British Cattle Conference

Organised by

BCBC

The British Cattle Breeders Club

DIGEST 75

‘Focusing on succession to build a sustainable future’

Annual Conference Papers
20th - 22nd January 2020

British Cattle Conference

Organised by

The British Cattle Breeders Club

Registered in England 480001
Registered Charity 271147

President:
Mike Coffey

Chairman:
Laurence Loxam

Secretary:
Heidi Bradbury

British Cattle Breeders Club
Underhill Farm
Glutton Bridge
Earl Sterndale, Buxton
Derbyshire
SK17 0RN
Tel: 07966 032079
E.Mail: heidi.bradbury@cattlebreeders.org.uk
Web: www.cattlebreeders.org.uk

Contents

Message from the Chair

‘Focusing on succession to build a sustainable future’

For the best part of three days, the 2020 British Cattle Breeders Conference delivered above and beyond what I could have wished for, with a programme packed with a mixture of world class scientists, beef and dairy producers and practical cattle breeding discussion.

As Chairman, I could not be prouder and with this my year of Chairmanship has come 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.

Since its inception over 70 years ago, the BCBC conference has become a unique event, renowned for its mix of practical, high quality speakers and its drive for innovation. With the future of cattle breeding at its heart, the BCBC conference links a wide spectrum of farmers, scientists, students and industry influencers.

The BCBC conference is a fantastic forum to kick off the New Year, challenging ideas, introducing new science and technologies and providing the opportunity to meet people, stimulate thought, debate and discussion. The conference itself is a focal point of the year for the club where we embark on finding answers and solutions to today’s fast moving environment. In a world with a rapidly growing population that increasingly demands of ‘more for less’, how can we ensure that an overriding need for quantity does not detract from the quality of the food we produce?

Succession and sustainability were the two key messages I wanted to address during the 2020 conference and I believe this was achieved, with feedback from attendees, sponsors and speakers of positivity and enjoyment, very much the vibe the British Cattle Breeders Club strives to promote. I personally would like to thank everyone that attended over the course of the two and a half days, thank you for your enthusiasm, participation and support. In conclusion, the club owes a huge debt of gratitude to Heidi Bradbury, our club secretary and also our fantastic sponsors and speakers, without them, there would be no conference, or club!

Some of our challenges transitioning into 2020 are; how do we combat the rise of veganism and the rapidly changing environment, especially in the realms of global warming? We aimed to answer some of these questions during the conference and will continue to strive on finding answers.

If you would like to see videos, papers, pictures and the presentations ‘Talking Slides’ from the 2020 British Cattle Breeders Conference then please visit www.cattlebreeders.org.uk

I hope to see you at the 2021 conference and I wish Clive Brown the best of luck.

Laurence A. G. Loxam
Chairman

The British Cattle Breeders Club

CLUB PRESIDENTS

1956	Joint Presidents: Sir John Hammond CBE, FRS Mr George Odlam
1965	Professor Alan Robertson OBE, FRS (retired 1987)
1988	Dr Tim Rowson OBE FRS (died 1989)
1990	Sir Richard Trehane (retired 1997)
1997	Mr John E. Moffitt CBE, DCL, FRASE (retired 2005)
2005	Mr W Henry E. Lewis (retired 2011)
2011	Dr Maurice Bichard OBE (retired 2017)
2017	Professor Mike Coffey

