmanship to an end. I'd like to thank the BCBC Committee for electing me and for their support; it has been a truly great honour to have been Chairman and to have played a part in the Club's rich history.

Whatever direction the committee decide to go in for 2022 I have no doubt that the Conference will continue to go from strength to strength in both content and profile. Feedback from delegates for the online version has again emphasised just what a fantastic forum the BCBC is to highlight and discuss not just new science and innovation but also practical technologies and opportunities.

The theme of the 2021 conference was all about learning from the past but very much focussing on the future and ensuring that as an industry our breeding goals enable us to meet the challenges and opportunities that are coming our way in the cattle sectors. We have seen over many years how cattle breeding has greatly benefitted from the appliance of science, new technologies, and innovation. In this 'new era' I have no doubt that science and innovation will never have been more important for farmers, both now and for generations to come. New thinking, and strengthening the ability to innovate, will provide the advances and improvements that will increase efficiencies and produce populations of animals that can respond to the demands of a changing market place. By the nature of cattle breeding new science adopted today may take years to deliver its full reward, so we have to ask ourselves what science, new technology and innovation can also add value to beef and dairy production in the short and medium term? Also, how do we engage young people, encourage their passion for agriculture and secure their future?

The fact that the conference was online meant that we were able to involve a greater number of international contributors and so assemble a line-up of world class speakers from research, industry and farming who were truly inspirational for all that attended. By taking an overview of the sectors and then covering subjects from practical breeding approaches, genomic developments and the likely environmental challenges, I hope there was something for everybody and by encouraging more colleges to engage with the conference we were also inspiring the next generation to get involved in our fantastic industry.

Finally, can I thank all of our sponsors for their support, which enabled us to continue to deliver a conference, and also those people who have supported me as we faced an ever-changing world. The committee, particularly my vice chair Karen Wonnacott, plus Andy Dodd for the numerous Zoom calls, but most of all the ever-efficient Heidi Bradbury, our company secretary, who would admit to being on a steep learning curve but managed to pull everything together as always with invaluable help from ESW.

The British Cattle Breeders Club has a proud history and after proving it can rise to modern day challenges, even if they were a little unexpected, I am sure it has a bright future and so I wish Karen and Amy all the best in planning the 2022 conference. I look forward to seeing you there!

Clive Brown

The British Cattle Breeders Club

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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

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1994–1998	Malcolm Peasnall
1999–2000	Janet Padfield
2000–2015	Lesley Lewin
2015 *onwards*	Heidi Bradbury

Optimising beef selection in Northern Australia

Rebecca Burnham
Australian Beef Producer and International Nuffield Scholar, Boogal Cattle, Eidsvold, Queensland, Australia

Rebecca aims to breed profitable cattle to thrive in northern Australia, while addressing social concerns and environmental signals. Rebecca travelled to 14 countries during 2019 as part of her research to discover how to further optimise her herds genetic progress in traits of importance, especially those that drive profit and are not recognisable by eye, eg fertility, feed efficiency, carcass yield and eating quality.

Growing up working at Boogal Cattle, Monto QLD, with her family, Rebecca was curious how to select cattle with only visual tools in the hard to measure traits. In addition, time spent away at university, as a beef consumer meant Rebecca experienced a wide variation in the eating quality of beef. Rebecca left the family's seedstock business and spent 15 years co-managing a commercial beef breeding and fattening business. During this experience, many herd management changes of the *Bos indicus* breeders resulted in fewer inputs and more calves from the same number of cows, along with increased kilograms/ha and improvement in the Meat Standards Australia (MSA) index or eating quality. In short, more profit from management change. Rebecca learnt first-hand that the combination of environmental and herd management changes had a big impact on production and profit.

While these improvements were satisfying, Rebecca knew that fertility and eating quality could be further improved with genetics. The difficulty encountered was sourcing bulls for the above-mentioned 'hard to measure' traits (HTMTs) that would meet or supersede management improvement and breeding objectives. The purchase of bulls was a larger annual expense, yet these purchases had previously been made visually, as no breeding values were available and therefore with little attention to return on investment. Bull buying seemed to be a gamble.

We are driven to question things, when motivated by a greater need or want. Does Jan Bonsma's dictum of a 'man must measure a epitomise our future road in Australian beef? Hence, Rebecca decided to apply for a Nuffield Scholarship to research world best practices in selecting and breeding for profit.

The key aspects of animal breeding were summarised concisely at the beginning of the authors research journey, at the Animal Genetics and Breeding Unit (AGBU), Armidale Australia, into this basic formula (Johnson, Wolcott, & Walmsley, 2019).

Phenotype = Genotype + Environment

Phenotype is the animal. The measurable and visual traits, or the expression of the genes that are distributed to the progeny, as a result of the sire and dam pairing.

Genotype refers to the DNA of an animal, or the distribution of genes from relatives.

Environment is the effect that the quality of pasture or nutrition, climate or health status has on the chosen genetics, or 'E' for everything else.

Animal breeding can be described as the management of both the genetic and non-genetic *differences* to breed a desired animal. (Johnson, Wolcott, & Walmsley, 2019).

The introduction of genetically superior bulls is one of the quickest ways to achieve change in a beef cattle herd. As genetic change is permanent and cumulative, the effect of a single bull's genetics will remain in a herd through retained breeding females and their descendants for decades. Therefore, ensuring that each new sire has a positive genetic and profitable impact in the herd is vital. (BREEDPLAN, 2020)

In the author's visits to production enterprises around the world, extraordinary genetic gains were observed in beef and other animal species. Commonalities identified were:

a) clearly defined 'long-term' breeding objectives

b) ongoing animal measurement (collection of phenotypes)

c) genotyping

d) genetic evaluation

e) and the use of <u>all</u> the selection tools available

Globally it was noted that leading livestock operations were focussed on

breeding animals that not only achieved profitability yet fulfilled environmental and consumer expectation goals.

Currently there are many genetic selection tools available in the Australian cattle breeders toolbox. They could be summarised as visual selection, pedigree, physical measurement, genotyping and genetic analysis. BREEDPLAN was released for beef industry use 36 years ago, with over 70% of southern Australian bulls offered for sale supported by EBVs, whereas in northern Australia only 15% of sale bulls are accompanied by EBVs. Therefore, it is not surprising that, on average, the current rate of genetic progress in British breeds is just over $4/cow joined/year, compared to the Northern Australia's rate of genetic progress of just $1/cow joined/year (Banks, 2019).

Increased measurement of northern cattle would increase our range of selection tools in the genetic toolbox. Selection is never based on one attribute alone. As Mark Gardiner from Gardiner Angus, Kansas USA states, 'Why not select the bulls that will make you the most money?' and he adds 'Just use ALL the tools available!' (Gardiner, 2019).

Of the national beef herd, 64% is located in northern Australia (Queensland, Northern Territory and northern Western Australia), and the remaining 36% inhabit southern Australia (ABARES, 2019).

Figure 1: MLA Beef Regions – northern and southern Australia (ABARES, 2019)

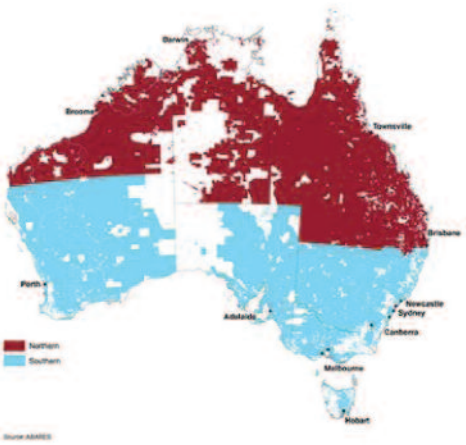


Table 1: Potential for improvement in northern Australia (Holmes & McLean, 2017)

	Areas of Performance	*Income increase*	*Physical Result (Holmes & McLean, 2017)*
5% increase	Reproductive rate	7%	Extra five weaners from every 100 cows
1% decrease	Mortality rate	2%	One less death per 100 cattle run
5% increase	Average sale kgs	4%	Average sale kgs of all animals sold increases by 5%

Beef CRC results showing low weaning rates of 62 and 78% for Brahman and Tropical Composite, respectively, suggests opportunity to improve reproduction rates, thus productivity and profitability for northern beef breeders (CRC, 2003). Northern Australia can benefit from improving reproductive rate, sale weight and decreasing mortality, within the limitations of carrying capacity and available markets as shown in Table 1 above (Holmes & McLean, 2017). These authors also found that the top 25% of producers in the northern region, despite these challenges, have a significantly higher Earnings Before Interest and Tax (EBIT).

The differences between northern and southern Australian beef operations range from climatic differences, pasture quality, scale and proximity to markets. All are contributing factors to the moderate and low results observed (MLA, 2019).

Australian beef producers operate in varying environments. However, there is potential to manage what we can control. The Australian Beef Report 2017 stated two barriers to profit in the beef industry are Operating scale (Number of animal units) and Operating efficiency. Assuming an adequate operating scale and number of animal units, three factors that influence operating efficiencies and are able to be managed by producers:

- Grazing land management
- Herd management
- Genetics (Holmes & McLean, 2017)

While the importance of grazing land and herd management in overall business profitability can never be underestimated, the authors global research showed how focussed genetic selection has played a role to complement existing best practice management and improve overall business profit and sustainability.

Genotyping

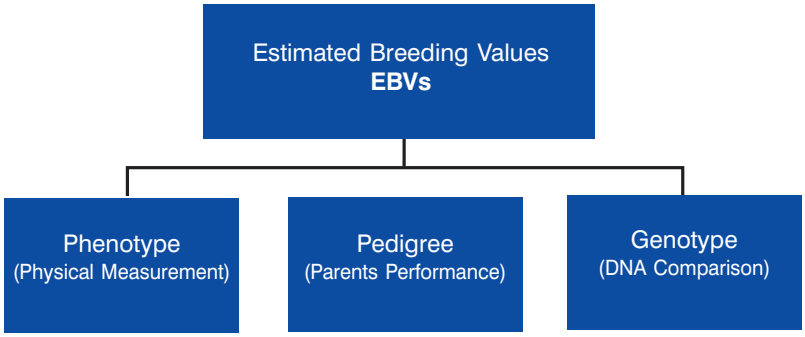
In Australia, genotyping tests became available as early as 1963, then in 1993 with micro satellite technology and more recently single nucleotide polymorphism (SNP) technology in 2011–13; however, adoption has increased significantly since 2018 (Neogen, 2021). Genotyping offered diagnostic results for parent verification or genetic disorders in early years. Nowadays with sufficient phenotypes, genomics can evaluate the genetics of an animal by combining information on pedigree, phenotype and genotype to produce a Breeding Value (BV). Cattle that have never been measured before, now can gain a breeding value from genomics.

Although easy to collect and seen to be a 'silver bullet' for northern Australias lack of breeding values, genomic evaluations cannot exist without the physical measurements with which to compare. Utilising one platform of measurement for genetic evaluation is not as accurate as combining all platforms; phenotype, pedigree and genotype (Bertram, 2018) (see Figure 2 on page 7).

Phenotyping

Currently the collection of phenotypes are difficult and expensive to record

Figure 2: Increasing the accuracy of EBVs with multiple sources of information (Bertram, 2018)



in the extensive and rough terrain that northern Australias cattle exist. It is hoped that innovation and adoption of new technology observed globally may help to increase the phenotype collection in northern Australia. The integration of modern technology for animal measurement was observed at dairies, research stations and universities globally, mostly in intensive situations.

The collection of animal data observed, could be divided into the manual or automatic collection of phenotype. The main types of automatic measurement observed were:

- Individual animal management and monitoring

  e.g. On-animal sensors collecting Behaviour, State and Location

- Paddock based management and monitoring systems

  e.g. Walk Over Weighing (WOW), Auto-drafting

Date of birth is a trait that is difficult and time consuming for seedstock producers to capture in the extensive paddocks of Northern Australia. However, to be 7 days out on date of birth results in a 4% inaccuracy on the 200-day weight breeding value (Hudson, 2020) and distorts the accuracy of other breeding values in genetic analysis. The following are some alternatives seen both globally and in Australia to the current manual data collection of this trait.

Calf Alert is a telemetric device placed in the vagina of a pregnant cow with 100% tested retention for at least 6 months. It is capable of identifying the time and location of calving events and alerting the producer via SMS or computer messaging. (Stephen, D Menzies, Patison, Corbet, & Norman, 2019) Raoul Boughton of University of Florida had also tested a similar product, VIT or vaginal implant transmitters (Broughton, 2019).

Figure 3: Telemetric Calf Alert Device in the authors hand (Comiskey, 2019)

CQU Precision Livestock Management technology integrates on-farm walk-over-weighing systems (WOW), low-band width data transmission technology and sophisticated analysis systems to deliver real time information about individual animals and infrastructure direct to a mobile app. The project aims to record several phenotypic measurements for inclusion in national genetic evaluation programs. It will also enable commercial producers to manage individual animals with targeted nutritional supplementation, temporal sequencing for age of puberty with cameras and video recognition etc. The date of birth for more than 120 calves has been successfully captured at AgForce's Belmont Research Station, QLD, Australia.

For more information:
https://www.datamuster.net.au/

Figure 4: Remote Australian WOW at a water yard (Central Station, 2020)

However, easier than the above-mentioned and part of routine breeder management may be considering the use of ultrasound foetal aging at pregnancy diagnosis to ascertain date of birth for genetic analysis.

Age at puberty and lactation anoestrus interval are some of many HTMTs that contribute to the complex profit driving trait of fertility. Research performed in the Cooperative Research Centre (CRC) for Beef illustrated the genetic variation in age at puberty as shown in Table 2 below, (BREEDPLAN, 2020). Currently Australian research projects are measuring by internal ultrasound to provide information to incorporate fertility information as breeding values for tropical breeds and across breeds. Developments were observed to measure oestrus with automatic modern technology such as individual collars and tags, promising to replace the current manual ovarian scanning for northern beef fertility phenotyping.

Table 2: Mean and range for all heifers at age of puberty trait and age at 1st CL (TBTS, 2020)

Trait	*Mean*	*Range*
Age at 1st CL (months)	23	11–40
Weight at 1st CL (kg)	332	196–485

Table 2 illustrates the huge genetic variation that exists in our northern cattle herd. The future is being able to have the tools to select the genetics that suit an operations breeding objective. Many other novel traits and applications of modern technology were observed, however just these two key profit driving traits have been covered for the BCBC digest.

Conclusion

Given the recent surge of interest in genotyping in Australian Beef, this study was to learn what modern technology can offer our industry, especially in optimising selection. Although cattle with no prior measurement could gain breeding values through genomics, the authors investigation uncovered the importance of innovation around the collection of phenotype measurements. Phenotypes are needed to support genotyping. Hopefully modern technology can increase the amount of current measurement and change the paradigm that measurement is difficult in northern Australia, as without continual physical animal measurement, genomics will be dust (Hayes, 2018).

In addition to establishing an efficient management template for grazing land and herd management, Australian beef producers should seek to optimise their selection and profitability by utilising ALL the genetic selection tools available. It was observed in many global examples, if it can be measured, it can be managed.

References

ABARES. (2019, December 18). Australian Government. Retrieved from Department of Agriculture – Australian Bureau of Agricultural and Resource Economics and Sciences: https://www.agriculture.gov.au/abares/research-topics/surveys/beef#data-and-other-resources

Banks, R. (2019, July/August). Mr. MLA Feedback, pp. 2–3.

Breedplan. (2020, Jan 7). Breedplan. Retrieved from ABRI :http://breedplan.une.edu.au/tips/Maximising%20Genetic%20Improvement%20in%20a%20Seedstock%20Beef%20Breeding%20Enterprise.pdf

Bertram, J. (2018, July 9). (R. Comiskey, Interviewer)

Boughton, R. (2019, August 20). Dr (R. Comiskey, Interviewer)

Comiskey, R. (2019).

CRC, 2003

Gardiner, M. (2019, September 10). Gardiner Angus, Kansas USA. (R. Comiskey, Interviewer)

Hayes, D.B. (2018, September). (R. Comiskey, Interviewer)

Holmes, P. and McLean, I. (2017). Australian Beef Report. Retrieved from www.bushagri.com.au

Hudson, S. (2020, July). (R. Burnham, Interviewer)

Johnson, D., Wolcott, M. and Walmsley, B. (2019, July 22). Animals Genetics and Breeding Unit. (R. Comiskey, Interviewer)

MLA. (2019). Global Snapshot Beef. Retrieved from https://www.mla.com.au/globalassets/mla-corporate/prices—markets/documents/os-markets/export-statistics/jan-2019-snapshots/global-beef-snapshot-jan2019.pdf

Neogen, (2020, 2021). (R. Burnham, Interviewer)

Pryce, Jennie. (2020) Genetics Australia 2020 Webinar – Session 6

Stephen, C., D Menzies, D. S., Patison, K., Corbet, N. and Norman, S. (2019). Telemetric monitoring of calving using a novel calf alert device. Clinical Theriogenology, Vol 11, No 3.

TBTS (2020) Tropical Breed Technical Services. http://tbts.une.edu.au/media/1062/variation_puberty.pdf

Adapting to the changing consumer landscape and maximising future consumer opportunities for the meat industry

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There have been significant changes in consumer dynamics in light of Covid-19 with 2020 turning out to be a year nobody could have predicted. We are all aware of the impact Covid-19 has had on our day-to-day lives, with everything from panic buying in the supermarkets and working from home to high unemployment and school closures.

All of this has led many people to re-evaluate their needs and priorities, for both themselves and their families, especially with the added financial pressure of a recession.

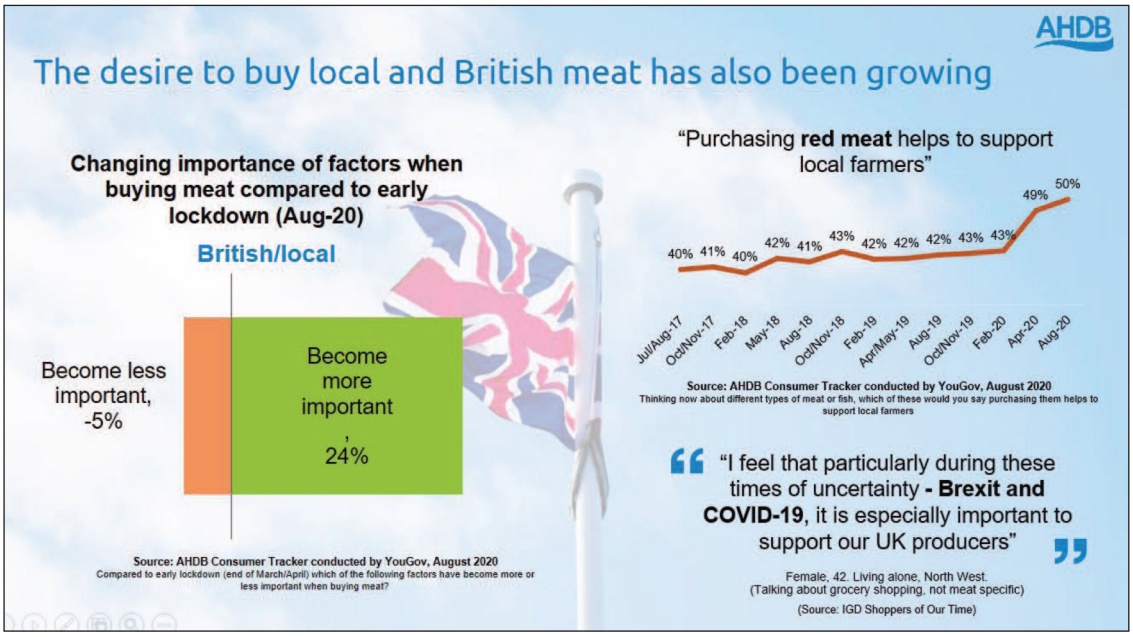
What we eat and where we shop has seen a dramatic shift over the course of the year.