CHAIRMEN

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

1949–1951 R. H. Howard
1952 B. H. Theobald
1953 Mrs D. M. Wainwright
1954–1956 Peter Redfern
1957 C. B. Cooper
1958–1959 Major C. Wheaton-Smith
1960–1961 Brevit-Colonel S. V. Misa
1962 E. J. Boston
1963 M. O. K. Day
1964 F. J. Coney
1965 E. J. Wynter
1966 Miss J. H. Barry
1967 H. N. Haldin
1968 H. N. Haldin/P. Dixon-Smith
1969 P. Dixon-Smith
1970 Miss M. Macrae
1971 R. G. Galling
1972 N. J. D. Nickalls
1973 J. A. Moss
1974 Mrs S. Thompson-Coon
1975 J. W. Parsons
1976 T. A. Varnham
1977 David Allen
1978 H. W. S. Teverson
1979 D. A. Nutting
1980 Dr J. W. B. King
1981 J. M. Johnston
1982 J. E. Moffitt
1983 D. J. Bright
1984 Sir Richard Trehane
1985 Richard Linnell
1986 B. P. Pringle
1987 J. R. Mulholland
1988 Peter G. Padfield
1989 Malcolm J. Peasnall
1990 Mike Trevena
1991 Chris Bourchier
1992 Barrie Audis
1993 Dr Geoff Simm
1994 Geoff Spiby
1995 Tom Brooksbank
1996 Miss Sybil Edwards
1997 Keith Cook
1998 Tony Blackburn
1999 Chris Watson
2000 Henry Lewis
2001 John Downing
2002 Christopher Norton
2003 Mark Roberts
2004 Philip Kirkham
2005 David Hewitt
2006 Dr Duncan Pullar
2007 Dr Mike Coffey
2008 Paul Westaway
2009 Rob Wills
2010 Miss Lucy Andrews
2011 Duncan Sinclair
2012 Philip Halhead
2013 Neil Darwent
2014 Dr Philip Hadley
2015 Roger Trewhella
2016 Iain Kerr
2017 Andy Dodd
2018 Mrs Anya Westland
2019 Laurence Loxam
2020 Clive Brown

SECRETARIES

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

Do you understand change, its impact on emotions and performance?

Roddy McLean
Director of Agriculture, NatWest Bank

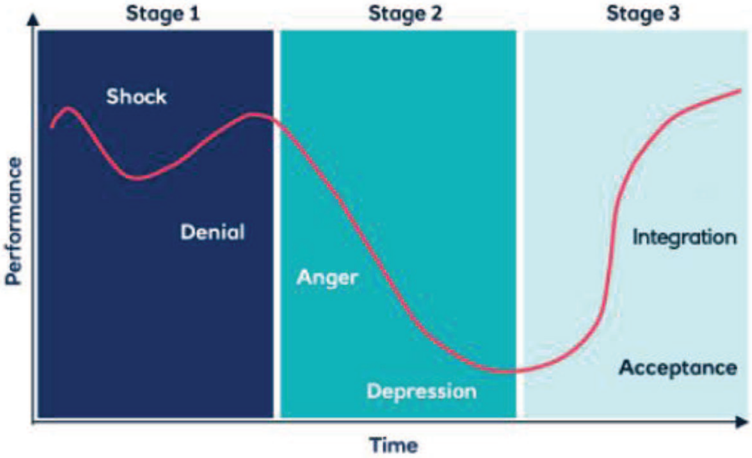
We are in a period of time when one of the constants is change, the pace of which is only going to get faster as the disruption we face personally and so in our businesses increases.

It is important that we as individuals understand how we react to change and how we can support our team whether family, employees or colleagues.

As individuals we all react differently to change and it is important that business leaders recognise this and support appropriately, if not the performance of the individuals drop with a knock-on effect to the business.

A model was developed by Elisabeth Kubler-Ross almost 60 years ago and the schematic below is based on that work to show how people react to change.

Figure 1: Change curve.



There are 3 stages, with associated emotions, that can predict how performance is likely to be affected by the introduction of change.

Stage 1 – Shock and Denial

- The first reaction to change is usually **shock**
- Performance tends to dip sharply and your team, who are normally clear and decisive, need more guidance and reassurance
- Individuals can be particularly affected by this first stage. It is common for people to convince themselves that the change isn't actually going to happen or, if it does, that it won't affect them
- Your team carry on as they always have and may deny having received communication about the changes and may well make excuses to avoid taking part in forward planning

Communication is key. Repeating what the actual change is, the effects it may have and providing as much reassurance as possible will all help to support members of your team experiencing these feelings.

Stage 2 – Anger and Depression

After the feelings of shock and denial, **anger** is often the next stage. Focusing the blame on someone or something allows a continuation of the denial by providing another focus for fears and anxieties.