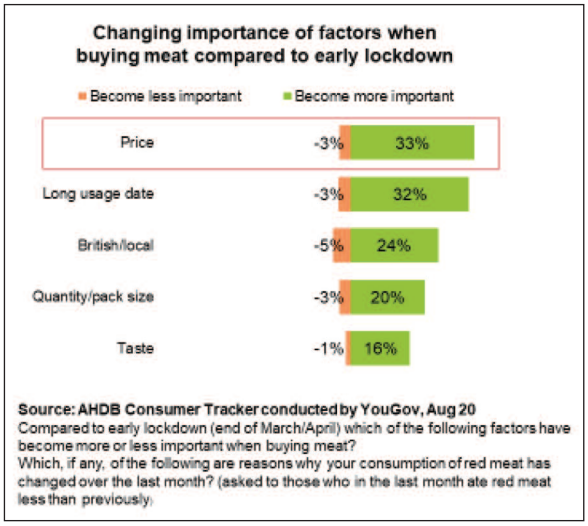
Meat purchase habits during 2020

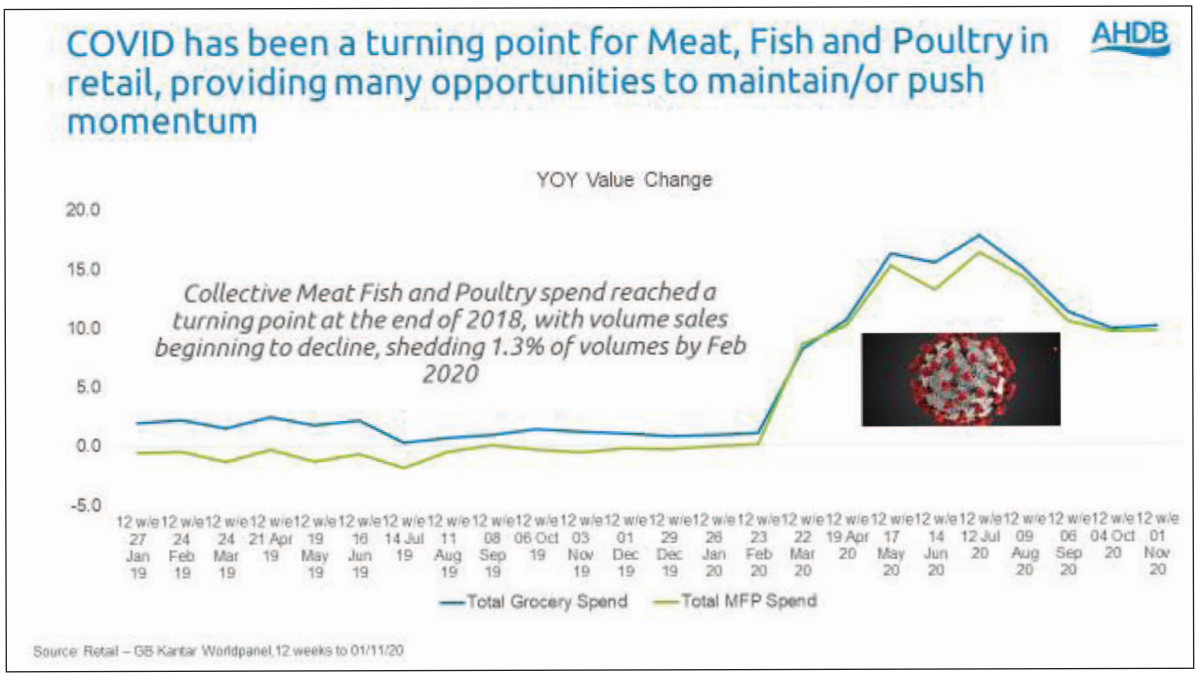
The economic ripple effect of Covid-19 led consumers to re-evaluate their buying behaviours – with price, value for money and buying local becoming more of a priority during lockdown. This led to wider reputational issues such as health, animal welfare and the environment easing off, as factors which consumers had greater control over rose to the surface. However, these concerns are reemerging and it is critical that the meat industry take steps to bolster the reputation of red meat.

Evidence from AHDB's consumer tracker research showed that with the pandemic dominating the news, negative media around red meat fell – with fewer people reducing their average consumption of red meat. The desire to buy local and British meat grew during 2020.

But it's important to remember that simply labelling products as British is not enough to convince shoppers.







Communicating to consumers on the benefits of local is vital, in particular the quality and trusted messaging that comes from buying British. During the second half of 2020 evidence from AHDB/YouGov Consumer tracker signalled that 33% stated price had become more important to them. This sensitivity to price is likely to be critical to consumers, particularly at the current time, when household budgets are being squeezed.

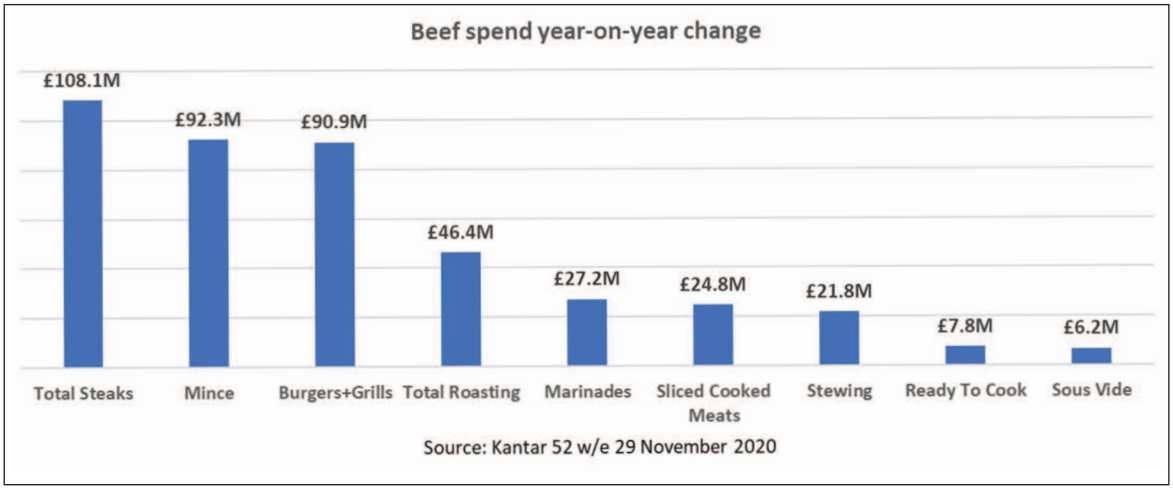
For Beef the largest actual growth in retail spend was around steaks, burgers and mince. These cuts proved popular during a large part of 2020 due to the closure of food-service, resulting in a significant rise in meals cooked in the home.

Overall red meat spend across retail outlets increased 12% in the 52 weeks to 29th November (Source Kantar Worldpanel). However, butchers outperformed traditional retail outlets with growth of 22.6% compared to the previous year. While that growth is positive for local butchers, it's vital they communicate quality and don't assume shoppers will stay, as the longer-term trend pre Covid was a channel in decline.

Meat and Health

Covid-19 created a health paradox, with many people anxious about the pandemic and its impact on their health, but also feeling a desire to comfort eat. While healthy eating means different things to different people, the top health priority for most consumers was eating more fruit and vegetables.

Health remained the main reason stated behind those who claimed to be reducing their meat consumption, with evidence from AHDB/YouGov Consumer Tracker showing this as a critical topic for consumers. While 'health' dipped in intensity as a claimed reason for reduction during April 2020 (23%) it did bounce firmly back in August (41%).



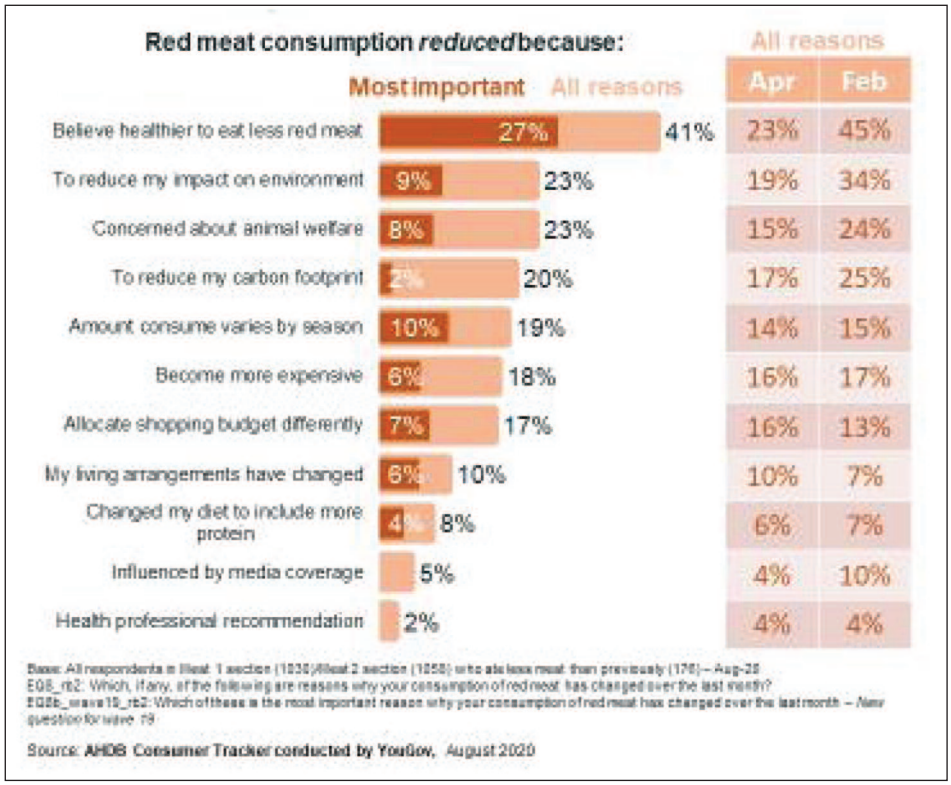
During significant periods of 2020, there were signs that consumers were thinking more about comfort than health and choosing traditional meals that they associate with good, hearty dinners for the whole family. In the longer term with the government's new obesity strategy being proposed, some red meat products such as back bacon and 20 per cent beef mince, could be impacted, both in retail and out of home.

This all highlights the importance of communicating the nutritional benefits of red meat to ensure the sector remains in a strong position now health concerns are starting to reemerge.

Consumers and the Environment

On balance, most consumers believe farmers care about the planet with 64 per cent in agreement (AHDB/Blue Marble Trust Research 2020). And with more people buying local this year, farmers and independent retailers have a great opportunity to capitalise on shoppers' approval ratings.

When it comes to what people can do themselves, issues such as food waste and plastics are top concerns. There are lots of different exposure points for consumers on environmental messaging, with many consumers finding it confusing in regards to what is global and what is local. This provides difficulties for consumers to separate what they see on a documentary to what happens on farm. In the longer term, there has been a significant rise in the desire from consumers to see businesses tackle environmental topics, with the agricultural industry not alone in being urged to promote any environmental initiatives.

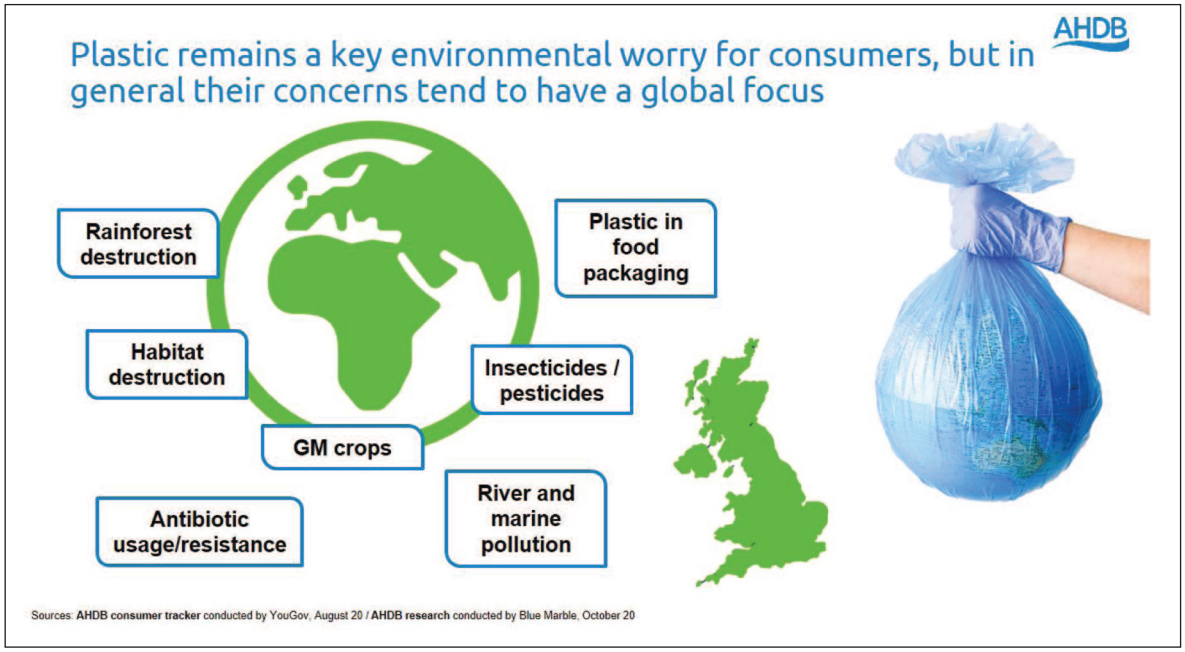


In recent years, concerns about the environment has led to a rise in meat-free products as the majority of consumers believe a vegan diet is more environmentally friendly. However, during lockdown, the number of households buying meat-free dropped by almost two percentage points – while the number of households buying red meat grew in comparison.

This is clearly welcome news for our livestock sectors, although experts warn that reductions may be temporary. In what is still a relatively small market, the meat-free sector is expected to grow in the longer term.

Looking ahead

We know that a lot of the shifts in buying behaviours are the result of the pandemic and while red meat had a reprieve from negative media coverage and enjoyed a year of strong growth, concerns around



reputational issues have not disappeared and will rise back up consumer's radar in the long term.

It is vital that industry addresses concerns around the environment, communicates the nutritional benefits of red meat as well as promoting the high welfare and quality of buying British. Simultaneously consumers will also be adjusting to 2021 in the backdrop of a hard economic reality that will start to influence behaviour changes in British homes. AHDB combine the evidence on consumer demand with how product supplies are changing to produce a forward picture to produce Agri-Market Outlooks. These can be found here https://ahdb.org.uk/agri-market-outlook

Behaviours characteristics to watch as economic ripple effect takes shape

Consumers seeking value – Heavy price focus, strong value for money. Desire for households to make good use of leftovers/reduce waste.

Scratch cooked, family meals – Increased likelihood of families building on this year's experiences of cooking and eating together more frequently – which will also be more economical.

Snacking/comfort through food – Taste, convenience and enjoyment are critical purchase drivers. Health considerations likely to rise on consumers agendas once uncertainty eases but communicating the nutritional benefits of eating red meat remain important.

Adapting to consumer needs means meat must satisfy consumer desires for

- *Versatility*
- *Great taste*
- *Meals that are quick and easy*
- *Inspiration and ability to personalise*
- *Permission to eat – strong product credentials across health, environment and welfare*

To keep up-to-date with all the latest consumer retail trends, visit https://ahdb.org.uk/retail-and-consumer-insight

Resilient or robust cattle? defining a breeding objective

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Background

Agriculture is being redefined, as we shift focus from production and productivity, to the three pillars of sustainability, Profit, People and Planet. The way we produce food and the impact this has on our wider environment will be critically important for providing a 'licence to farm' and for reversing current trends in climate change, while feeding our human population.

This shift warrants re-examination of the attributes animals need for a sustainable agricultural system and re-examination of how we farm them. How can we use the natural attributes that nature has shaped in animals, to deliver more sustainability farms?

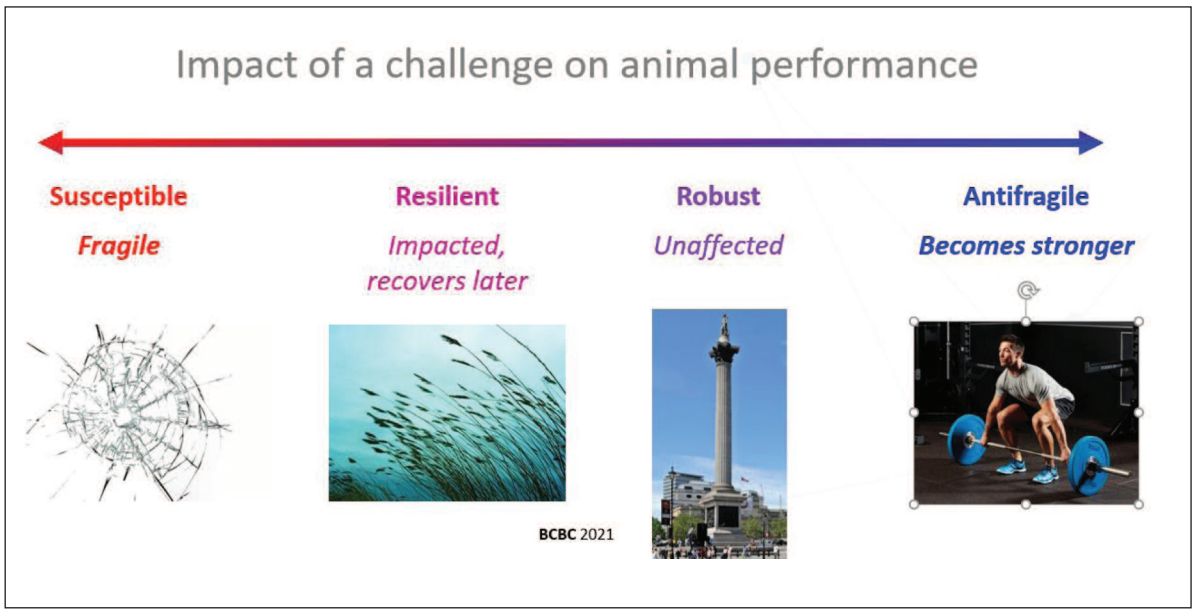
A key focus should be effects of the environment on animals. Farm systems vary in extent to which they control the environment, or cope with challenges it delivers. There is increasing interest in the idea of animal **resilience** or **robustness**. Do these two terms best describe what we need?

A name for an existing phenomenon

In 2012, Nassim Nicholas Taleb published a book, *Antifragile: Things That Gain From Disorder*. He coined a name for a phenomenon that had no English word: **antifragile.** He showed this is important in many systems, from investment and economics through human behaviour to basic biology. It is best considered as a long-term or permanent response to a challenge (Figure 1).

Fragile systems suffer permanent 'damage' with functionality reduced (e.g. productivity or longevity). A good example is permanent effect of a poor rearing season on adult size of one birth cohort compared to others. **Resilient** systems show a short-term reduction in performance but bounce back, while **robust** systems show no effect of the challenge. **Antifragility** is an even better response. In this case,

Figure 1: ***From fragile to antifragile – possible responses to challenge.*** From fragile (adverse impact, long-term) through resilient (bends and bounces back) and robust (imperturbable) to antifragile (emerges stronger).



challenge leads to a stronger system that outperforms the pre-challenge state. Neither *resilient* or *robust* adequately explain this phenomenon.

Is antifragility real?

Antifragility is real. It is the basis of how immunity functions, how training improves the performance of athletes and how learnt behaviour allows animals to avoid the worst of life's challenges. It may explain why animals raised in challenging conditions often outlive those raised in easy conditions.

Some may define **antifragility** as **toughening** and **fragility** as **brittleness.** In an engineering sense, antifragility is where challenges makes structures stronger, however only living systems can do this because nature has shaped them to do so.

Antifragility is the idea behind the saying *'What doesn't kill you, makes you stronger.'*

Why is antifragility important?

Animals are farmed in environments that vary, to varying degrees. We should see challenge as something of value, where it makes animals better able to cope with future challenges.

Where environments are variable, antifragility, allows local adaptation. We should view environmental variation as good where advantages are delivered. Common and 'reasonable' challenges which exploit an animal's innate ability to respond in an antifragile way should be valued. Stronger performance in future may outweigh the short-term cost of a challenge.

How does antifragility work?

For immunity, immunological memory prepares animals to mount an effective response to future challenges of the same type. **Learnt behaviour** uses a different type of memory. Rats in a maze learn to get through the maze faster and more easily to get the reward. For cows, it is how they avoid troublesome interactions with dominant animals in a herd or how they know the best parts of a field for grass. **Exercise** is probably the example we best relate to. Loading the body leads to signals interpreted as a need to build stronger bone and muscle.

There is evidence that feeding regimes, where both quantity and quality vary, may lead to better physiological control of body weight (the idea behind the human 5–2 diet). Might this idea help improve feed efficiency in livestock?