- Common feelings include suspicion, scepticism and frustration
- The lowest point of the curve is when anger begins to wear off and the realisation that the change is genuine. Feelings during this stage can be hard to express and depression is possible as the impact of what has been lost is recognised. This period can be associated with apathy, isolation and remoteness

Your team can be reassured by the knowledge that others are experiencing the same feelings.

Providing information about the change curve and that others are experiencing the same emotions/ feelings helps progression along the curve.

Stage 3 – Acceptance and Integration

After the emotions of the second stage, a more optimistic and enthusiastic mood begins to emerge.

Your team **accept** that change is inevitable and begin to work with the changes rather than against them. Now come thoughts of exciting new opportunities and relief that the change has been survived.

The final steps involve **integration.** The focus is firmly on the future and there is a sense that real progress can now be made. By the time everyone reaches this stage, the changed situation has firmly replaced the original and becomes the new reality. The primary feelings now include acceptance, hope and trust.

During the early part of this stage, energy and productivity remain low, but improve slowly. Your team will have lots of questions and be curious about possibilities and opportunities.

Summary

You and your team react differently to change and not all will experience every phase. Some may spend a lot of time in stages 1 and 2, whilst others who are more accustomed to change may move swiftly into stage 3.

Moving from stage 1 through stage 2 and finally to stage 3 is most common, however there is no right or wrong sequence. Team members going through the same change at the same time are likely to react to each stage at different times.

Knowing where an individual is on their journey will help when deciding on how and when to communicate information, what level of support they require and when best to implement final changes.

Giving individuals the knowledge, that others understand, and experience similar emotions is the best way to return, with as little pain as possible, to a performing team.

Thinking about you and your team

Addressing the following questions will help identify where you and the team are on your journey of change and what actions you can take to manage emotions.

1. Where are you on the curve?
2. How are you feeling?
3. What needs to happen to make you feel better?
4. What can you do to make you feel in control?
5. Where are your team members on the curve?
6. What can you do to support them?

Finally, to be successful with any change you must first start by understanding why change must take place.

	Potential feelings, responses and behaviours seen	**Leadership behaviours and actions required**
Shock and Denial	• Shock • Fear • "I'm fine" • Initial relief • "They'll change their minds when they see sense" • "I'll be fine" • "This can't/won't last" • "I can keep going as I was"	• Understand and explain the reason for the change • Deal with individual needs; don't assume reactions will be the same for all • Give time to let the message sink in. Show you understand concern • Be clear, in a supportive way, about what, if anything, is non-negotiable • Give as much information as you can on plans for the future
Anger and Depression	• Anger • Bitterness • Betrayal • Worry • Scepticism/Suspicion • Exaggeration of events • Self-doubt	• Early involvement in how the change will happen • Provide something that they can have control over • Regular team and individual meetings to discuss issues and concerns • Ask for and provide facts to keep the situation grounded and real • Provide any relevant good news stories • Draw on those who are more positive
Acceptance and Integration	• Warily accepting • Accepting it but not liking it • Getting there • Starting to see the benefits come through • Growing in confidence • Forward thinking • Making the change work	• Recognise and feedback on positives • Understand and clarify the benefits • Watch for slipping back to anger and depression • Stick to new ways of working • Provide training and allow time to learn new skills/ways of working • Involve and give ownership to making things work

Beef into the future: customer focus and a retail perspective

Sophie Throup
Head of Agriculture, Wm Morrison plc, Bradford

Introduction

There is no doubt that the past twelve months have seen the topic of eating red meat, and beef in particular, brought into the media headlines and consumer interest more than they've been for a long time. Whether we should eat the same, less or no meat to protect the planet and our own health has been a matter of public debate across social and mainstream media, and for consumers throughout the UK.

But what does this mean for beef producers and what are customers saying?

Background to Morrisons

Wm Morrison plc started life as an egg, milk and butter market stall in Bradford, back in 1899, firmly planting its roots as a fresh-focused local grocer with close connections to the farmers who supplied it. That heritage has continued throughout Morrisons growth.

We are now Britain's 4th biggest supermarket chain, with stores across the country, as well as online shopping options. Uniquely, we also manufacture the majority of the fresh food we sell in 18 manufacturing sites and in our 496 stores including bakery, seafood, meat, fruit and veg, flowers and chilled products. This manufacturing part of the business also gives us the ability to 'whole-sale' products both in the UK and for export, opening up more opportunities for the products we buy from British farms.

100% of the fresh meat, milk and eggs sold by Morrisons are British; vegetables, fruit and salad are also British as much as possible within season. We're still the only retailer to have livestock buyers, who are out meeting the farmers we buy from every day and helping bridge the gap between customer buying and farm production.

What sets our strategy?

As a business with 12 million customers shopping with us every week, we listen carefully to what our customers want. We find out this information through product sales, but also through customer listening groups and larger scale surveys.

One of the influencing surveys we have is the annual corporate responsibility report[1] which asks up to 7,000 participants every year to prioritise their most important issues from a list of around 40 subjects. Since the survey started, food safety has rated as number 1, with supporting British farmers coming in at number 2 – a feature which reflects the strong and long-lasting relationship we have had with our farmers at Morrisons.

Managing plastic waste has been a rapidly emerging issue of recent times, and rates number 3 in our current survey, in part stimulated by the 'Blue Planet' documentary series. This helped catalyse the moves we have made across the business from introducing paper carrier bags, more 'loose' fruit and veg into our stores, to taking out all the hard to recycle black plastic from our own label food and drink packaging.

Beef considerations

Ensuring good standards of animal welfare is a matter which has risen from number 8 in 2017, to number 6 in 2018 and number 4 in 2019. Customers are increasingly keen to ensure that we are transparent, know about and can measure good outcomes for the animals in our supply chain by working with the farmers and buyers we source from.

Whilst focus and headlines have often been on the pig and poultry sectors, welfare standards for any livestock in our chain is important. Animal health, medicines use, stockmanship skills, space and stocking density and safe and clean environments – for staff and stock – are all key elements to manage on farm.

In addition to animal welfare considerations, whilst we're still waiting for the results of the 2020 Corporate Responsibility survey to come through, it is likely some of the environment challenge headlines seen in the last 12 months for the meat sector will be ranked.

Data recently shared by the AHDB from Kantar survey results, demonstrated that while 94% of UK households continue to eat meat, fish and poultry in 2019 on a weekly basis, the amount of product they have eaten has fallen. There are multiple factors contributing to these results, however, thinking about what may lie behind some of the issues are worthwhile considerations on future farming strategies.

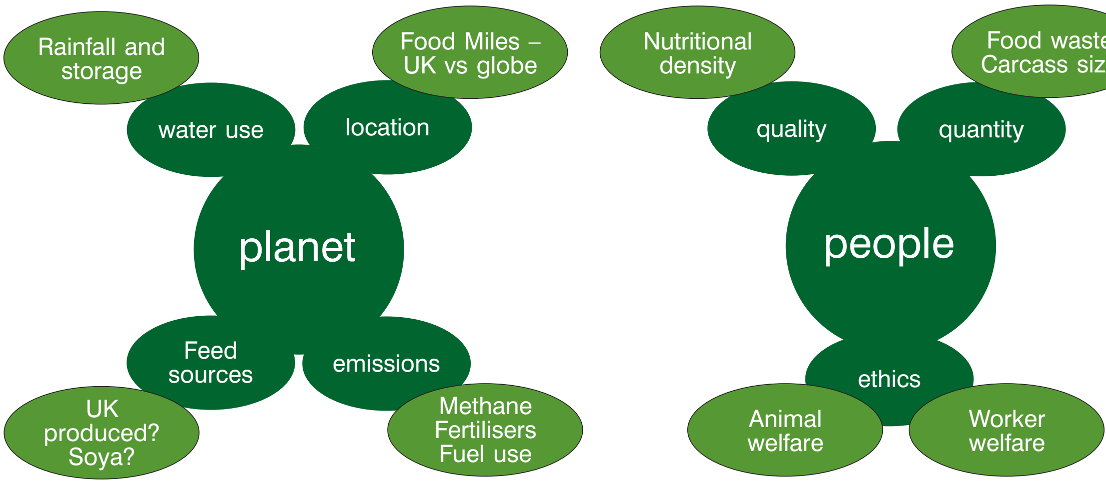
People and planet:

Planet – questions to think about

- **Emissions:**
  – How are emissions being managed in the cattle grown on

[1] Morrisons Corporate Responsibility Report 2018–19.