Epigenetics has shown us how environment affects gene regulation and gene effects are manifest. We know that it affects proteins folding, and so how they interact with other proteins in the body.

We need to quantify the effect of environmental challenges on future performance of livestock, in terms of feed efficiency, productivity (growth, reproduction, lactation and health), in the long-term, and on longevity itself. In particular the effects of weather, feeding level and disease challenges should be studied. Modern tools for precisely monitoring nutrition, the environment, health and performance of **individual animals, throughout their lives** will allow us to do this.

How can we use antifragility?

An antifragile response is a sign of adaptability at the level of the individual. It delivers benefits when farming in a variable environment. So how do we incorporate antifragility into a basket of traits to define overall merit in the long-term? Some outcomes, like disease resistance and longevity, may indicate expression of antifragility. While, long-term responses define antifragility, shorter term responses in these and other traits may prove to be good predictors.

Variable environments are the norm for some classes of livestock farming e.g. outdoor or more extensive pastoral based systems. Rather than thinking we should protect animals from most challenges, we should perhaps define 'good' levels of challenge that strengthen future animal performance. It is highly likely that this already happens in outdoor systems to some degree, even if we do not deliberately try to gain an **antifragile response.** It may explain why experienced farmers say animals reared in more challenging environments shift well to easier country, but not *vice versa*.

An animal's ability to mount an antifragile response is likely to bear a cost. This is a sort of 'insurance policy' against challenges negatively impacting on performance in the long-term. A narrow focus on productivity may limit an animal's ability to adapt when challenged. Arguing that more production is best ignores the fact that environment challenges impact on animal performance.

Can we exploit antifragility in livestock management?

Animals are not machines that perform at a level related to just feed inputs. The reason we farm animals is that they can roam across land and utilise feed that we as humans would obtain much less benefit from. In doing so they encounter environmental challenges but have innate systems designed to cope with those commonly encountered. This natural ability to respond to environmental challenge is something we can take advantage of, rather than seeking to control the environment.

For farming cattle, we should consider what level of production is right, for a given cow size, in a given environment. More challenging environments will most likely have a lower target for this. The aim here is to use the animal's natural ability to cope with challenge rather than bearing the cost of eliminating the challenge through controlling the environment.

We need to know what levels and patterns of challenge lead animals to perform better over the long-term. A key question is what challenges are helpful as opposed to those which exceed an animal's ability to deliver an antifragile response. Animal science needs to quantify the size of effects and the range of challenges

we can manage to deliver benefits from antifragility.

Some relevant questions are:

- How do we define and measure antifragility?
- What levels of pathogen challenge best potentiate the immune system?
- Is there a pattern of variation in feeding level that best 'tunes' control mechanisms animals have to prioritise nutrient partitioning for production, reproduction, health and managing body reserves, while making efficient use of feed?
- What patterns of weather (rain, wind and temperature) potentiate animals for better behaviours and better control of body processes when challenged in the same way later?
- How do we manage herd behavioural dynamics to reduce negative interactions? Are there positive outcomes to these interactions we are failing to see?

It is about living with environmental variation and exploiting the response it can deliver as **antifragility.** Effectively antifragility is an 'output'. We want animals to have this potential and use it to overcome environmental challenges, quickly and easily.

Can we exploit antifragility in genetic improvement?

Mounting an antifragile response is 'adaptable'. Adaptability is also a population attribute, where variation between animals allows a population to respond to a changing or different environment. Antifragility is more short-term, acting on the individual. *Antifragility is within animal adaptability.*

International genetic evaluations have shown animals adapted to more challenging environments do not perform as well as those that are not, when those challenges are removed. The converse can be true when assessed with those challenges. Is this difference explained by antifragile responses?

Antifragility as a concept may help interpret data used in genetic evaluation and add value to formulation of breeding objectives for sustainable livestock systems.

Some questions for animal genetics are:

- Can we select for potential to manifest antifragility?
- How should we farm elite genestock to assess potential to express antifragility?
- Does antifragility explain some of the noise in datasets used for genetic evaluation? e.g. bulls reranking when progeny are run in more challenging conditions?
- Can new models for analysing data estimate size of antifragile effects and identify genes or gene combinations that potentiate animals to stronger antifragile responses?
- How do we account for benefits from antifragile responses when defining genetic merit?

Conclusions

Antifragility may be part of the solution for lower impact livestock farming. It can help animals cope with expected challenges and reduce costs incurred by managing the environment. Environmental variation is natural and animals have evolved systems to cope with this and thrive.

Environmental challenges can have advantages as well as disadvantages. We should evaluate the benefits of environmental challenge, not just harm.

Antifragility is a positive outcome from a less than ideal situation. However, it may be better interpreted as *variable environments are best because they deliver antifragile benefits* i.e. challenges are good when they lead to animals becoming more efficient, healthier or longer lived.

Antifragility is real phenomenon but we do not know enough yet to advise livestock managers on how to use environmental challenges to improve livestock performance.

Antifragility may explain why animals with extreme merit for high productivity are less suited to a variable environment and more suited to highly controlled environments. We need to know more about trade-offs, if any, between productivity and the ability to deliver antifragile responses.

Defining the genotype of 'sustainable livestock' should consider exploiting antifragile responses. To do this, we need to know how to best characterise it? A challenge is to define breeding objectives that allow animals to adapt to environmental challenge. However, traits like disease resistance and longevity, outcomes that antifragility affects, will help do this.

Acknowledgements

Views in this paper are those of the author alone. I have benefitted from talking to different people about the idea of antifragility as applied to livestock. More thinking is needed to see how this can be used best to manage cattle and to define breeding objectives for cattle of the future.

Reference

Taleb, N.N. (2012). *Antifragile: Things That Gain From Disorder*. Penguin Publishing. 519pp.

Heifer replacement strategies: cost reduction in the suckler herd

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Introduction

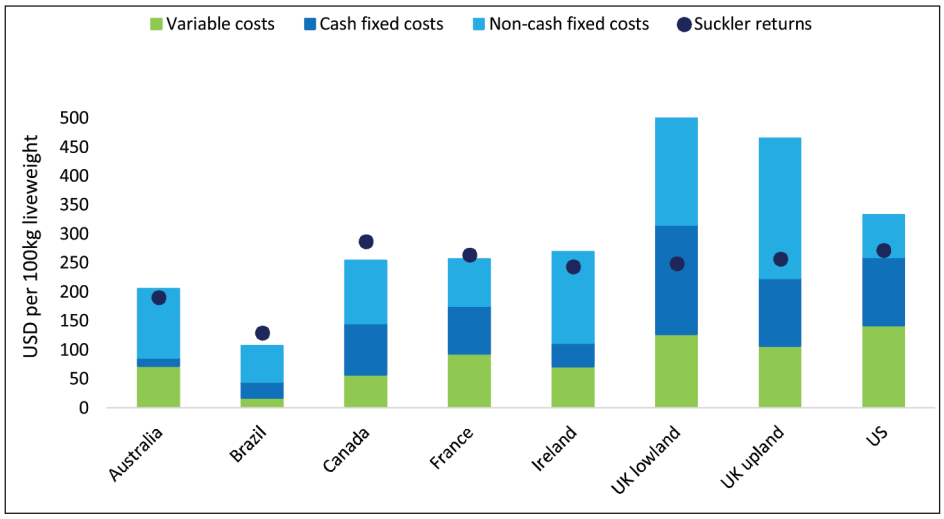
Calving heifers for the first time at two years of age has been commonplace in many beef producing countries since the 1970's; however, in the UK it is estimated that only 40% of suckler herds carry out the practice, with the average age at first calving being 32.8 months (BCMS, 2019).

When we compare ourselves globally, the UK suckler herds cost of production is significantly higher than elsewhere, and even with a relatively high beef price, often income does not cover cash costs (Figure 1).

It has been estimated that calving heifers at two years of age, rather than three, reduces costs by £600 per heifer. Heifer development costs equate to around 9% of total cost of production (Davis C., a conversation in 2020) and therefore if more herds implemented a calving at two policy, profitability within the industry could be improved.

In addition, heifers which calve for the first time at two years of age produce more calf weight, wean more calves over their lifetime and remain in the herd longer (Nunez-Dominquez et al., 1985).

Figure 1: Typical farm suckler herd production costs and output, 2018.
Source: Agribenchmark, AHDB (2020)



Breeding heifers

The first stage in heifer development is identifying suitable sires and dams to breed heifer replacements from and this is where breeding and selection decisions are paramount. Estimated Breeding Values (EBVs) provide producers with information which help them understand the value of the individual as a genetic parent. Uptake of EBVs within the industry is disappointing, with only 30% of producers reporting using them in the most recent Farm Practices Survey (DEFRA, 2020).

The most effective way to create genetic change is through careful bull selection. When choosing sires to breed heifer replacements from, EBVs to primarily consider are calving ease daughters, calving ease direct, age at first calving, scrotal size, mature size and milk. It is also important to consider maternal indexes. The big emphasis placed on maternal traits is driven by the fact that two thirds of the cost of producing a finishing animal equates to the suckler cow (Lardner., a conversation in 2019) and therefore by effectively implementing EBVs within the herd, costs can be reduced.

Over the past 35 years, mature cow weight has been steadily increasing, following the 2.5kg increase in carcase weights each year. Mature

cow size is highly correlated with feed costs and is one of the primary reasons why average mature size in the USA, Canada and Australia is much smaller at 550–600 kg. A recent study conducted by AHDB found that the optimum cow size in the UK to be approximately 680 kg. Cows exceeding 700 kg, not only require more feed, but also require feed which is of higher quality, resulting in feed costs increasing at a faster rate (AHDB, 2019).

The replacement heifer index developed by the Irish Cattle Breeders Federation (ICBF) was introduced to ensure more emphasis was placed on maternal traits when breeding decisions were being made. Within the index, 86% of the weighting is allocated to maternal traits and only 14% attributed to carcase traits. Since its creation and incentivisation, the number of calves born per cow has increased by 5%, the number of heifers calving at 24 months has increased by 23% and the calving interval has reduced by 10 days (ICBF, 2020).

However, it is important to remember that selecting superior cows to produce heifers from, is just as fundamental to breeding success, as sire choice. Preferably, replacement females should not be bred from cows which:

- Required assistance at calving
- Calved late in the breeding season
- Failed to wean a calf
- Have large teats making suckling challenging
- Weaned a calf which grew at less than 1 kg/day
- Flighty temperament

Studies have shown that cattle with flightier temperaments have higher levels of the stress hormone, cortisol, in their blood stream, which can disrupt reproductive hormones for ovulation and conception, reducing their reproductive efficiency (Cooke, 2019). Therefore, not only are flighty animals a health and safety risk, they can also impact the productivity and ultimately profitability of the herd.

Birth to breeding

The main aim of this stage of heifer development is to ensure that heifers reach 65% of their mature weight before breeding; this is mainly achieved through effective nutrition.

Whilst suckling their dams, heifers are required to grow at least 1 kg/day without creep feed and 0.7 kg/day until maturity. This can be achieved through good quality silage or if required, supplementation with concentrates. Ideally the development ration should mirror the diet which they will be expected to thrive on as mature cows.

Selection is key during this stage with studies suggesting that it is more economically viable to cull heifers before the breeding season, rather than retain unsuitable heifers for an extended period of time (Lamb, 2013). Heifer selection is driven by:

- Size: Heifers which do not retain 65% of mature weight by 14 months should not be retained
- Birth date: Retain heifers born in the first cycle of the calving season
- Temperament: Flighty animals should not be retained

Breeding to calving

The main aim between breeding and calving is for the majority of heifers to conceive within the first three weeks of the breeding season; pregnancies to be maintained and that the heifers reach 85% of their mature weight by calving time.

One of the key factors determining the success of calving heifers at two years of age is bull choice. Heifers that experience calving difficulties at two years of age produce fewer calves over their lifetime, and the calves are younger and lighter at weaning. Dystocia also extends post-partum anoestrus, reduces conception rates and increases the likelihood of the heifer being culled from the herd (Perry and Cushman, 2019).

Bull selection for heifers must focus on calving ease direct, birth weight and gestation length traits. In Canada and the US producers would not use a bull which weighed more than 30 kg at birth to prevent calving difficulties. A breeding period of between 45–60 days is also advised; this is a great way of selecting for long term fertility whilst also ensuring that most calves are born early in the breeding season.

Nutrition is also key during this stage. Inadequate maternal nutrition at any stage of foetal development has been shown to impact calf development, producing calves with lower birth weights; which have a higher chance of morbidity and mortality. Even though 75% of the foetal growth occurs during the last trimester (Reynolds et al., 2006), most of the placental growth occurs during the first two thirds of gestation (Reynolds et al., 1990) and therefore any disruption caused during this stage can have a big impact on future development of the calf.

Approximately 75–80% of calf losses from breeding to calving are due to early embryonic death (Edwards and Schrick, 2019). This is because the embryo does not attach fully to the uterus until 42 days after fertilisation and therefore any dietary changes during this time can impact embryo survivability by altering the uterine environment (Perry et al., 2013).

Nutrition in late gestation is also important. Heifers have an extended post-partum interval (time between calving and first oestrus) because they require energy for growth and lactation before finally directing some of it towards reproduction. The post-partum interval for heifers is around 86 days, 18 days longer than cows, and therefore it is important heifers calve early in the breeding season or alternatively calve a couple of weeks before the cows to ensure they are cycling before the onset of the breeding season (Anderson and Crites, 2019).

Body condition is the single most important factor linked to resumption of oestrus cycles. Nutrition pre-calving has an increased impact on post-partum interval, compared with

nutrition post calving. Thin heifers have a 30-day extended post-partum interval compared to those which calve at body condition score 3 (Anderson and Crites, 2019). In addition, heifers which are thin at calving, have increased risk of dystocia (Corah et al., 1975) and their colostrum is often of poorer quality which impacts calf survivability (Odde, 1988). The most successful way of reducing dystocia is through genetics.

Post calving

Post calving management is key to ensuring heifers rebreed successfully and calve again within 365 days. Cattle prioritise growth and lactation over initiation of the next pregnancy and therefore adequate rationing is vital to ensure heifers remain in good body condition. This can be achieved by ensuring that spring calving heifers are provided with preferential pastures and kept separate from the main herd until they have produced their second calf.

Heifers who fail to rebreed successfully within a 60-day breeding period should be culled from the herd. This strong culling policy will increase selection for more fertile females.

Conclusion

Calving at two years of age is commonplace across the world. It undoubtedly reduces cost of production, but is very dependent upon the effective use of genetics, selection and management practices. By developing heifers effectively this will inevitably produce a functional suckler herd, where cows calve unassisted every 365 days and wean a live calf, have low maintenance costs and remain productive for a sufficient period of time to cover their development costs.

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References

AHDB (2019). Assessing effects of mature size on the efficiency, performance and profitability of sheep and beef breeding enterprises at farm, processor and national level. Available at http://beefandlamb.ahdb.org.uk/research/genetic-selection/genetic-selection-generic/assessing-efficiency-of-breeding-enterprises/ [Accessed 12 May 2020].

Anderson, L. and Crites, B. Proceedings, Applied Reproductive Strategies in Beef Cattle; August 20–21, 2019; Knoxville, TN.

British Cattle Movement Service part of The Rural Payments Agency. 2019. Data request [Accessed 16 November 2020].

Cooke, R. (2019). Proceedings, Applied Reproductive Strategies in Beef Cattle; August 20–21, 2019; Knoxville, TN.

Corah, L.R., Dunn, T.G. and Kaltenbach, C.C. (1975). Influence of prepartum nutrition on the reproductive performance of beef females and the performance of their progeny. *Journal of Animal Science*, 41(3), 819–824.

Department for Environment Food & Rural Affairs (2020). Farm Practices Survey Autumn 2019 – England. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/870305/fps-general-statsnotice-05mar20.pdf [Accessed 4 December 2020].

Edwards, J. and Schrick, F. (2019). Proceedings, Applied Reproductive Strategies in Beef Cattle; August 20–21, 2019; Knoxville, TN.

ICBF (2020). *Genetic trends in EBI; Latest Analysis*. Available at: https://www.icbf.com/wp/wp-content/uploads/2020/03/Dairy_Proofs_Mar2020.pdf [Accessed 20th May 2020].

Nunez-Dominquez, R., Cundiff, L.V., Dickerson, G.E., Gregory, K.E. and Koch, R.M. (1985). Effects of managing heifers to calve first at two vs three years of age on longevity and lifetime production of beef cows.

Odde, K.C. (1988). Survival of the neonatal calf. *Veterinary Clinics of North America: Food Animal Practice*, 4(3), 501–508.

Perry, G. and Cushman, R. (2019) 'Effect of age at puberty / conception date on cow longevity', in Patterson. D.J. and Smith, M. F. (ed.) *Management considerations in beef heifer development and puberty*. Pennsylvania: Elsevier. 579–590.

Perry, G.A., Perry, B.L., Walker, J.A., Wright, C.L., Salverson, R.R. and Patterson, H.H. (2013). Evaluation of prior grazing experience on reproductive performance in beef heifers. *The Professional Animal Scientist*, 29(6), 595–600.

Reynolds, L.P., Caton, J.S., Redmer, D.A., Grazul-Bilska, A.T., Vonnahme, K.A., Borowicz, P.P., Luther, J.S., Wallace, J.M., Wu, G. and Spencer, T.E. (2006). Evidence for altered placental blood flow and vascularity in compromised pregnancies. *The Journal of Physiology*, 572(1), 51–58.

Reynolds, L.P., Millaway, D.S., Kirsch, J.D., Infeld, J.E. and Redmer, D.A. (1990). Growth and in-vitro metabolism of placental tissues of cows from day 100 to day 250 of gestation. *Reproduction*, 89(1), 213–222.

British breeds used on our ranch

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Maddux Cattle Company is a diversified 134-year-old cattle ranching and farming operation in southwest Nebraska. The ranch consists of roughly 45,000 acres, 30,000 acres of deeded land (27,000 rangeland 3,000 farmland) and leases roughly 15,000 acres consisting of cornstalks for winter grazing. The ranch receives around 18 inches of precipitation annually.

The ranch is a combination of a third hard land and two thirds Sandhills grass, with roughly 1,000 acres of sub-irrigated meadows. Grass species are a combination of warm and cool season. Green grass is available from early April through November. Very little dormant season grazing is done, with rented cornstalks providing the bulk of the winter grazing for both steers and cows. Around 2,500 acres of the farmland is pivot irrigated with the balance producing dry land wheat. One half of the irrigated land is leased out, the balance being farmed by ranch employees.

Our ranch has developed our suite of enterprises based on our location, competitive advantages and resources. We have identified 2 major areas that we feel we are competitive. We can produce large number of uniform feeder cattle that are attractive to large commercial feed yards. We have decided that we are best suited to produce these feeder cattle for the feeding complexes rather than retaining the cattle to slaughter weights. Additionally, we sell 500–600 of high-quality low input type bred cows and heifers, primarily to an aging cow calf producer demographic. Seedstock breeding bulls are sold as well.

The ranch runs 2,500 mother cows plus 1,000 replacement heifers. The cows are maternal composites, British in type. All replacement heifers and bulls are generated internally. The major contributing breeds are Red Angus, Tarentaise (French breed), South Devon, Devon and Red Poll. The purpose of selecting these breeds is to build high heterosis and fertility in a modest input maternally oriented cow. A high percentage of heifers are saved for replacements and exposed for a short breeding period. All steers and any heifers not kept for replacements are carried over and sold as grass yearlings. If calves are weaned in the fall, no feed or supplementation is fed to mature cows. If cow/calf pairs are sent to cornstalks, they are supplemented with wet distillers' grains. This supplemental nutrition is necessary to maintain the lactating cow and her nursing calf.

We are fans of crossbred cattle. In our opinion, there is no single management practice, which can have more impact on your bottom line than crossbreeding. The use of crossbreeding yields two important advantages over straight-bred cattle. First, is that the crossing of two breeds results in higher levels of performance for most economic traits. Secondly, the use of multiple breeds allows producers to harness the traits of one breed to "compliment" and improve desirable characteristics of another breed. No one breed has optimum levels of performance however, through breed combinations and hybrid vigor, one can develop highly desirable animals for a broad range of traits.