People and planet



my farm? Is it possible to selectively breed for reduced emissions? Can and should feed additives be introduced to lower methane output? How does the farm benchmark against my peers – how do I know?

- **Feed sources:**
  - How are livestock fed on my farm? Are they pasture based? What nutrients are added to the grass in the growing season? How is the application of these nutrients managed to ensure minimum emissions?
  - If wheat and other cereals are used, are these homegrown? Or locally sourced? How are the cereals being grown – i.e. how are fertiliser application, crop yield and resource use being managed for environmental benefit?
  - Is any feedstuff imported? If so, is this sustainable in terms of deforestation issues and food miles?
- **Water Use:**
  - How do the livestock on my farm get their water? Is this sustain-able – i.e. through rainfall capture <u>and</u> water storage?
- **Location:**
  - While UK livestock are 2.5 times more efficient than the global average[2], there is still an efficiency gap in terms of days to finish. Could this be better managed to ensure improved productivity as well as reduced resource use and emissions? How can overall land management be a positive in offsetting emissions?

People

- **Quality:**
  - There is a wealth of interesting science about nutritional density[3] in red meat and milk. The taste and consistency of meat is also important to encourage and maintain customer interest. Are there any further improvements to this through breed, feed, soil and health management to consider?
- **Quantity:**
  - Carcass size: from diet, food waste, family eating patterns and time perspectives, customers in general want to buy smaller sized steaks and meat cuts. Do I know the market I supply so I can get the best price?
- **Conscience:**
  - Worker welfare: research shows that how well staff are looked after has a direct correlation with the welfare of the livestock under their care. Are there any areas that need thinking about on your farm? If you do not employ any staff, do you know someone to contact for help, even if it's just to share a problem?
  - Animal welfare: we all want to know that the animals going into our supply chain have had a good life, with the ability to express all the behaviours associated with positive animal welfare, from good enrichment and housing conditions, to the ability to positively interact with other stock and to be well cared for by stock people. Are the animals on your farm living a 'good life'? How do you know?

As the only retailer to have its own livestock buyers, abattoirs, processing plants and butchery counters, the meat industry is important to us. We look forward to continuing to work with the industry for a positive and rewarding future for all.

[2] NFU Climate Friendly Farming paper.
[3] AHDB meat nutrition facts.

How heavy is too heavy?

T. Byrne, N. Howes, T. Kirk and J. Crowley*
AbacusBio International Ltd., Roslin Innovation Centre, Easter Bush, Edinburgh, UK

Summary

The objective of this study was to assess what increased mature cow weight means for profitability, what tools there are to manage mature weight (genetic and non-genetic) and what are the messages that should be communicated to industry.

This analysis shows that, for a typical UK beef farm, there is an optimum breeding female mature weight in the range of 680kg to 725kg for cows, depending on assumptions about the cost per unit of feed for heavy cows. In a situation where marginal feed costs are high and/or heavy cows (>700kg) can't be maintained on the feed resource available (e.g. hill country/upland farms, where bigger cows might need to be fed an imported higher quality and cost diet), then the optimum is 680kg. In a situation where heavy cows (>700kg) can be maintained on the grass resource available, then the optimum is 725kg. This optimum is also heavily influenced by the weight at which penalties are applied for over-weight progeny carcases.

Introduction

Breeding herds represent the backbone of beef production in the UK, and the productivity and profitability of these enterprises must be improved to ensure they remain sustainable. While there are many parameters that determine the productivity and profitability of a breeding business, it has long been recognised that the profitability of such enterprises is related to the productivity of the breeding female population; the mature weight of breeding females and the associated biological changes in other traits.
In the UK, data suggests that steer and heifer carcase weights have consistently increased for the past 45 years, at a rate of 2.5kg per year. Cow carcase weights increased from 1972 to 1996 at a rate of 1.5kg per year and plateaued in 2006, with little change since then[1]. Analysing enterprise efficiency and profitability relies on knowledge of the biological mechanisms underlying the system, the cost of inputs as well as the revenue from output. Establishing the relationships between breeding female mature weight, productivity, and profitability will support industry messaging about the implications of, and mechanism to manage, increases in breeding female mature weight. Thus, many stakeholders in the beef value chain identify the assessment of the efficiency and profitability of breeding enterprises, linked to differences in breeding female mature weight, as an important area.

Methods

To determine the implications of differences in breeding female mature weight, we first evaluated how changing cow breeding female mature weight impacts other biological traits in the farm system and then modelled the costs and revenues on farm, associated with all the traits implicated (breeding female mature weight included).

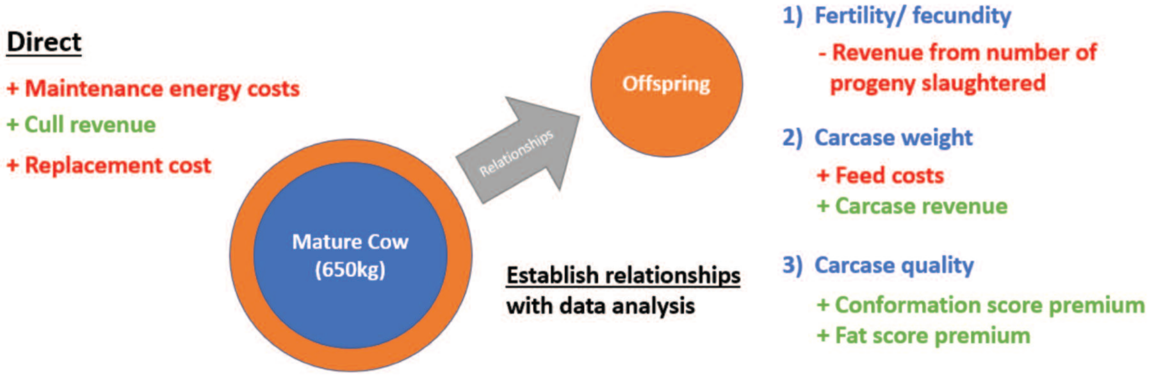
Costs and revenue per animal were calculated (breeding female, replacement female, or slaughtered progeny), and scaled to reflect a herd of 100 breeding females. The age distribution of breeding females, the replacement rate, and the slaughter offspring produced are representative of typical beef farms in the UK. Costs were subtracted from revenues across the entire herd at each breeding female mature weight, to identify changes in margin over feed across a range of breeding female mature weights.

The avenues (i.e. traits) by which mature weight affects total annual cost and revenue can be defined as direct or indirect. The direct effects, which are a function of breeding female mature weight, are the annual maintenance cost, replacement heifer cost, and the cull carcase revenue. The indirect traits are the number and value of slaughtered progeny. The degree of change in costs and revenue depends on the biological relationship between breeding female mature weight and each trait. Indirect traits include the number of progeny (cow fertility) and the value of those progeny that are slaughtered (carcase weight and carcase quality).

We describe the base system performance, direct trait changes, and indirect trait changes associated with a 100kg difference in breeding female mature weight (Figure 1 on page 10). The impact of a 100kg difference in breeding female mature weight is calculated, so that the scale of differences can be presented, before a breakdown of revenue and cost components, and margin over feed for a farm of 100 breeding females, across a range of breeding female mature weights is reported. Differences in breeding female mature weight will result in different overall

[1] Cow carcase weight data used as a proxy for mature weight of cows when culled.