Hybrid vigor, more commonly referred to as heterosis, is the superiority that crossbred animals exhibit over its straight-bred parents. Generally, heterosis has the greatest effect on those traits, which have a lower level of heritability, moderate heterosis is observed in moderately heritable traits, while highly heritable traits show little or no affects from heterosis. Traits such as fertility, longevity, and health have relatively low heritability yet show large responses from cross breeding. This is important for two often overlooked reasons. One is that while most genetic change is focused on the highly heritable traits like frame size and growth, the truly important economic traits like overall cow productivity are not the focus of the seed stock community, because of the low heritability. Even if it were a focus in selection, making change in these areas would be quite limited. Secondly, crossbreeding allows one to make much larger strides in genetic improvement by utilizing breed differences. Through recent efforts to characterize the important economic traits and biological type for beef cattle breeds, one can easily identify which breeds excel in any one trait and use that breed to introduce those genes for that trait into your crossbred population. You can make much more progress in one cross than a lifetime of selection for a trait, even one with high heritability.

Producing crossbred calves has advantages in terms of heterosis and blending of breed differences but the major advantages of cross breeding accrues to the crossbred cow. Hybrid females generate a more desirable environment for her calf through improved maternal ability. This results

in higher calf survivability and higher weaning weights. On average, a crossbred cow has a 4% higher calving rate, raises one more calf, and produces a cumulative 600 more pounds of calf over her lifetime. This higher productivity gives you more pounds to sell every year per cow and reduces your replacement rate due to higher fertility, longer lives and healthier more "maternal" cows. This higher productivity and lower replacement rates are powerful factors affecting overall ranch profitability.

In order to capture the benefits of hybrid vigor, we developed our composite population of "Maternalizers". Our Maternalizer cows are designed to emphasize maternal traits. We feel these cows are well suited for our environment and production system. They are smaller framed, easier fleshing, early growth cows with desirable udders. We want cows that deliver low birth weight calves without assistance. Our composite is designed to graze year-round with minimal feed inputs. With this genetic emphasis, and through the use of cornstalks and late spring calving, only in the case of severe weather has any hay or supplementation been fed. And while some emphasis was given to carcass quality/marbling in our breed selection, our focus is on whether the breed can deliver fitness and convenience traits. Moreover, with our composite herd, genetic change is not necessarily our goal. Instead, we are trying to fix a set of traits at a given level of production. High growth and more milk are not necessarily desirable because of the higher maintenance and feed costs associated with higher production. Selection for fitness and convenience traits trumps high production. Our goal is to have every cow pregnant and raise a calf albeit at a lower weaning and yearling weights than most conventional systems.

Our ideal cow will have the following convenience and fitness characteristics:

1. 1150 lbs. mature weight
2. Frame score 5 or less
3. Fault free udders
4. Docility
5. Fertility
6. Polled
7. Longevity
8. Pigment on eye and udder
9. Fleshing ability
10. Calving ease
11. Modest early growth and milk

Here is a table Modified from the USDA MARC Germ Plasm Evaluation project that characterizes the production traits and biological type of the parent breeds, which we have selected to be contributors to our composite (see Table 1).

We have confidence that the Red Angus breed provides an excellent base for our composites. The Red Angus breed offers carcass quality, maternal traits and calving ease. One drawback is that they have a far smaller breed population compared with Black Angus. The Tarentaise, South Devon, Devon Red Poll Breeds complement each other and make a positive contribution to our goal of producing high fertility, low input females in an extensive production system.

In addition, roughly 3–4,000 Angus calves, averaging around 475 pounds are purchased and wintered on the ranch. Growing calves are supplemented with wet distillers' grains. We are able to buy high quality Angus calves and winter them on relatively cheap crop aftermath and ethanol

Table 1: Characterizes the production traits and biological type of the parent breeds.

Breed	*Growth Rate*	*Age Puberty*	*Milk Production*	*% Retail Product*	+	-
AR Red Angus	XXX	XX	XXX	XX	Good all-round maternal traits	Limited genetic base
TA Tarentaise	XXX	XX	XXX	XXX	Excellent convenience traits i.e., udders, size	Greater than optimum milk and growth
DS South Devon	XXX	XX	XXX	XXX	Excellent docility and carcass traits	Greater than optimum milk and growth Marginal udders
RP Red Poll	XX	XX	XXX	XX	Excellent Fertility and marbling	Marginal udders Not much fleshing ability
HE Hereford	XXX	XXX	XX	XX	Optimum Milk Right biological type	Poor Marbling Questionable udders
DE Devon	XX	XXX	XX	XX	Optimum milk Correct Biological type	Poor Marbling Extremely small genetic base

biproducts. Our goal is to produce 725 pounds steer going to grass in the spring. We then expect these steers will gain around 2 pounds/day on grass during a 100–120-day grazing period. The use of Angus genetics allows us to grow the animals at a slow rate and produce feed yard ready animals at under 1000 pounds at 18 months of age. Higher growth yearling steers over 1000 pounds are heavily discounted in the marketplace. All yearlings are summered on leased land in Nebraska, Wyoming and Colorado. They are sold on video auctions as 9 weights for delivery in the late summer.

Our marketing/risk management plan relies heavily on using market seasonality. While not bullet proof, seasonality offers an approach to risk management that improves the probability of transacting on favorable terms. We purchase calves in the fall of the year, when most calves come to market. This wave of calves allows us to buy calves when historically prices are depressed. These calves are wintered and sent to grass in the spring. They are marketed in July when there is generally an uptrend in price of feeder cattle. These seasonal trends are driven by the climate of North America and consequently are not likely to change dramatically on year-to-year basis.

One competitive advantage we have is our location. We have a good base of native range, surrounded by large amount of irrigation development and cornstalks to rent. This allows us to economically winter a large number of cows and yearlings. In addition, we have access to wet distillers' grains byproduct. This coupled with our own irrigated land allows us to have good access to feed resources to winter cattle and for drought protection. Another competitive advantage is our employees. With a stable workforce we can delegate responsibilities and have been able to invest in the training and development of our workforce. Another advantage is our relationships with various ranches in the west. We send yearlings to different areas of the west and then offer large numbers of uniform feeding cattle that are well suited for filling the needs of the cattle feeding infrastructure.

Genome editing approaches to augment cattle breeding programs

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Take Home Messages

- Genome editing refers to the use of site directed nucleases (e.g. Zinc finger nuclease, TALENS, CRISPR/Cas9) to introduce targeted alterations into genomic DNA sequence.
- It offers a way to repair genetic defects, inactivate or knock-out undesired genes, or move beneficial alleles and haplotypes between breeds in the absence of linkage drag.
- Genome editing would synergistically complement, not replace, traditional breeding programs.
- It has been used to introduce useful genetic variants impacting disease resistance, product quality, adaptability, and welfare (e.g. polled) traits into cattle breeding programs.
- The regulatory oversight of genome editing in animals varies by jurisdiction; in 2018 the European Court of Justice ruled that organisms obtained by directed mutagenesis, including genome editing, will be regulated as genetically modified organisms (GMOs).

Abstract

Genome editing research in cattle to date has focused on disease resistance, production, product quality, and welfare traits. Modelling has revealed how editing could be used to introduce beneficial alleles into cattle breeds and maintain, or even accelerate, the rate of genetic gain accomplished by conventional breeding programs. As with earlier genetic engineering approaches, whether breeders will be able to employ the breeding method in cattle genetic improvement programs will depend upon the regulatory framework and governance of genome editing for food animals.

Introduction

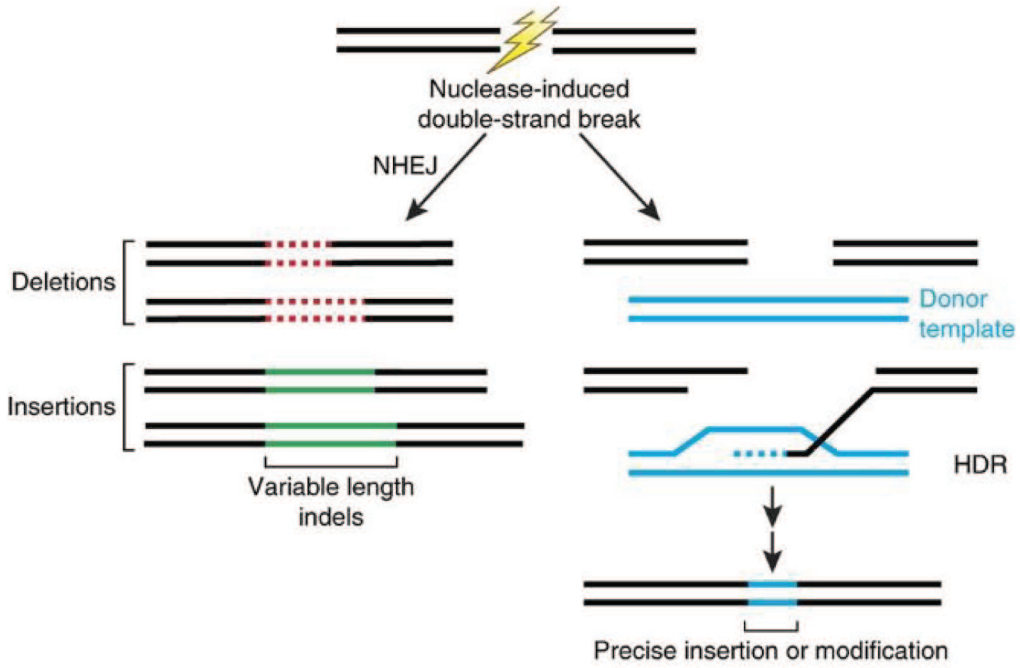
The previous generation of genetic engineering tools, resulting in the first transgenic livestock over 30 years ago, was limited to the insertion of foreign DNA into the genome. As integration was random, there was no way of predicting all of the possible effects that introducing the transgene would have on the animal as the epigenetic environment varies among different regions of the genome. It also meant that each genetically engineered founder animal had the gene inserted into a different location in the genome. To date, there is only a single approved genetically engineered animal for food purposes globally, the fast-growing AquAdvantage Atlantic salmon.

Genome editing presents an approach to introduce targeted modifications into existing genes and regulatory elements within a breed or species, without necessarily introducing foreign DNA, potentially avoiding concerns regarding transgenesis. It offers a new opportunity to accelerate the rate of genetic gain in livestock by precisely introducing useful extant genetic variants into structured livestock breeding programs. These variants may repair genetic defects, inactivate or knock-out undesired genes, or involve the movement of beneficial alleles and haplotypes between breeds in the absence of unwanted genetics from the donor breed.

Genome or gene editing refers to the use of site-directed nucleases (e.g. Zinc finger nuclease, TALENS, CRISPR/Cas9) to precisely introduce a double stranded break (DSB) at a predetermined location in the genome. The cell can repair that DSB break in one of two ways – nonhomologous end joining (NHEJ) or homologous-directed repair (HDR) using a nucleic acid donor template that includes the sequences homologous to either side of the double-strand break. The outcomes of these repair processes result in random mutations, or precise gene edits, respectively (see Figure 1 on page 23).

Genome editing research in cattle to date has focused primarily on monogenic (single gene) traits like disease resistance (e.g. tuberculosis), production (e.g. myostatin knockout), generation of sex-ratio skews (e.g. increase proportion of male calves), elimination of allergens (e.g. beta-

Figure 1: Nuclease-induced double-strand breaks can be repaired by nonhomologous end joining (NHEJ) or homology-directed repair (HDR) pathways. Imprecise NHEJ-mediated repair can produce insertion and/or deletion mutations (indels) of variable length at the site of the double-strand break. HDR-mediated repair can introduce precise point mutations or insertions from a single-stranded or double-stranded nucleic acid donor template.



lactoglobulin knockout), and welfare traits (Table 1). In the absence of editing, livestock producers may be resistant to the introduction of a useful new allele that is associated with sires of inferior genetic merit, or sires from another breed. For example, the polled allele which results in hornlessness is associated with dairy sires of lower genetic merit, and bulls from several beef breeds. Using gene editing, this allele has been introduced into dairy genetics in a proof of concept experiment. If this allele could be edited into the genome of a number of elite dairy sires, then artificial insemination could be used to disseminate that dominant polled allele through the dairy cattle population, and eliminate the need for horn removal which is an animal welfare concern.

One could potentially envision editing several alleles for different traits – such as known fertility impairing haplotypes, polled, and to correct known Mendelian genetic defects that affect cattle, all while using

Table 1: Examples of proposed and potential targets for genome editing in cattle.

Target	*Targeted Trait / Goal*
Myostatin (MSTN) gene knockout	**Increased lean muscle yield**
Intraspecies *POLLED* allele substitution	**No horns/welfare trait**
Intraspecies *SLICK* allele knockout	**Heat tolerance**
Diluted coat color	**Heat tolerance**
Beta-lactoglobulin gene knockout	**Elimination of milk allergen**
CALPAIN & CAPASTATIN allele substitution	**Improved meat tenderness**
Omega-3 (Fat-1) transgene insertion	**Increased omega-3 fatty acids**
Prion protein (PRNP) knockout	**Disease Resistance (Bovine spongiform encephalopathy (BSE) or 'Mad Cow' Disease)**
Insertion of lysostaphin transgene	**Disease Resistance (Mastitis)**
CD18 gene edit	**Disease Resistance (Bovine Respiratory Disease)**
Insertion of SP110, NRAMP1 gene	**Disease Resistance (Tuberculosis)**
Intraspecies SRY gene duplication	**Increased proportion of male offspring**
NANOS gene knockout	**Infertile males (for surrogate sire)**

conventional selection methods to keep making genetic progress towards a given selection objective. Although single gene traits present good targets for genome editing and can have tangible animal health, environmental and economic outcomes, nearly all economically important livestock traits are complex traits controlled by many genes. These include milk yield and composition, carcass yield, composition and quality, feed conversion, feed efficiency, growth rate, wool yield and quality, fertility, egg yield, and disease resistance. Some individual genes can have large effects on polygenic traits: for example, mutations in the myostatin gene that result in 'double muscle' phenotypes greatly contribute to the polygenic trait of carcass yield. Other alleles with more modest effects on polygenic traits could still be good targets for gene editing, particularly with the inevitable improvements in gene editing that will meet the coming decades.

Genome editing conceptually offers an approach to translate the thousands of single nucleotide polymorphisms (SNP) markers discovered through livestock sequencing projects, the information obtained from numerous genome wide association studies, and the discovery of causative SNPs (Quantitative Trait Nucleotides; QTNs) into useful genetic variation for use in animal breeding programs. One modeling study reported that combining gene editing with traditional genomic selection could improve the response to selection four-fold after 20 generations. It is worth noting, however, that this study modeled editing a complex polygenic trait that had 10,000 known QTN. In reality, breeders do not currently have a comprehensive understanding of which edits would be impactful on quantitative traits, i.e. those controlled by many genes. It is unlikely that all of the genes affecting such traits are known, nor is it typically evident which edits might be the most desirable for these genes (i.e. what is the sequence of the desirable allele). It is likely that, at least in the short term, editing will focus on large effect loci and known targets to correct genetic defects or decrease disease susceptibility, and conventional selection will continue to make progress in selecting for all of the many small effect loci that influence the complex traits that contribute to the breeding objective. In other words, **editing will complement, not replace, conventional breeding programs.**

Intersection with Conventional Breeding

To become an important driver of genetic change, genome editing methods must seamlessly integrate with conventional animal breeding programs. That means that they must reliably function to germline-edit animals that are selected to be the next generation of parents. Edits can be introduced through gene editing of somatic cells followed by somatic cell nuclear transfer (SCNT) cloning (e.g. Dolly), or introduction of the gene editing reagents into zygotes (early-stage one cell embryo) of the next generation of selection candidates (see Figure 2 on page 25).

To date, SCNT cloning has been the primary method to deliver nuclease-mediated genetic changes into livestock. The advantage of SCNT is that the gene edited cell line can be genotyped and/or screened prior to transfer into the enucleated oocyte to ensure that the desired edits, and no donor template integrations, have occurred. The disadvantage is that there are well-documented drawbacks and inefficiencies associated with cloning including early embryonic losses, and birth defects. Additionally, the EU parliament voted to ban the cloning of farm animals in 2015.

Direct editing of zygotes is advantageous since it is modifying the next generation, but the disadvantage is that not all embryos will have the desired edit, and often embryos are mosaic – meaning some cells are edited and some are not. However, on average fewer embryos are required to gene edit a pig, for example, using this approach as compared to SCNT due to the inefficiencies associated with cloning. Knockouts using NHEJ have been achieved through editing of zygotes from a number of livestock species, and can be obtained with relatively high frequency, with some reports of 100% efficiency. Targeted gene knock-ins using a donor repair template and HDR have proven more challenging, although my laboratory reported the birth of a zygote-mediated genome edited SRY knock-in bull calf in 2020. The calf is predicted to produce 75% male offspring.

Regulations

As with earlier genetic engineering approaches, whether breeders will be able to employ genome editing in cattle genetic improvement programs will very much depend upon global decisions around the regulatory framework and governance of genome editing for food animals. Currently, the global regulatory status of genome edited livestock is uncertain, and is the primary concern for further investment and development of gene edited animals. Editing that does not introduce novel recombinant DNA sequences would not be treated differently to conventional breeding in some countries e.g., Argentina, Brazil and Australia; whereas in the US all intentional genomic alterations in animals are going to be regulated as veterinary drugs. Similarly, in 2018 the European Court of Justice ruled that organisms obtained by directed mutagenesis, including genome editing, will be regulated as genetically modified organisms (GMOs). Additionally, in the European Union, animal cloning is currently prohibited which would also preclude SCNT-enabled editing approaches. Conversely, in Canada traditional mutagenesis is not regulated unless it produces a novel trait. In that country it is the novelty of product that triggers regulation, not the method or process used to produce that novel trait. And finally, New Zealand plans to regulate all genome edited plants and animals, irrespective of the nature of the edit, as GMOs.

Figure 2: Steps for producing gene edited livestock through somatic cell nuclear transfer (SCNT) cloning (left) or zygote editing (right). Schematic showing the typical steps involved to produce homozygous, non-mosaic livestock by either SCNT cloning of gene edited and screened somatic cells or cytoplasmic injection (CPI)/electroporation (EP) of zygotes with gene editing components.

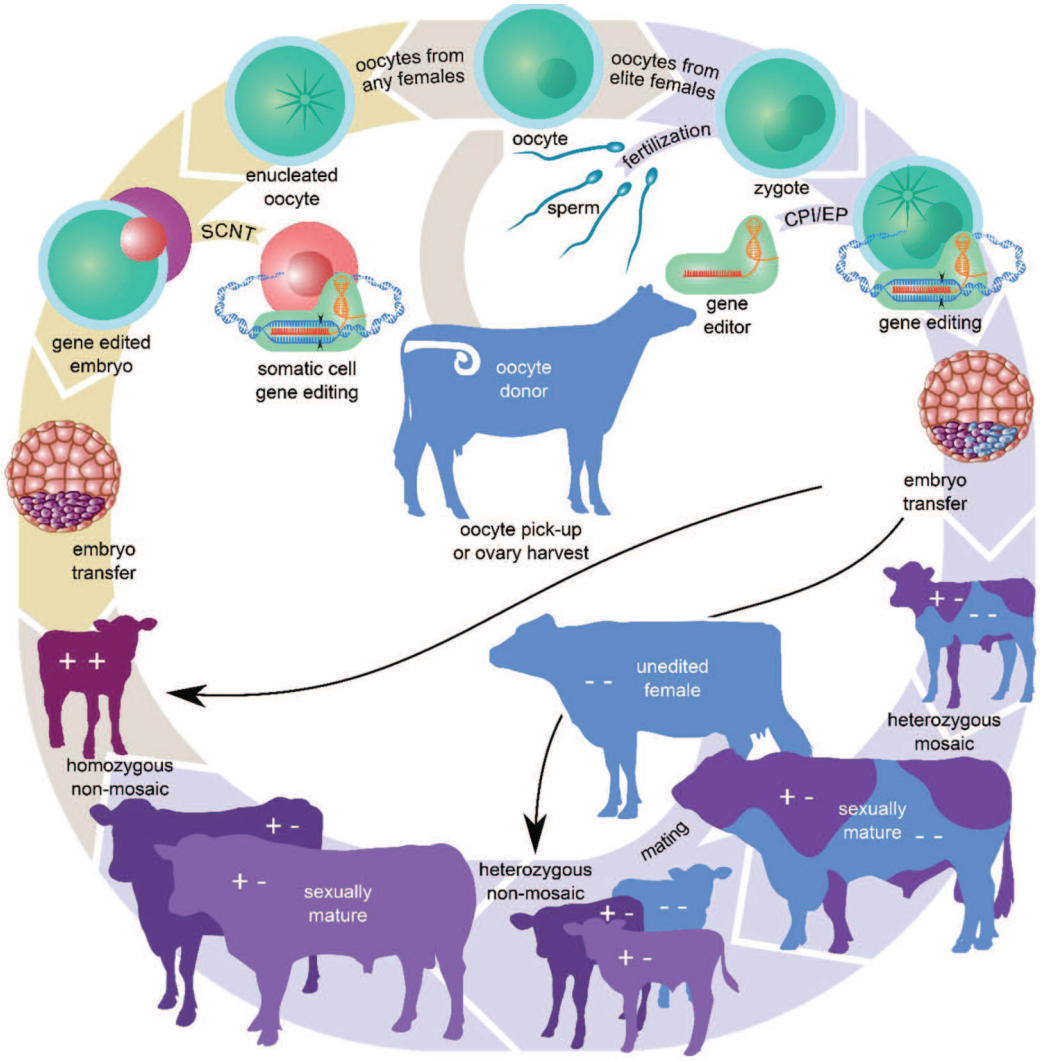


Image from Bishop and Van Eenennaam (2020) Journal Experimental Biology 223: jeb207159.