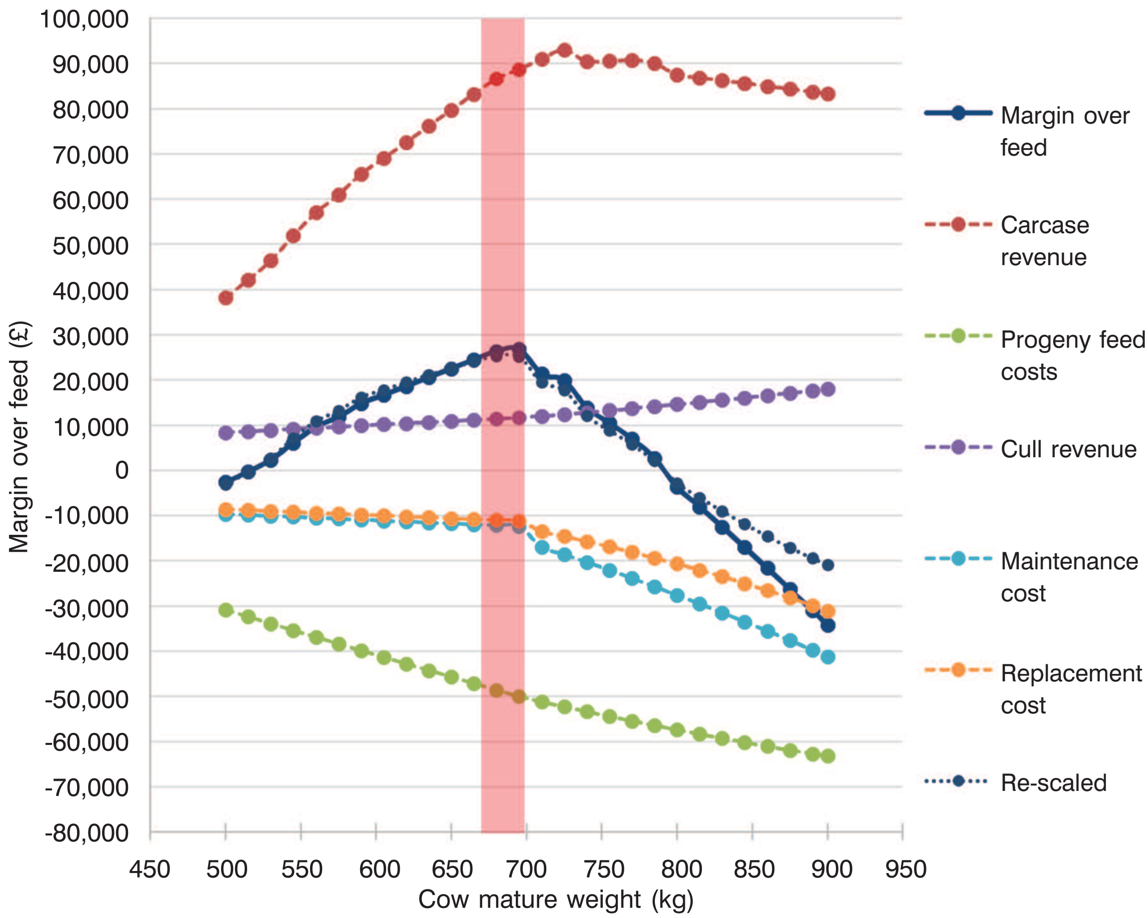
Figure 1: Summary of traits relevant to measuring the impact of increases in breeding female mature weight in beef farm systems.



levels of feed demand; this requires additional land for pasture and thus incurs rental costs. To capture the cost of this, the number of breeding females has been adjusted down to reflect the limited pasture resource; this is assumed to be equivalent to the cost of renting additional land.

With increasing breeding female mature weight, cull cow revenue increases, while cow maintenance costs, replacement costs, and progeny feed costs all increase (Figure 2 below). Breeding females heavier than 700kg requires higher quality and higher cost feed, which accounts for maintenance and replacement costs increasing at a faster rate above 700kg. Increasing breeding female mature weight up to 725kg significantly increases prime carcase revenue (when progeny are slaughtered on an age constant basis). After 725kg, prime carcase revenue plateaus (to 785kg) and then decreases slightly, due to lower fertility (less progeny being slaughtered) and because heifers and bulls are also being penalised for weighing over 440kg. The optimum breeding female mature weight for a typical beef production system is

Figure 2: Breakdown of revenue and cost components (age constant), and margin over feed for a 100-breeding female herd, for breeding female mature weights of 500kg to 900kg.



680 kg (rescaled), which for a 100-breeding female herd is associated with a total margin over feed of £25,281.