From a risk perspective, it does not make a lot of sense to have a different set of regulations for a genome edited calf carrying a naturally-occurring genetic variant such as the polled allele (free of any foreign or 'transgenic' DNA), as compared to a calf that inherited that same naturally-occurring allele from its parents. The regulatory situation in selected countries is summarized in Figure 3 on page 26. Many countries have made regulatory decisions about genome editing in livestock in the absence of engagement with the scientific community, industry, stakeholders or publics. In particular, the judgement of the European Court of Justice to subject gene edited organisms to GMO regulations, but to exempt organisms produced using the older less precise process of mutagenesis breeding defied risk proportionality and reasonableness, to the dismay of many European scientists. It remains to be seen whether animal breeding companies can successfully overcome the technical and regulatory challenges that must be faced to employ gene editing for the genetic improvement of commercial livestock.

Conclusions

Significant improvements in the efficiency of milk and beef production have historically been accomplished through conventional breeding of superior individuals with an eye towards specific breeding objectives. Genome editing is a tool that is well suited for modifying qualitative, single-gene traits at comparatively rapid rates in the absence of linkage drag, and could be used in conjunction with conventional selection approaches to address issues such as disease resistance and improved welfare traits. Animal breeders need regulatory certainty regarding genome editing. If editing is used to introduce alterations that are no different from those that could have been obtained using conventional breeding, risk proportionality suggests it should not

Figure 3: Breakdown by country of whether a gene-edited knock-in via HDR of donor template of a naturally-occurring allele (e.g. polled) in livestock would be subject to additional regulations.

Country	Additional Regulations?	Basis of trigger/regulation?
Argentina	No	Novel DNA sequence/transgene
Australia	Yes	Use of donor repair template
Brazil	No	Novel DNA sequence/transgene
Canada	No	Trait novelty (i.e. novel product risk)
European Union	Yes	Is a GMO if used a mutagenesis technique not in existence before 2001
Japan	No	No exogenous genes
New Zealand	Yes	Using of in vitro technique that modifies the genes/genetic material
United States	Yes	New Animal Drug

trigger additional layers of regulatory scrutiny and expense. Regulations should be proportionate to any novel risks inherent in the product, and not the process used to produce that product. Regulating genome edited livestock as GMOs based on the use of genome editing techniques, as has been proposed in the EU, USA and New Zealand, will effectively forestall the application of genome editing in animal agriculture in these countries for the foreseeable future. This will put them at a disadvantage when it comes to incorporating genome editing into livestock breeding programs, as compared to countries (e.g. Brazil, Argentina, Canada) where novel product risk-based regulatory approaches are being implemented.

Acknowledgements

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Why methane from cattle warms the climate differently than CO2 from fossil fuels

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Methane is a potent greenhouse gas with a warming potential more than 28 times that of carbon dioxide (CO2). But when it comes to livestock and climate change, there are many other characteristics that set it apart from CO2. Here are an important four:

- It stays in our atmosphere for about 12 years
- It's derived from atmospheric carbon, such as CO2
- It's part of the biogenic carbon cycle
- It eventually returns to the atmosphere as CO2, making it recycled carbon

It should be noted that **methane from fossil fuels** doesn't have all the same characteristics as biogenic methane – that is methane from ruminant animals such as cattle, or wetlands. Aside from its short life span, fossil methane shares more traits with CO2 from fossil fuels in how it warms our planet, since it's not derived from atmospheric carbon (it's pulled from the earth) and is new to the atmosphere. It's worth noting that methane emissions from fossil fuel extraction have been **severely underestimated.**

Methane stays in our atmosphere for 12 years

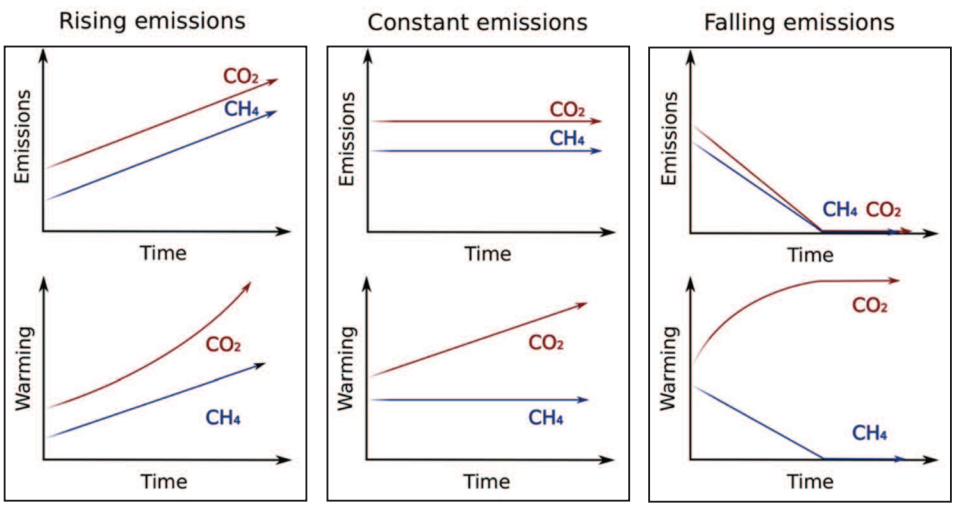
Methane has a relatively short life of **12 years** compared to the hundreds or even thousands of years that CO2 hangs around. After about 12 years, 80 to 89 percent of methane is removed by oxidation with **tropical hydroxyl radicals** (OH), a process referred to as hydroxyl oxidation. As a result of its short lifespan, methane is only significantly warming our atmosphere for those 12 years, which is why it is considered a short-lived climate pollutant (SLCP).

Its short lifespan is further relevant in regard to warming, because it means that as methane is being emitted it is also being destroyed in the atmosphere, making it a **flow gas.**

This illustrates that methane's warming impact isn't determined by how much is being emitted – since it's destroyed relatively quickly – but by how much more or less methane is being emitted over a period of time. This is a change in the rate of emission.

What is notable about methane, is that it's possible the amount being emitted can equal the amount being destroyed. For example, if a herd of cattle emits the same amount of methane over 12 years, they are contributing to warming for those 12 years. But afterward the same amount being emitted is the same

Figure 1: Schematic illustration of how global mean temperatures respond to different emissions trends in carbon dioxide (CO2) and methane (CH4).



Source: Briefing paper, "*Climate metrics under ambitious mitigation*".

that is being destroyed through oxidation, and thus warming is neutral (see Figure 1 on page 27).

It should be pointed out that additional methane outside of that equilibrium – such as before reaching it or adding more after – warms at 28 times that of CO2, making it important we do not increase methane emissions.

But a really intriguing aspect of biogenic methane, is that if we are able to reduce it, such as with **dairy digesters,** then we can create a cooling effect since there is more methane being destroyed than emitted. These warming and cooling situations are considered in a new climate change matrix **called GWP*,** which better quantifies the warming effects of short-lived climate pollutants such as methane.

Methane is created from atmospheric CO2

The critical difference between biogenic methane and a fossil fuel greenhouse gas, is that methane from sources like cattle begin as CO2 that is already in the atmosphere. Gases that result from fossil fuel production begin deep in the earth, where they've been stored for millions of years, away from the atmosphere.

So how does CO2 become methane? Meet the biogenic carbon cycle

The cyclical nature of biogenic carbon starts with plants. Think back to your grade school years – what do plants need to grow?

Water, sunlight and CO2

As part of the **biogenic carbon cycle,** plants absorb carbon dioxide, and through the process of photosynthesis, they harness the energy of the sun to produce carbohydrates such as cellulose. Indigestible by humans, cellulose is a key feed ingredient for cattle and other ruminant animals. They are able to break it down in their rumens, taking the carbon that makes up the cellulose they consume and emitting a portion as methane, which is CH4 (note the carbon molecule). After about 12 years, the methane is converted into carbon dioxide through hydroxyl oxidation. That carbon is the same carbon that was in the air prior to being consumed by an animal. It is recycled carbon (see Figure 2 below).

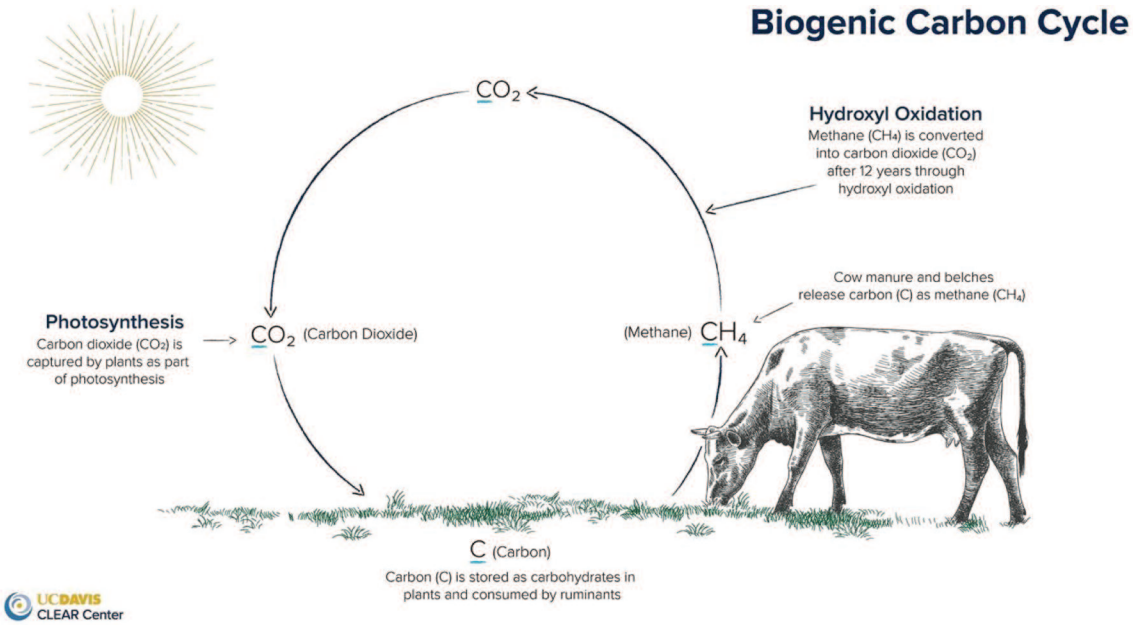
A quick note: while both biogenic and **methane from fossil fuels** are chemically identical, the resulting CO2 from oxidation has a different warming impact. The biogenic carbon from cattle and wetlands is returned to the atmosphere as that is where it started, while fossil carbon is brand new atmospheric carbon, and hence, new warming.

What does this difference mean?

The difference between biogenic methane and CO2 is significant when we talk about warming, which is ultimately what we care about when discussing greenhouse gases. The current standard for determining how greenhouse gases warm the planet, which is GWP100, doesn't reflect the **differing characteristics of methane** and other short-lived climate pollutants from CO2 and long-lived climate pollutants.

If we really want to find climate solutions, then we need to accurately understand how various greenhouse gases actually warm the planet, because we may be missing opportunities to reduce global warming because we misunderstand the roles different greenhouse gases play in climate change. This isn't to negate the value of GWP100, because it does a good job of representing CO2 and other long-lived climate pollutants, but it's more productive to look at short-lived climate pollutants in a better way – in other words, having the right tool for the right job.

Figure 2: Biogenic Carbon Cycle.



If our efforts to reduce biogenic methane shouldn't come at the expense of reducing CO2 from fossil fuels. If they do, then we're likely to end up with a warmer climate, because the effects of a reduction of biogenic methane would be short lived as the emissions would balance out like mentioned above. On the other hand, CO2 would continue to build up in the atmosphere and warm.

Overall, it is worthwhile to reduce biogenic methane emissions from animal agriculture, as it can buy time for the global community to develop solutions that stop climate change. But we must consider how methane and other greenhouse gases actually warm the planet if we want to have long-lasting effects, otherwise we may nonetheless end up with a warmer planet.

Useful links

Below are useful links giving further explanations:

Methane from fossil fuels – BG – Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane? (copernicus.org)
https://bg.copernicus.org/articles/16/3033/2019/

Severely underestimated – Oil and Gas May Be a Far Bigger Climate Threat Than We Knew – The New York Times (nytimes.com)
https://www.nytimes.com/2020/02/19/climate/methane-flaring-oil-emissions.html

12 years – Overview of Greenhouse Gases | Greenhouse Gas (GHG) Emissions | US EPA
https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane

Tropical hydroxyl radicals – Sinks for atmospheric methane – ScienceDirect
https://www.sciencedirect.com/science/article/abs/pii/0306261992900419?via%3Dihub

Flow gas – Greenhouse gas emissions: What is the difference between stock and flow gases? | CLEAR Center (ucdavis.edu)
https://clear.ucdavis.edu/news/greenhouse-gas-emissions-what-difference-between-stock-and-flow-gases

Climate metrics under ambitious mitigation
https://www.oxfordmartin.ox.ac.uk/publications/climate-metrics-under-ambitious-mitigation/

Dairy digesters – What is a Dairy Digester and How Does it Affect Methane Emissions? | CLEAR Center (ucdavis.edu)
https://clear.ucdavis.edu/explainers/what-dairy-digester-and-how-does-it-affect-methane-emissions

*called GWP** – A solution to the misrepresentations of CO 2-equivalent emissions of short-lived climate pollutants under ambitious mitigation | npj Climate and Atmospheric Science (nature.com)
https://www.nature.com/articles/s41612-018-0026-8

Biogenic carbon cycle – The Biogenic Carbon Cycle and Cattle | CLEAR Center (ucdavis.edu)
https://clear.ucdavis.edu/explainers/biogenic-carbon-cycle-and-cattle

Methane from fossil fuels – Special Report: Millions of abandoned oil wells are leaking methane, a climate menace | Reuters
https://www.reuters.com/article/us-usa-drilling-abandoned-specialreport/special-report-millions-of-abandoned-oil-wells-are-leaking-methane-a-climate-menace-idUSKBN23N1NL

Differing characteristics of methane – Guest post: A new way to assess 'global warming potential' of short-lived pollutants (carbonbrief.org)
https://www.carbonbrief.org/guest-post-a-new-way-to-assess-global-warming-potential-of-short-lived-pollutants

A changing market landscape – what behavioural changes has Coronavirus driven for dairy consumers in 2020?

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Introduction

2020 has been a difficult year for everyone, both in the UK and overseas. Repeated lockdowns and restrictions on businesses, as well as coronavirus itself, have caused panic buying, cupboard filling, widespread foodservice closures and difficulty with labour on farm and in processing units. The strain placed on both food supply chains and consumers has been unprecedented in peacetime.

The impact on dairy supply chains became the subject of headlines as the first lockdown restrictions came into effect. Initially, stockpiling in retail gave way to longer term buoyancy as people moved their consumption in home and supermarkets saw double digit levels of growth. Difficulties arose as the abrupt closure of food service outlets meant the loss of that valuable market resulting in oversupply of milk. This was exacerbated by coinciding with the spring flush and processing capacity being full. As a result of this we saw distressing scenes of milk having to be tipped away on farm with no home.

Over time the supply chain has balanced out and the market has reached more equilibrium. Suppliers for food service have pivoted to retail and in some cases adopted new routes to market. However, the challenges remain as tiering restrictions continue and British consumers struggle to adapt to that very-overused phrase, the new normal.

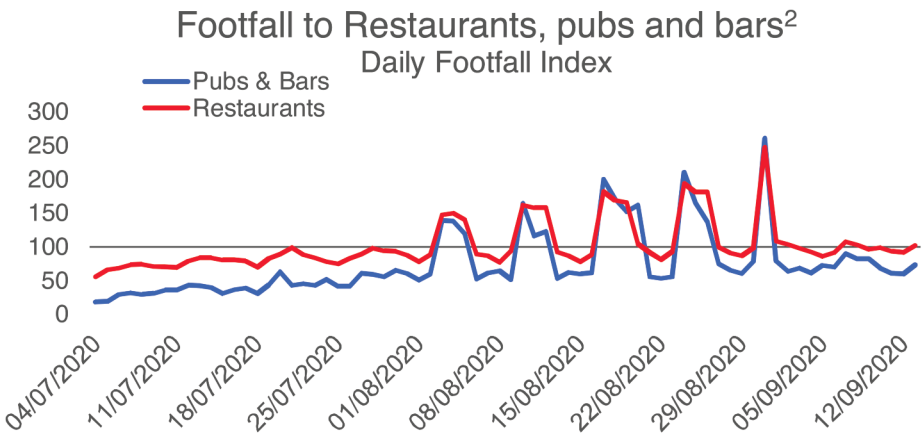
This paper explores how dairy consumers have adapted over the course of this year, both in buying and consumption behaviour and in their attitudes and highlights the key challenges and opportunities for the coming year for dairy producers.

Out of home challenges

At the peak of the first lockdown, the number of out of home eating occasions had fallen by 62% compared to the same period last year. There was growth in in-home eating occasions at the same time of 30% but this was not enough to compensate for overall losses across the whole market.[1]

As the first lockdown eased and cases fell, the British government sought to encourage foot traffic back to retail with Rishi Sunak's welcoming the Eat Out to Help out (EOTHO) scheme. This was moderately successful in encouraging consumers to return to eating out again. Kantar reported an additional 121m out of home occasions in 4 w/e 9 Aug, vs 4w/e 12 Jul 20. The uplift was particularly felt in Monday to Wednesday dining out occasions which grew by 177% in Aug vs Jul, compared to the average out of home market uplift of 27%. The number of

Figure 1.[2]



people leaving their homes for the purpose of eating out rose from 9% in early July to 38% by the week of the August bank holiday, however these gains were short lived and immediately began to tail off with a sharper fall as new restrictions came into force in November.[3]

In September, when consumer confidence was at its highest, the vital coffee shop market was only seeing foot traffic of half the levels compared to before the pandemic.[4] We may expect to see the coffee market demonstrating resilience as we did after the 2008 recession, however, the structure of the market will not be quite the same as many outlets have permanently closed.

Similarly, although we have seen movements to takeaway, with growth in menu items such as pizza, this has not been enough to offset the losses in food service. Pizza has seen a 20 million growth in occasions but burgers, overall, have lost 183 million occasions. As city centre traffic has diminished, food to go has also dwindled and cheese sandwiches have lost 52 million occasions.[5]

Even as restrictions start to ease again there will continue to be headwinds in food service. Over half of consumers (57%)[6] expect to be eating out less than before the pandemic. This is driven by both health and safety consideration but also economic necessity as the growth in unemployment and a shrinking economy are felt.

Growth in retail

As consumption moved into the home, retail volumes soared. After the initial stock piling and panic buying settled and confidence in the supply chain resumed, total food and drink volumes for the 24 w to 6th September 2020 grew by 12.4% year on year. Dairy products helped some of that growth with cheese up by 16.5% and butter and cream up by 23.5% and 31.8% respectively. Milk and yogurt has more sober levels of growth at 8% and 5.3%, but milk's sheer size meant that in volume terms it accounted for the biggest portion of dairy growth.

Figure 2.

The dairy alternatives market remained buoyant, driven by an extremely strong performance in oat milk, although alternatives remain a comparatively tiny part of the dairy market at 4%.

The key changes in behaviour driving dairy growth were the uplift in hot drinks in home, particularly tea (which had been seeing some decline in recent years) and lunches being consumed at home. This drove good levels of growth for both cheese and butter as sandwiches performed well. While there was much hype about baking banana bread and sourdough, baking itself only accounted for a small uplift in volumes, although more influential for categories like cream.

All categories of cheese, apart from individually portioned cheeses for lunchboxes performed well. Territorials saw the most growth overall, reversing the pattern of ongoing decline. Whilst cheddar as by far the largest type of cheese in the market accounted for the most volume growth, the most dramatic grower was mozzarella, boosting volumes by 48% year on year as consumers made their own pizza and other Italian dishes.

Changing attitudes

The Covid-19 pandemic has wrought some changes in how consumers feel about the food system. Three quarters believe that British farmers have done a good job in producing food for consumers during the crisis.[7] In a separate survey this year we found that trust in all parts of the supply chain had deepened to some extent with retailers and food service seeing the biggest uplifts (10% and 12% respectively).[8] Positivity towards agriculture had also improved from 62% to 66%, driven mainly by horticulture and pork.

A shift in balance of media reporting around red meat and dairy, due to the dominance of coronavirus coverage, has had a positive impact. Dairy coverage has dropped from 24% at its peak last year to 16%. This has had the effect of 'reducing the reducers' and the number of people who say they are cutting back on dairy has fallen to a low of 11%.[9]

However, we should not expect this respite to continue. As the vaccine is distributed through next year and the threat recedes we expect negative coverage to pick up again. The key issues of concern for consumers are health, the environment and animal welfare.

Reputational issues

Around 1 in 3 consumers have concerns about how milk is produced. Concerns tend to be generalised with 'animal welfare' coming up as a top consideration. However, there are some welfare specifics that are also

cited particularly around cow-calf separation, the fate of bull calves, access to grazing and the erroneous belief that growth hormones and antibiotics contaminate the milk supply. More technical considerations such as mastitis or lameness are less well-known or compelling for consumers.

In addition to welfare, environmental impact of dairy production is one of the fastest growing concerns and there is growing scepticism about the environmental credentials of dairy. Five years ago, 67% of consumers felt that dairy farming was good for the countryside. That figure has now fallen to 45%. There has also been a growth in the belief that dairy farming is a contributor to climate change.[10] As more and more consumers start to consider the environmental credentials of their food it will be vital for the industry to manage communication around these issues.

Health has also been an issue during this pandemic. There has been somewhat of a paradox: on the one hand people wanted to be as healthy as possible due to fears about the pandemic, but on the other hand many people were bored, scared and frustrated which led to more indulgence. Health seems to have bounced back after a lull during the year so it is important that we can demonstrate the important role that dairy products can play in a healthy, balanced diet.[11]

Conclusion

There will continue to be structural disruption in the market next year, both from a weakened food service market, uncertainty around the levels of working from home and broader disruptions from the EU Exit. Economic challenges will be real but as a cheap and well-loved source of protein, dairy is perhaps well placed to weather some of that storm.

Producers must continue to be agile to be able to pivot route to market where necessary but there is opportunity here – the return of custom to traditional milkmen demonstrates this. They must also be innovative in exploiting both demand for more health-focused foods and also in demand for recreating food service experiences at home (in home lattes, pizza, sandwiches and desserts).

Finally, as the spectre of dairy alternatives looms it is vital that dairy producers address some of the reputational challenges, or risk more consumers dropping out of the category. The industry has demonstrated that it is possible to work together through the supply chain in responding to consumer demands in thorny issues such as bobby calves and the environment. Tomorrow's consumer will demand even more, and will not necessarily be prepared to pay for it. There is a key need to reinforce the role of dairy in the diet and the key nutrients that it can deliver to add value for consumers.

References

1 Kantar Worldpanel Total Food and Drink | Total In Home Occasions and Total Out of Home (excl alcohol) Occasions | YOY Growth % | Rolling 12 w/e to 09 August 2020.

2 Kantar Worldpanel Plus.

3 Kantar Worldpanel / Office for National Statistics, Coronavirus and the social impacts on Great Britain.

4 Kantar Usage/TEA/coffee/ OOH sales to 6 September 2020.

5 Kantar OOH, 24we 6 Sept 2020; *Total burgers not just those with cheese.

6 AHDB/YouGov Aug 2020.

7 AHDB/YouGov 2020.

8 AHDB/Blue Marble 2020.

9 AHDB/YouGov 2020.

10 AHDB/YouGov 2020.

11 Kantar Usage.

FARMEXCELLENCE

AHDB

Establishment, opportunities and challenges at Forde Grange goat dairy

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Forde Grange Goat Farm, Childhay Manor, Beaminster
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Forde Grange goat farm was first established in 1996 and replaced an existing cow dairy herd. The cow unit was a third herd and part of Childhay Manor Farm owned and managed at the time by my father Tim Frost. Milk Quota had become very expensive to both buy or lease and the alternative of goat milk production looked like a market which had long term potential.

Establishment was most challenging as it was a case of learning from ones mistakes as there was little industry knowledge and advice to help larger scale herds at the time.

The first goal was to study the market. It has now grown into a market with UK production in the region of 37 million litres producing predominantly liquid milk, cheese and butter.

In our case we have a very strong relationship with Delamere Dairies based in Cheshire with milk bottled for them at Shepton Mallet. In the UK producers are regulated by the processors and the processors will not let the producers produce more than what is required for the market. New entrants are only allowed when the processors feel there is a growth in demand.

Herd health is also another crucial factor in establishment of a goat herd. In the early years stock was very hard to come by and our establishment was developed with the help of one or two existing producers who supplied us with kids to get numbers on the ground. The herd has been a closed herd for the last 20 years and has concentrated on herd improvement through the use of breeding our own Bucks using AI onto the best female lines within the herd.

There are huge opportunities from improving genetics within the UK goat industry. Our yields have improved from 850 litres/goat to 1,280 litres/goat in the last 20 years but within the herd there would be goats giving 850 litres/year and goats giving 2,000 litres. We have also within the last 5 years started genomic testing Bucks. We have initially dabbled with Yorkshire Dairy Goats but now have had more success with collaboration with a more robust French breeding programme.

The UK industry has also had the challenge of dealing with unwanted male billy kids. This has seen the development of rearing kids for meat and we sell through Cabrito Meats which, as well ourselves, has been largely invested in by Delamere our milk processor. The marketing of goats meat has been challenging especially with the onset of a pandemic but sales have been increasing and demand is gradually growing. There has also been introduction into NZ of sexed semen which will have potential in the future. AI in goats is growing more popular but still challenging. We feel as a UK industry that laparoscopic AI is quite evasive and we have gone down the route of trying to improve the conventional AI technique. Goats are synchronised and groups are AI'd to allow a specialist to carry out a group service on a visit. Currently success rates are improving with a 50% conception rate achievable.

Forde Grange has stuck with a TMR type feeding system using a Keenan wagon. Nutritional expertise comes from Kelly Farm Consulting who have helped us over the last 20 years. The farm grows 300 acres of Maize with 200 acres fed to the goat herd and 100 acres sold locally. Yields of Maize have vastly improved over the last 20 years largely due to improved soil condition. The land would predominantly contain a large proportion of Clay and would compact easily. All the manure comes in the form of FYM and is heaped throughout the year and spread by contractors in the spring and ploughed under. The soil condition has become more friable, aerated and richer over the years. Goat manure has good P and K levels and spread on dry ground in the spring avoids soil compaction which slurry spreading might do.

Rations also consist of grass silage, sugarbeet nuts, rapemeal, non gm soya, home grown crimped wheat as well as megalac and minerals. The milk is produced to a non gm standard

to access an export opportunity into the German non gm cheese market.

The enterprise grew in 2008 to establish a new exciting joint venture with Forde Abbey estate which is ran as a contract farming operation. The herd with the backing of Delamere dairies grew to a herd size of 2,200 goats producing 2.8 m litres. The estate provided land, investment in building infrastructure and operate a no 2 account. Childhay provide stock, management, labour, milking facilities and machinery. Childhay also rear all the goat youngstock on its home farm. Further investment has been made into youngstock rearing facilities so a batch kidding system is operational. The joint venture has given both parties a strong enterprise with any profits shared and also giving scale of production.

The main challenge going forward is the market place. 20 years ago, there would have just been cows milk with goats milk as an alternative health choice on the supermarket shelves. Now of course there are many different types of milk having an impact on market share. This has thrown up opportunities for other markets abroad and at home and Delamere have new potential markets developing worldwide. The improvement in yields and growth in production has to be done hand in hand with the processor to avoid overproduction.

Breeding opportunities are amongst one of our aims. Remaining a high health closed herd is so important and bolstering levels of biosecurity, herd surveillance and accreditation are all objectives going forward to allow marketing of male and female goat lines at home and abroad.

Use of Actiphage® to detect bovine TB and Johne's disease: achievements and unanswered questions

Dr Cath Rees
Associate Professor, School of Biosciences,
University of Nottingham and CSO, PBD Biotech Ltd

Summary

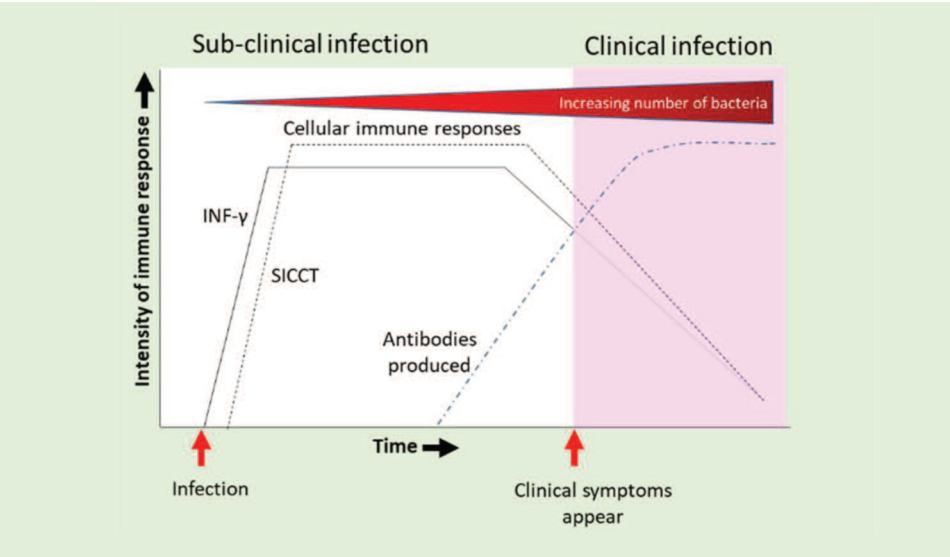
Actiphage® is a new test that can directly detect the presence of the bacteria that cause bovine tuberculosis and Johne's disease, so this test is more linked to culture-based methods of detection. Other methods to diagnose these infections rely on detecting different aspects of the animals' immune response; either tests that detect cell-mediate immune responses, such as those detected by SICCT or gamma interferon, or ELISA tests that detect the production of antibodies in response to infection. Since each of these tests measures different things – and each has their own limitation – trying to compare the performance of these different tests is difficult. In addition, the animal's immune response to these diseases is complicated, making comparison of test results even more difficult. However, Actiphage can now provide direct evidence of the presence of the bacteria in blood during infection, and the information we are gaining may help us better understand how to best use all of the available tests to tackle these difficult endemic diseases.

Difficulties detecting Mycobacterial infections using standard methods

The gold standard for confirming infection by most types of bacteria is culture, i.e. the organism is grown in the lab from a sample taken from the infected animal. Unfortunately, culturing Mycobacteria (the type of bacteria that cause both Johne's disease [JD] and bovine TB [bTB]), is very challenging because they grow very, very slowly in the lab and even rapid methods take up to 40 days. Not only is this method very slow, samples have to be treated with harsh chemicals to kill off the fast-growing organisms which will otherwise swamp the agar plates. However, this treatment also kills some of the Mycobacteria, so there needs to be about 100 cells in a sample to ensure that 1 colony will grow. Hence, although still considered the gold standard method for proving mycobacteria are present in a sample, culturing is not routinely used as a diagnostic.

Instead of culture, most routine tests used to detect both bTB and JD focus on detecting the immune response. In most infections there is a simple relationship between infection and the animal's response such that there is an increasingly strong response over

Figure 1: Summary of pattern of immune responses to mycobacterial infections. Based on diagrams produced by Vordermeier et al. (2004) and Rosseels and Huygen (2008).



time. However, Mycobacteria have evolved immune-escaping systems which then allow the establishment of a latent infection and the long, slow development of disease symptoms. It is reported for both JD and bTB that the initial immune response to infection is primarily cellular, and this can be detected using tests such as SICCT and gamma interferon (INF-γ). However, as latent infection is established, the cellular immune responses level off and then start to decline (see Figure 1 on page 35).

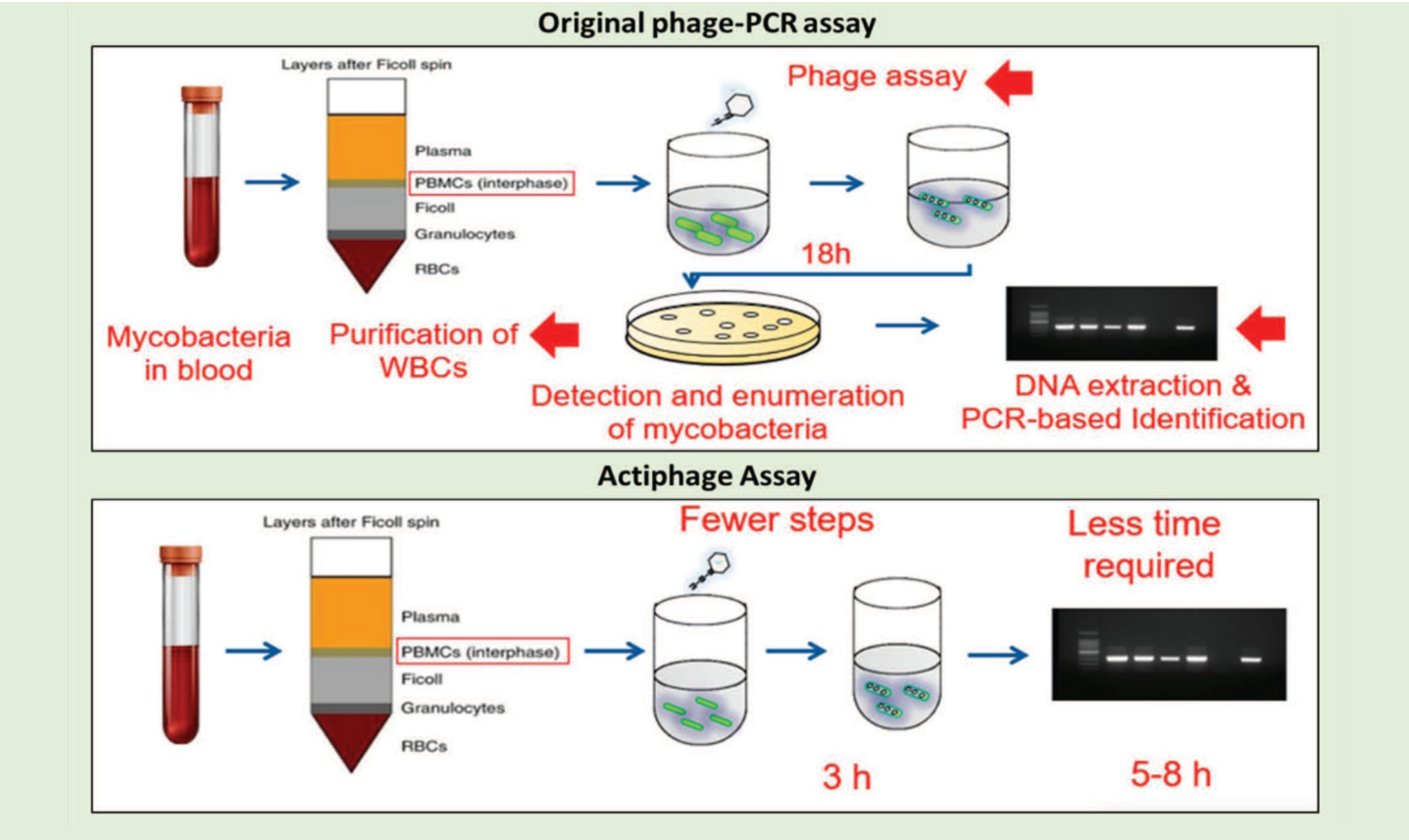
Also associated with the development of latent infection, antibody production is delayed and detectable levels of antibodies are often only produced once symptoms of clinical infection start to become detectable. It seems that the antibody response only really starts to develop once the animal loses control of the latent infection, and then bacterial numbers start to increase and clinical symptoms and pathological signs of infection become evident.

Actiphage – a new approach

Actiphage is based on a method that was developed and approved as a human TB test 20 years ago which was used to detect the Mycobacteria that cause human TB in sputum samples. The method uses a bacteriophage (a virus that is specific for bacterial cells) to detect the presence of the Mycobacteria. In the original assay format, virus particles were allowed to infect the Mycobacteria present in a sample and this process protected the bacteriophage against chemical inactivation. Thus the presence of Mycobacterial cells was indicated because the viruses survived and resulted in to the formation of plaques (zones of clearing) in a lawn of bacteria. Each plaque indicated the presence of one Mycobacterial cell in the original sample, and so the number of Mycobacteria present could be counted (see Figure 2 on page 36).

The development that allowed this method to be used to detect animal infections was the discovery that DNA from the Mycobacteria that was being detected was still present in the plaques. This now allowed standard PCR assays, routinely used in labs to identify different types of Mycobacteria, to be used to identify the type of cell that had protected the virus. This method was originally developed to detect *Mycobacterium paratuberculosis* (MAP) in milk (Stanley et al., 2007), but was then adapted to detect MAP in blood samples (Swift et al., 2013). Then the method was used to try and detect *Mycobacterium bovis* in blood from SICCT-positive cattle (Swift et al., 2016) and this produced some unexpected results. Although it was well known that MAP could be found in the blood of cattle suffering from

Figure 2: Phage-based methods to detect mycobacteria in blood samples.



Mycobacteria in blood are found inside white blood cells (PBMCs). These are purified and then lysed to release the mycobacteria. In the Phage-PCR method, the myocbacteria are detected by the formation of plaques and DNA is extracted from these and PCR used to identify the type of cell detected. In the Actiphage method phage are just used to break open the mycobacterial cells to release DNA so that the cells present can be detected and identified by PCR. Diagrams provided by PBD Biotech Ltd. https://www.pbdbio.com/

JD, it had not been previously shown that *M. bovis* is circulating in the blood of cattle in the early stages of bTB infection.

However, the original phage-PCR method is quite laborious and can only be carried out in microbiology labs. So, a new version of the method was developed which is now called Actiphage (Figure 2; Swift et al., 2020). This method is simpler, quicker, does not require any agar plates, and was predicted to be more sensitive since there was less opportunity to lose the low levels of DNA during the assay. Indeed, this was found to be the case when comparing results using phage-PCR and Actiphage to test blood samples from animals infected with MAP or *M. bovis* (Swift et al., 2020).

How do you validate a new test?

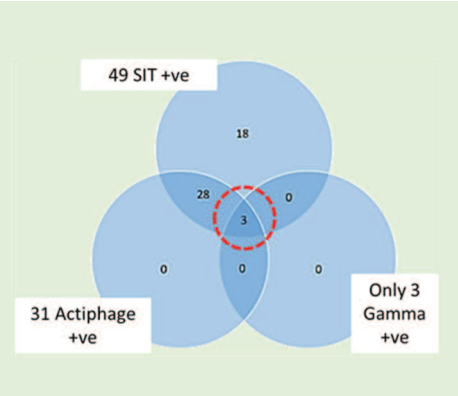
Normally new tests are compared with a gold standard method to demonstrate how well it performs. However how do you validate a method that measures something different to the existing tests (in this case SICCT, INF-γ, ELISA) and the gold standard method (i.e. culture) is not very sensitive? If you get more positive results than the gold standard, this can be interpreted as your new test giving false-positive test results.

As Actiphage uses PCR-based detection and identification, surely it would be possible just to compare results with standard PCR test results? Unfortunately, another unusual feature of Mycobacteria comes in to play here because their cell walls contains a thick, waxy layer of mycolic acid that makes them very difficult to break open. Commercial PCR kits that use standard chemical or physical methods to extract DNA from bacteria are therefore not very effective, and the limit of detection of these PCR kits when testing for Mycobacteria is also about 100 cells. The viruses that we use in the Actiphage assay have evolved powerful enzymes that can break the cells open far more efficiently than any chemicals, and so using Actiphage we can routinely detect fewer than 10 cells in a sample using PCR (Swift et al., 2020). So once again, our method is more sensitive than the standard method.

Since the immune response to both JD and bTB is complex, the results for culture (or Actiphage) may or may not agree with other tests, depending on what stage a sample is taken during infection (see Figure 1 on page 35). We have seen this in our own studies where there has been disagreement between the results gained using commercial JD milk and blood ELISA assays (Swift et al., 2013) and also between JD ELISA and tissue culture results (culture positive animals giving negative blood ELISA results; Swift et al., 2020).

In a study of a herd with a chronic bTB infection, conducted with veterinarian Dick Sibley in Devon, we selected animals on the basis of a positive single intradermal tuberculin (SIT) test result (positive reaction to PPB-B). This version of the skin test is used in many countries as it is considered to be the most sensitive form of the skin test, but it is known to be less specific as cross-reactions in the immune response can occur to other types of Mycobacteria, such as *Mycobacterium avium*. The animals selected for enhanced testing gave a stronger response to PPB-A than to PPB-B (i.e. were SICCT-negative)

Figure 3: Comparison of Actiphage result with INF-γ.



Actiphage results confirmed that SIT-positive animals were true infections and provide added information about specificity of SIT result.

and therefore the SIT result was considered to be non-specific. When a set of 49 of these SIT animals were tested with Actiphage, 31 gave a positive test result, confirming that *M. bovis* was present at detectable levels in their blood (see Figure 3 on page 37). However, only three animals gave a positive INF-γ test result, and these three animals were also blood ELISA negative – as might be expected as antibody levels are known to rise to detectable levels only after INF-γ responses start to decline (see Figure 1 on page 35). Again, this points to the fact that we really need to better understand the animals response to infection to understand what test results are telling us and when to use them.

All this disagreement between test results make the validation process very difficult – which test result do you use as the gold standard? All we can do – and we are actively engaged in this – is to continue to work with farmers and gather data from many different sources until we have a body of information that will satisfy the regulatory bodies, even if on occasions our test does give more positive results than existing methods.

So which test to use, when?

What farmers need to be able to eradicate disease are sensitive, accurate tests to inform their disease management decisions. What we are beginning to understand is that the complexity of the interaction between Mycobacteria and their hosts is not going to make this easy. From all of the data available, we know that when using the most specific forms of these tests – such as SICCT – false-positive results are unlikely. Our results testing SICCT-positive animals have shown that even NVL animals have detectable levels of *M. bovis* circulating in their blood (Swift et al., 2016, 2020), and these test results need to be accepted at face value. In JD, using Actiphage to detect the presence of bacteria in the blood indicates that systemic infection has been established, and removes worries about positive faecal culture results that may result from passive transmission or cross-contamination of samples.

Less specific tests than SICCT do run the risk of producing false-positive results. However, Actiphage only gives a positive test result if the DNA of the bacteria is detected in the blood sample, and we have shown that it can be used in combination with the SIT test to provide confidence that the results are due to *M. bovis* infections. Tests based on the immune response also have the limitation that they cannot be carried out too close together, leading to long periods when testing cannot be performed. Since Actiphage detects the bacteria rather than an immune response, it can be used at any time and with no need for a gap being left between tests when residual disease can spread to other animals. It can also be used for animals at any age – we have detected both JD and bTB infections in calves. This allows farmers to test young stock and save them the cost of rearing animals that are infected and help the long-term control of disease. Actiphage can also be used to screen animals before they are moved – either within a farm or between farms – to help prevent spread of disease.

However sensitive, all tests are prone to producing false-negative results and test results tend to fluctuate between positive and negative in the early stages of infection before the signal reaches a threshold that can be confidently detected. The complex nature of the biology of Mycobacteria means that antibody responses are slow to develop, and ELISA-based assays are not likely to become consistently positive until the disease is well progressed. The situation is even more complicated for JD and bTB, because in longer, chronic infections the initial cell-mediated immune responses start to decline again, and so infections may then be missed as the disease progresses. Even Actiphage cannot detect infection in its very earliest stages because the levels of mycobacteria in the blood have to get to a sufficient level to allow us to detect it in every blood sample. However, Actiphage now provides a new test option that is not dependent on the vagaries of the immune response and provides definitive evidence that an animal is systemically infected.

Concluding remarks

We are still in the early days of this science, and there is still much to learn about the way that both JD and bTB develop in their hosts. What is becoming clear, however, is there are far more parallels between these two diseases that has often been appreciated. We believe that in addition to providing new information to help disease control programs, Actiphage can also be a new tool that will help us better understand Mycobacterial infections and to pin down exactly which of the available tests is most informative at different stages of infection. Hopefully then we can finally provide a definitive answer to the question of 'which test to use, when'.

References

Rosseels & Huygen (2008) Vaccination against paratuberculosis. Expert Rev. Vaccines, 7: 817–32.

Vordermeier et al. (2004) The interferon-gamma field trial: background, principles and progress. Vet. Rec. 155: 37–8.

Stanley et al. (2007) Development of a New Rapid Combined Phage and PCR method for the detection and identification of viable *Mycobacterium paratuberculosis* within 48 h. Appl. Environ. Microbiol. 73: 1851–7.

Swift et al. (2013) Development of a rapid method for the detection of viable *Mycobacterium avium* subsp. *paratuberculosis* in blood within 48 h using a phage-based assay. J. Microbiol. Meths. 94: 175–9.

Swift et al. (2016) Evidence of *M. tuberculosis* Complex bacteraemia in intradermal skin test positive cattle detected using phage-RPA. Virulence, 7: 779–88.

Swift et al. (2020) The development and use of Actiphage to detect viable mycobacteria from bovine tuberculosis and Johne's disease-infected animals. Microb. Biotechnol. 13: 738–46.

Maximizing genetic gain at Rathard Holsteins

Peter Hynes
Rathard Holsteins, Co Cork, Ireland

My farming career didn't begin until 2010 when at the age of 36 I returned home to Aherla to what is now Rathard Holsteins. At the time the herd comprised of fifty cows grazing 240 days a year producing 270 kgs milk solids per cow. The herd was spring calving with a 31-week calving spread and a calving interval of over 400 days. No AI was being used on farm with a Friesian stock bull being used to breed replacements whilst the herd was being mopped up by an Aberdeen Angus stock bull once it had served all the heifers. All heifers were calved down at 36 months.

Whilst my immediate focus was on educating myself through agricultural college and discussion groups along with changing grassland management it was imperative for the long-term benefit of the herd that I improved the breeding program along with increasing genetic gain. I completed an AI course in 2011 to gain a more educated view on the breeding cycle of dairy cows.

In 2012 a team of daughter proven AI bulls was selected for the herd with the help of breeding advisor Eustace Burke whom is still a key part of the farm team. I believe it is vital a progressive dairy farm has a good breeding advisor who understands the herd but also has clear sight of the long-term vision for the herd. I commenced AI in 2012 whilst also shortening the breeding season to 12 weeks. We use EBI (economic breeding index) which is a single figure profit index aimed at helping farmers identify the most profitable bulls and cows for breeding dairy herd replacements. Our average herd EBI at the time was 62 with a target of 110 by 2020 through genetic gain.

High EBI genotyped bulls were starting to become more available in Ireland but with a view to expanding the herd with removal of EU quotas in 2015 I decided to go the route of using sexed semen in 2013 ensuring we would have maximum numbers of home-grown replacement heifers calving into the herd in 2015. I also decided to switch to using an AI technician as whilst I had been successful at AI cows myself the fact that a technician serves between 10,000 and 20,000 cows each year solidified to me that their strike rate would ultimately be better than mine. A missed heat or missed serve costs the farm 250 euro per cow therefore using a top-class technician can easily be financially justified.

Sexed semen was successful for us with a 65% strike rate on cows to first service. Cows selected for sexed semen had to tick all the right criteria for us, early calving with no calving issues and no metabolic issues. Heifers were switched to calving at 24 months and in 2014 my wife Paula also joined the farm whom herself has now also obtained an AI license.

Rathard Holsteins comprised of 100 cows in 2015 with the herd being doubled in one calving season with a further view to expanding to 120 cows in 2016. Whilst our grazing season was now maximized to 320 days at grass it became clear that maximizing genetic gain would see the greatest gains long term. The decision was taken to switch to using genotyped bulls in 2015 along with genotyping all heifers giving us increased reliability and data on dairy stock.

Our calving interval had reduced to 374 days by 2015 with a 6-week calving rate of 54% so parameters were going in the right direction but ultimately herd expansion slows down the rate of improvement as ultimately every cow available to be milked stayed within the herd and our vision was to get to 180 cows as fast as possible. Milk price was still slightly below the co-op average with cows producing 350 kgs milk solids per cow.

Having grown a close connection with NCBC (national cattle breeding center) which flys under the Ireland Genetics flag in the UK we took the decision to use a team of G1 bulls for AI which are essentially elite young genomic bulls. Further to that myself and Paula also took the decision to use these bulls for breeding our maiden heifers. I must stress that we do look at back breeding on these bulls to check for any signs of calving difficulty as it is not recommended to use the bulls on heifers without any calving data however this is a decision that has worked to our advantage with no difficulty in calving heifers.

We calved down 150 cows in 2017 with enough replacements on the ground to take us to 180 cows in 2018. 2017 was also the year we won the farmer of the year but also built new facilities to allow for cow comfort, better cow flow and ease of manage-

	Genetic Gain 2000–2018		
Herds	2000–2018	2008–2018	2013–2018
Rathard Herd	€10.0	€19.2	€22.4
All Herds	€8.9	€12.1	€9.7
Top 100 EBI Herds	€10.9	€12.9	€9.2

ment. The milking parlour was upgraded from an 8 unit to a new 20 unit all designed for ease of cow flow. A new cubicle shed was built increasing the number of cubicles from 60 to 195 with enough feed rail for 240 cows. We strongly believe in order to maximize production from cows, they require comfort with no competition for feed (see Table above).

Average herd EBI stood at 102 in 2018 however the average EBI for our 2017 born calves stood at 148 with the average for our 2018 calves being 174. We had reduced the herd calving interval to 364 days by 2018 with a 6-week calving rate of 84% along with 84% of heifers calved at 24 months. The average EBI for the team of bulls we used in 2018 stood at 279 and genetic gain was finally starting to be reflected in milk price with our average price being 36 cent for the year which was 1 cent above the co-op average.

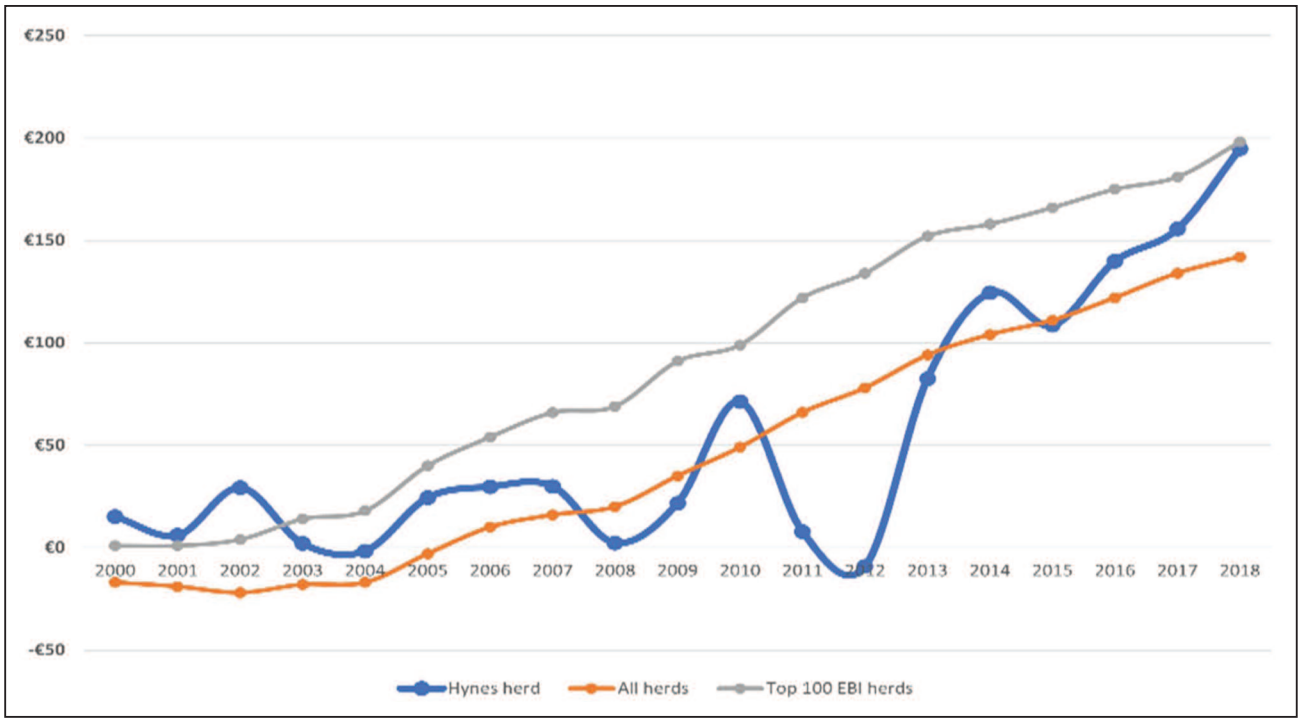
2019 became the year where hard work and decisions finally came to fruition. We finally had surplus heifer calves to sell. All heifer calves were reared on farm to 12 weeks of age and were also genotyped. A detailed look at the genetic breakdown of all heifer calves, analyzing which heifers were getting big EBI gains through genotyping led us to compiling a list of 40 heifers to be retained on farm with all surplus made available for immediate sale commanding above market prices with the view being taken it would not be financially viable to rear these surplus heifers to point of calving and a better route being to put all our efforts into rearing required stock.

2019 also saw our homebred heifer Rathard Alanna winning the All Ireland Munster EBI championship and she also went on to win the highest genetic merit female at the National Dairy Show. Born with an EBI of 279 which climbed to 292 after genotyping, she is sired by FR4513 whom we used as a first season sire. Her granddam still sits within the top seven EBI cows in the herd along with 4 other family members. The granddam has since produced a bull calf with an EBI of 316 sitting higher than his sire.

Rathard Alanna has held her EBI at 292 after 18 months and 9 proof runs and is due to calve on 3rd February 2021 incalf to a G1 sire FR5530.

We also changed to synchronizing all heifers in 2019 using CIDRs with a 70% incalf rate to first service. The important thing in breeding heifers through synchronization is that they are already cycling or sexually mature. We took this breeding decision for ease of management due to busy workloads at the start of the breeding season and believe the extra cost is recouped through less time required for heat detection on heifers, days gained in milk and

Figure 1: EBI Trends for Hynes herd relative to All herds and 'Top 100' EBI Herds.



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Economic Breeding Index (EBI) Herd Summary - Nov 2020

icbf

Report Date: 30/11/2020 (Nov 2020 Evaluation)
Herd Owner: PETER HYNES
Herd No: D2570689

1. EBI Herd Summary

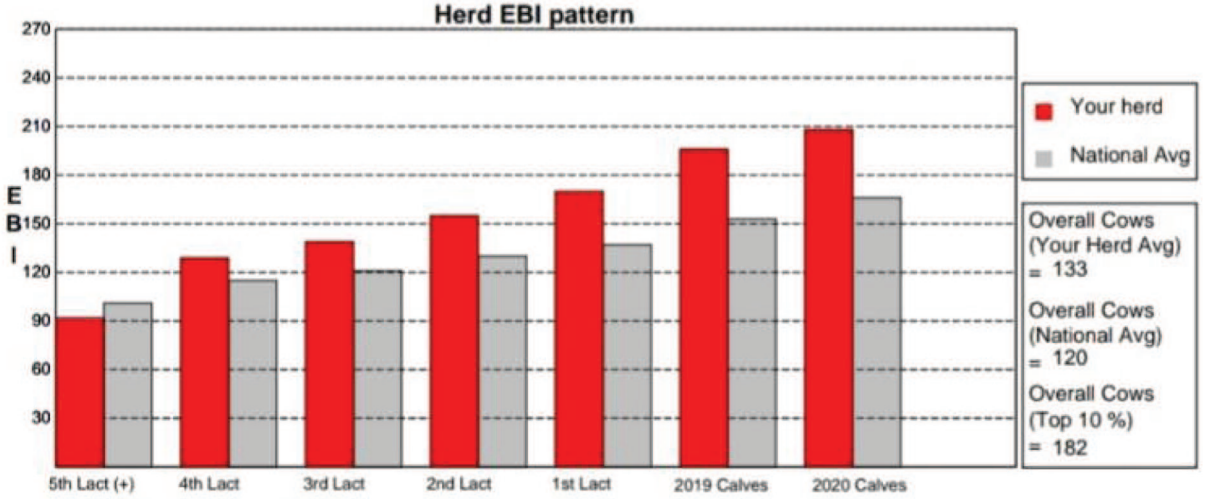
Average EBI for all dairy cows with; (i) a known sire (or milk recorded progeny with a known sire) and (ii) are currently on your farm.

* Number of animals that are missing an EBI result

Animal Group	Num of Cows	Milk Kg / Fat / Prot	% / %	Surv% / CI Days	Milk % Cont	Fertility % Cont	Calv % Cont	Beef % Cont	Maint % Cont	Mgmt % Cont	Health % Cont	EBI €
Cows with EBI	165	33			€ 42	€ 67	€ 23	€ -16	€ 14	€ 2	€ 1	€ 133
Missing EBI*	3	7.2	0.10	1.6	25.5%	40.7%	13.7%	-9.7%	8.3%	1.2%	0.9%	
Total Cows	168	5.1	0.07	-3.8								
1st Lactation	30	15			€ 52	€ 81	€ 33	€ -22	€ 19	€ 2	€ 4	€ 170
		8.6	0.14	2.2	24.5%	37.7%	15.6%	-10.3%	8.8%	1.1%	2%	
		6.1	0.1	-4.3								
2nd Lactation	26	68			€ 48	€ 81	€ 25	€ -11	€ 9	€ 2	€ 1	€ 155
		7.4	0.09	1.4	27.5%	45.8%	14.3%	-6.1%	4.8%	0.9%	0.6%	
		6.7	0.08	-5.0								
3rd Lactation	41	64			€ 50	€ 65	€ 26	€ -18	€ 13	€ 3	€ 0	€ 139
		9.4	0.12	1.5	28.5%	37.3%	14.7%	-10.1%	7.4%	1.8%	0.2%	
		6.1	0.07	-3.7								
4th Lactation	24	78			€ 43	€ 59	€ 24	€ -14	€ 13	€ 1	€ 3	€ 129
		6.6	0.06	1.8	27.4%	37.3%	15.4%	-8.9%	7.9%	0.9%	2.1%	
		6.2	0.06	-2.9								
5th Lactation (+)	44	-29			€ 24	€ 58	€ 10	€ -15	€ 15	€ 1	€ 0	€ 92
		4.4	0.10	1.3	19.8%	47.2%	8.2%	-12%	11.9%	0.6%	-0.2%	
		2.1	0.05	-3.3								

2. Dairy Youngstock

2020 Calves	38	74			€ 72	€ 93	€ 38	€ -15	€ 12	€ 4	€ 5	€ 208
Missing EBI*	0	12.2	0.16	2.3	30.1%	38.9%	15.8%	-6.4%	5.2%	1.5%	2.1%	
Total Calves	38	9.0	0.12	-5.0								
2019 Calves	35	142			€ 75	€ 81	€ 35	€ -12	€ 10	€ 3	€ 4	€ 196
Missing EBI*	2	11.9	0.11	2.1	34.2%	36.7%	16%	-5.4%	4.6%	1.4%	1.7%	
Total Calves	37	10.8	0.1	-4.4								



higher conception to AI. The positive impact this has shown is that due to heifers having more time to recover from calving we have seen a higher incalf rate to first service for our first lactation cows in 2020. Again, all heifers were synchronized in 2020 using CIDRs with 68% in calf to first service.

2020 has seen the herd progress with only 7% of cows empty after a 12-week breeding season. 100% of heifers incalf and 150 due to calve in the first four weeks of calving in 2021. Average herd EBI now stands at 133 which is 23 points above our 2020 target. The average EBI for our 2019 born heifer calves is 196 with the average for our 2020 calves being 208. Again, surplus heifer calves were sold at 12 weeks of age following genotyping and we also sold 6 bulls as stock bulls. The extra financial return for the farm from selling top quality dairy stock is a great asset for any business (see Figure 1 on page 40).

The key learning point surrounding genetic gain on farm is that taking wrong decisions can have a disastrous effect on a dairy herd which can leave a lasting impact on a herd as shown in the graph. The herd was well placed genetically in 2002 however breeding decisions impacted the herd very quickly with the herd not regaining the same genetic potential until 2009 but again breeding decisions negatively impacting the herd until a change in breeding strategy in 2012. A clear vision of where we wanted to take the herd genetically in 2012 has seen genetic gain climb to that of the top 100 herds by 2020 albeit at a far greater pace with the herd genetic gain being over double that of the national average and top 100 herds. In order to maximize genetic gain a farm must have a strict breeding strategy, a clear vision and patience combined with belief. It has taken us 8 hard years to get to where we are, however now we are in a position where genetic gain will snowball dramatically year on year.

Our policy has remained the same over the last few years, use a team of elite genetic merit bulls, look at our herds requirements and match bulls to individual females depending on their genetic breakdown. Bulls must have a well-balanced EBI with a clear focus on fertility index, positive in kgs of milk with high constituents and health traits must be positive. Sires we have used over the last number of years include HZB, LWR, FR2298, FR4513, FR4728, FR4760 etc. but it is important to remember all these sires were used as first season sires.

Lastly, we believe every farm requires a top-class breeding team. The AI technician can only reach top targets if heat detection is top-class with cows being presented for insemination at the correct time. Breeding advisors must be a part of the vision and also what genetic improvements the herd requires. Myself and Paula are indebted to the team at the NCBC whom have spent many hours walking the herd looking at stock with us, for spending numerous hours discussing genetic breakdown of the herd and for allowing us access to elite panels of bulls with the belief that we would make the best breeding decisions possible. That belief combined with the top-class data constantly available from the ICBF and Teagasc researchers has allowed us constantly track herd progress.

I firmly believe a fully genotyped herd is better positioned with the rapid evolution of research and has an advantage in data reliability to fully capitalize on lowering carbon footprint at a greater pace with the compilation of data on cows which produce less methane ultimately being the most carbon efficient cows per kg milk solids. That is the future for greener dairy, a holy grail which will be upon us sooner than we envisage. We as dairy farmers have the power to inspire researchers to achieve greater things by simply affording them the belief that we are implementing their work at a rapid pace.

Building on past foundations to create the profitable cow of the future

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Would you like to take a trip with me in a time machine?

While Genus-ABS may have access to a lot of new and emerging technology, we don't actually have a time machine. However, if you will use your imagination, you can take a trip with me to view the past, present and future of some of the many advancements in the dairy industry, made possible by genetic improvement. Along the way, we will visit one of the herds that is instrumental in driving faster genetic progress: De-Su Holsteins, the home of De Novo Genetics. At the end of today's journey, it will be your challenge to envision how these changes can improve the direction of your dairy operation in the future with the goal of more efficient and sustainable food production from dairy cows.

Dairy cattle have an important role in the production of protein to nourish the world. It has been a decades-long journey to improve the productivity of these beloved animals. Let's briefly review key milestones in that journey.

In the 1940's, artificial insemination was first introduced to many dairy producers, offering a wider distribution of genetics. In the 1950's, frozen semen enabled a wider selection of genetics domestically and internationally. To take advantage of these opportunities, progeny test and more sophisticated statistical models were employed in the 1960's – the industry was really starting to make progress!

In the 1970's and 1980's, embryo transfer became a reality, along with the Animal Model methodology to grant more opportunities for the female side of the genetic progress equation. In the 1990's, new traits were added to the selection process, looking directly at longevity and health.

The turn of the century ushered in an even faster pace of change. The 2000's have seen the use of IVF and sexed semen. In addition, the dawn of the genomic era has more than doubled the rate of genetic progress. These tools have been used to increase productivity and lower the costs of producing milk. Along the way, the dairy industry has certainly embraced new technology and grown in its use of big data to assist in the identification and dissemination of genetic improvement.

Let's consider the example of a progressive dairy today. De-Su Holsteins in Iowa was founded by Dean and Sue Meyer and today is run by various family members and managed by their son, Darin Meyer, titled by *Holstein International* as the "king of genomics". In 2016, De-Su Holsteins formed a Joint Venture with ABS to form De Novo Genetics. Both De-Su and ABS put all their Holstein female genetics into the nucleus foundation of De Novo. Today, De Novo is supplying a wide array of genetics for dairy producers around the world, exclusively available through ABS.

To accomplish this task, De-Su Holsteins houses animals on multiple farm locations in Iowa and Minnesota, including embryo donor facilities, 2 milking operations, calf and heifer rearing locations, and thousands of acres of crops. With nearly 2,000 cows and even more youngstock, there is never a dull moment on this family-run operation. A majority of calves born are the result of embryo transfer, each with the potential to be the next 'great' breed-changing animal.

Through extensive IVF and conventional embryo transfer work, around 400 calves are in line to be born each month at De-Su Holsteins, local cooperator herds and in the UK. These calves are each genomic tested, after which decisions are made. The best bulls are transported immediately to ABS in Wisconsin, while the best heifers are set on a course to become future embryo donors.

With such a wide variety of calves to choose from, you might expect that all donors come from this calf crop. However, De Novo continues to purchase new donor heifers, in addition to the internally created donors. This is done for multiple reasons. We are always looking for different bloodlines to incorporate new breed-leading cow families, bring genetic diversity, a different mix of traits, and a stronger foundation for potential change in the future.

While the goal of De Novo is to create profitable genetics, we know that different traits are valued in

different ways by individual farms around the world. As a result, De Novo is searching the globe to find a variety of genetics that perform well and then creating combinations from those genetics to discover animals that can perform even better.

Next, let's take a quick look at what data and technology do for us in the future. 50 years from now, when people look back, what will they see? Will we see as much progress as we have witnessed in the past 50+ years? Will there be more? What will have changed?

In the future, we certainly expect that cows will produce more milk of higher quality. They will be more efficient with the nutrients they consume. The next step in this direction is the newly released Feed Saved trait; the future steps could include innovative ways of collecting feed intake data. The cow of the future will be more fertile and healthier. New traits and technology can help with this as well. Every pregnancy will have a designed purpose. This could include cross-bred calves with a terminal outcome or carefully selected embryos with a specific purpose.

I am encouraged by the latest scientific studies that show how much progress the dairy industry has already made to lower the carbon footprint of each unit of milk produced, making the dairy industry more sustainable. Future methods of breeding and management will improve the industry further, gathering more data and utilizing new technologies. All of this will result in more food from less input; getting more from less.

After all of this, what can you do today to prepare for that future? A wide variety of tools are available to help you use the best genetics that fit the needs of your dairy operation. To move forward, you need to be sure that you have the right plan. This plan may include genomic testing to segment your herd, using beef on lower ranking females, sexed semen for your best females or embryos. Regardless of the plan that is best for you, I encourage you to work with a trusted advisor that can help design a custom index to select the best genetics to help you reach your goals.

Summary

In the past decades, we have made cows more efficient, with a lower carbon-footprint of producing milk.

This has been accomplished through management and improved genetics – made possible by improved technology.

In the future, this genetic improvement will continue to advance to more precisely create cows that make more from less.

You can utilize the results of these advancements in your herds today.

Profitability and efficiency of the five lactation average dairy cow

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Introduction

There is a growing desire to extend the productive lifetime of dairy cattle. Extensions of productive life could be good economically, and also have benefits for environmental sustainability and society's view of dairy farming. Productive life is generally defined as the time from first calving to leaving (exiting, culling) the herd because the cow is deemed no longer sufficiently productive and has no future on another dairy farm either.

In the UK, the average number of lactations before removal of unproductive cattle is approximate 3.6 lactations (Hanks and Kossaibati, 2019). In this survey of 500 farms, one quarter had cows exiting the herd with fewer than 3.2 lactations on average. One quarter of the farms had cows exiting the herd with at least 4.0 lactations on average. About 7% of farms reached averages of 5 lactations or more. The natural lifespan of cattle is said to be approximately 20 years (Nowak and Walker, 1999), but very few dairy cattle reach that age.

With lactation lengths typically a little longer than one year, the 3.6 lactations translates to an annual cull rate of 27% (Hanks and Kossaibati, 2019). This implies that the 5 lactation averages is equivalent to approximately a 19% annual cull rate. Such a low cull rate is likely not reached in any of the leading dairy countries yet (Schuster et al., 2020). A 19% annual cull rate is equivalent to a productive life of 1/19% = 5.3 years.

In contrast, annual cull rates in the USA are on average approximately 34%. In the USA, the trend is towards shorter productive lives. To illustrate, the current CDCB (USA) genetic evaluation system assumes an average productive life of 2.8 lactations, but likely will shorten this to 2.6 lactations later in 2021. The USA dairy production system is more confined, more intensive, and has higher producing cows than in the UK.

Risk factors

Judging from primary culling reasons given by dairy producers in the national milk recording scheme (DHIA) in the USA, frequently given reasons for cows exiting the herd indicate that these cows have problems. For example, the top 4 leading reasons are reproductive problems, injury or other problems, death and mastitis (De Vries and Marcondes, 2020). Low production is the fifth ranking reason given.

Looking at risk factors for culling, it is clear that older cows have greater daily risks of culling than first lactation cows (Pinedo et al., 2010). In addition, the first 60 days after calving have greater risks of culling, an indication of calving and metabolism related causes. Pregnancy protects against culling. A recent review describes many risk factors for culling (De Vries and Marcondes, 2020). To summarize that review, cows with 4 events per lactation (1 calving, 1 breeding, 1 pregnancy diagnosis, 1 dry off) survive the longest, at least if they are decent milk producers. These cows stay unnoticed. Removal of risk factors such as failure to conceive, lameness, mastitis, metabolic problems, and structural udder defects creates greater opportunity to keep cows longer.

Genetic selection is already resulting in cows that are genetically better able to get pregnant, with lower risk of mastitis, and lower chances of death in at least the last 20 years since more selection emphasis has been placed on functional traits (https://queries.uscdcb.com/eval/summary/trend.cfm). Selection in the past 60 years has resulted in an increase of approximately 20 months in the breeding value for the trait productive life in the USA. However, this gain has not resulted in a decrease of the annual cow cull rate. This fact shows that within-herd competition, rather than the absolute ability to avoid culling, is an important driver of the number of lactations that cows stay in the herd. Many cows exit the farm when the dairy producer has a choice, not because there is no future production possible.

In the USA, it is becoming widely recognized that the number of calving heifers drives cow cull rates (Overton and Dhuyvetter, 2020). High cull rates are often the result of too many raised heifers. In the USA, improvements in fertility and a greater use of

sexed semen are leading to more dairy heifers born than in the past. Traditionally, all dairy heifers are raised with the intent to become lactating dairy cows. Dairy producers make room for calving heifers by culling cows. Only in the last 5 years is a viable beef-on-dairy market emerging, which offers dairy producers the option to produce calves that are not raised as dairy heifers. This implies that dairy producers need to rethink the number of replacement heifers that are needed. There is some room to affect cow culling and the number of lactations they stay.

Given the options of conventional, sexed and beef semen (and embryos), dairy producers and their advisors are also rethinking how to best use these semen types in their heifers and cows. For example, a popular and simple strategy is to use sexed semen on all heifers and some first lactation cows, then use beef semen on all older cows. In this system there is no use of conventional semen and no consideration of individual genetic merit. Dairy heifer calves are obtained from younger and generally genetically better dams. The number of dairy heifer calves made is sufficient to replace cows in the future assuming a given annual cow cull rate. Clearly, if cows stay more lactations, fewer dairy heifer calves are needed and more beef semen could be used.

A simple economic model

The lowest possible annual cull rate, which would result in the greatest average number of lactations, is not necessarily the most profitable. What follows is a simple model that illustrates the impact of five key drivers on the cost of herd structure. Herd structure is here defined as the demographics of cows in the herd by age. A high annual cull rate leads to a greater fraction younger cows and fewer older cows than a low annual cull rate. Maintaining a herd structure has a cost per cow per year. The cost is the sum of either expenses or opportunity costs. The limiting factor in this simple model is a cow place or slot. The goal is to maximize profitability per cow place per year. This is equivalent to finding the herd structure that results in the lowest herd structure cost per cow per year. The annual cull rate which results in the lowest total herd structure cost is, in theory, the economically optimal annual cull rate. Hence, the economically optimal average number of lactations is determined. The model assumes that one lactation is one year. The risk of culling is assumed to be the same in every lactation. Annual cull rates are varied from 10% to 50%, which drives the frequency of cows in each lactation. An earlier version of this simple model was first described in De Vries (2020). The results are in USA dollars. Today, 1 USA dollar equals approximately 0.74 Pound sterling. Caution, the results aim to assist our thinking about the optimal number of lactations, but are not intended to be prescriptive.

Herd replacement costs

The first driver are herd replacement costs. Cows depreciate in value from first calving to the time of exit from the herd. In the USA, typical costs to obtain a calving heifer are $1,800. If the average income for a cow that leaves the herd is $800, then the depreciation costs are $1,000. Longer productive lives means that depreciation costs can be spread out over more lactations. The greater the average number of lactations, the lower the herd replacement costs per cow per year.

Lack of maturity costs and aged cow costs

The second and third drivers are related. The idea is that mature cows are the most profitable when considering milk sales and feed cost. Mature cows in this simple model are cows in their fifth and sixth lactation. In order to become mature, cows have to move through the first four lactations. Lack of maturity costs are the result of young cows in the herd that are not mature. These are opportunity costs. For example, first lactation cows may generate $500 less per year than mature cows. Aged cow costs are opportunity costs of keeping cows in the herd that are past maturity. In this simple model these are cows older than 6 years. Aged cow costs are difficult to estimate because few cows become aged and they are the survivors of earlier culling pressure. Therefore, the expected performance of aged cows is biased. Given the aged cow opportunity costs, one could cull all old cows, except that would increase herd replacement costs. Zero aged cow costs is therefore not necessary optimal.

Calf value opportunity costs

An advantage of a low annual cull rate is that fewer dairy heifers need to be made to replace culled cows. This allows more breeding for more valuable calves for sale, such as beef-on-dairy to produce crossbreds. The calf value opportunity costs are therefore greater with higher cull rates. This driver ought to include the genetic value of the dairy heifer calves that are made. Making fewer dairy heifer calves allows for greater selection intensity of the dams. On the other hand, a low annual cull rate results in fewer younger and higher genetic merit dams. Genetic value of calves is not included in the simple model.

Genetic opportunity costs

Genetic opportunity costs occurs when the herd is genetically older. Better genetics is only slowly brought into the herd. This delay causes opportunity costs. Because of genetic progress in sires, younger cows are on average genetically better than older cows. The rate of genetic progress has approximately doubled since the introduction of genomics a decade ago. This implies that the genetic opportunity costs have doubled compared to a decade ago. Genetic opportunity costs are never zero because of the time lag between the availability of high genetic merit sires, the lower genetic merit of females in the herd, and the almost three years between insemination and the start of milk production of the daughter. Genetic opportunity costs are greater with a lower annual culling rate. A review of the literature of more sophisticated cow culling models suggests that the annual cull

rate should increase at most a few percentage points when the rate of genetic progress is doubled (De Vries, 2017).

Other drivers towards a five lactation average

Adding the five drivers together with reasonable estimates gives the total herd structure cost in Figure 1 (see below). In this figure, the lowest herd structure cost is obtained with an annual cull rate of 25%. The opportunity costs from cull rates other than 25% are the blue line.

Other drivers of the desire to increase the number of lactations to five may not be directly financial, but nevertheless important for society at large (De Vries and Marcondes, 2020). For example, greenhouse gas emissions per unit of milk are lower with more lactations per cow because fewer heifers need to be raised. In addition, a relatively short length of life compared to the natural lifespan, and a majority of culling reasons that suggest health problems, may be undesirable to consumers.

Decision support

The main limitation to obtaining the five lactation average cow may be failure, or reduced performance, of too many cows. Genetic improvement and good management should be able to reduce these culls. On the other hand, optimal culling decisions are not necessarily intuitive to make. There is evidence that different dairy producers would not cull the same cows presented to them. Financially, it could be advantageous to keep cows longer or shorter, for example by treating a sick cow instead of culling her, or by culling a cow that is a low producer but otherwise healthy. Although many cow replacement decision aids have been developed in the past, with more or less accuracy, little has been implemented. To move to a five lactation average also includes revisiting and developing better decision support aids (De Vries and Marcondes, 2020). We are currently developing such aids.

Take home messages

The average number of lactations in the UK is approximately 3.6. A fifth lactation average implies that most UK farms would need to reduce their cull rate. Cows in their fifth lactation are mature and the most profitable in terms of milk sales and feed cost. However, the risk of culling increases with age, in part because of more health problems, including failure to conceive, and defects such as lameness and udder conformation. Increasingly cows are culled to make room in the herd for calving heifers. Dairy producers need to rethink the number of dairy heifers they need. This is easier said than done if one accepts that culling is in part driven by people making economic decisions. A simple model shows five drivers of the optimal number lactations. Using realistic inputs, the optimal cull rate is often lower than is observed in practice, suggesting that a five lactation average is an economically sound goal. Finally, there is a need for quantitative decision support aids to help dairy producers make better culling decisions. Collectively, the five lactation average maybe within reach.

References

De Vries, A. (2017). Economic trade-offs between genetic improvement and longevity in dairy cattle. *Journal of Dairy Science*, 100: 4184–4192. https://doi.org/10.3168/jds.2016-11847

De Vries, A. (2020). Symposium Review: Why revisit dairy cattle productive lifespan? *Journal of Dairy Science*, 103: 3838–3845. https://doi.org/10.3168/jds.2019-17361

De Vries, A. and Marcondes, M. (2020). Review: Overview of factors affecting productive lifespan of dairy cows. *Animal*, 14: S1,s155–s164. https://doi.org/10.1017/S1751731119003264

Figure 1: An illustration of five key drivers of the total cost of maintaining herd structure, in $/cow/year: herd replacement costs, lack of maturity costs, aged cow costs, calf value opportunity costs, and genetic opportunity costs. The optimal herd replacement rate is the one where the total cost is the lowest; 25% in this example. The opportunity cost from economically optimal is the increase in cost per cow per year from the optimal herd replacement rate in the blue line.

Hanks, J. and Kossaibati, M. (2019). Key Performance Indicators for the UK national dairy herd: A study of herd performance in 500 Holstein/Friesian herds for the year ending 31st August 2019. Veterinary Epidemiology & Economics Research Unit (VEERU), University of Reading, Reading, UK. http://www.interherdplus.com/wp-content/uploads/2020/01/Holstein-Friesian-500herds-Aug2019.pdf

Nowak, R.M. and Walker, E.P. (1999). Walker's Mammals of the World (Vol. 1). JHU Press, Baltimore, MD.

Overton, M. W. and Dhuyvetter, K.C. (2020). Symposium review: An abundance of replacement heifers: What is the economic impact of raising more than are needed? *Journal of Dairy Science*, 103: 3828–3837. https://doi.org/10.3168/jds.2019-17143.

Pinedo, P.J., De Vries, A. and Webb, D.W. (2010). Dynamics of culling risk with disposal codes reported by Dairy Herd Improvement dairy herds. *Journal of Dairy Science*, 93: 2250–2261. https://doi.org/10.3168/jds.2009-2572

Schuster, J.C., Barkema, H.W., De Vries, A., Kelton, D.F. and Orsel, K. (2020). Invited Review: Academic and applied approach to evaluating longevity in dairy cows. *Journal of Dairy Science*, 103: 11008–11024. https://doi.org/10.3168/jds.2020-19043