The optimum breeding female mature weight (rescaled) was not sensitive to weight constant versus age constant slaughter practices.

Industry-wide impact

A 100 kg difference in mature weight (651.4 kg to 751.4 kg) would yield 17,000 tonnes of carcase but reduce margin over feed by £208.9m, when progeny are slaughtered at a constant age. A 100 kg difference in mature weight would reduce output by 50,500 tonnes of carcase, but reduce margin over feed by £82.2m, when progeny are slaughtered at a constant weight. In theory, the total production of prime carcase weight should not change between the base and optimum mature weights when prime carcases are slaughtered at a constant carcase weight. However, this is not the case, as production at the optimum mature weight results in a 10.4% decrease in the number of breeding females, therefore total production also decreases.

Summary and communication

This analysis shows that, for a typical UK beef farm, there is an optimum breeding female mature weight in the range of 680 kg to 725 kg for cows, depending on assumptions about the cost per unit of feed for heavy cows. In a situation where marginal feed costs are high and/or heavy cows (>700 kg) can't be maintained on the feed resource available (e.g. hill country/upland farms, where bigger cows might need to be fed an imported higher quality and cost diet), then the optimum is 680 kg. In a situation where heavy cows (>700kg) can be maintained on the grass resource available, then the optimum is 725 kg. This optimum is also heavily influenced by the weight at which penalties are applied for over-weight progeny carcases.

Best tools, techniques and their use

When assessing the tools and techniques available, genetics offers the greatest opportunity. Breeding female mature weight has a very high heritability (0.40 to 0.60), meaning variation is very highly influenced by genetics. However, mature weight is also very antagonistically genetically correlated with early growth potential (0.60 to 0.90 depending of stage of early growth). There is therefore a trade-off between the value of additional growth and the cost of additional breeding female mature weight. There are tools available that could create clear signals to breeders and subsequently commercial farmers about the value of sires with different genetic merit for breeding female mature weight and growth potential. Importantly, these tools can be created/augmented to reflect the information available on optimum mature weights (non-linear functions etc.). These tools are economic selection indexes, which provide the appropriate rankings of bulls, based on the principles outlined above to manage breeding female mature size. Underpinning the robustness of estimates of genetic merit is quality data. Therefore, an increase in mature weight data recording (or indeed assigning sire to progeny, who go on to have cow carcase weight records) by the breeder tier of the industry, or via a scheme, or from commercially recorded systems would add significant value to the genetic evaluation system(s) and support accuracy of EBVs and selection indexes.

In the first instance these tools would be made available to breeders and with the correct implementation, the benefits would flow to commercial bull buyers. Breeders could also make use of EBV combinations to fine-tune selection for the right combination growth and breeding female mature weight; this does however require a clear understanding of EBVs and would likely require technical input from a specialist.

Commercial farmers are best to access genetics by buying from the bull breeder that best delivers on their commercial farm needs. Selection indexes, encompassing the appropriate weightings on early growth and mature weight (non-linear etc.), can be used as tools for breeders to communicate value to commercial farmers. With the appropriate methodology, responses to selection can be predicted for all traits in the index (including growth and breeding female mature weight); this provides clear messages to both breeders and commercial farmers regarding the implications of selection using an economic index (specifically, what it means for changes in mature weight).

While genetics offers permanent and cumulative (and potentially industry-wide) impact on the direction of the entire industry, the multiple, primarily non-economic, indexes and multiple evaluation systems create challenges in terms of ease of implementation of these tools. Implementation via an exemplar breed or in the industry combined breed analysis selection indexes would represent excellent case studies.

While there are some management tools available to control increases in mature weight, significant practice change is required to implement these management tool/techniques. Strategies, like more widespread use of AI (in commercial beef herds for example) using the 'right' bulls would significantly increase the realised rates of genetic gain in the beef industry. Better use of maternal genetics and terminal genetics in combination within herds would enable the benefits of hybrid vigour to be realised, while controlling cow mature weight. The ability of commercial farmers to control increase in breeding female mature weight through feeding (under-feeding) is likely to be unfeasible in terms of animal welfare and farming best practice.

Key messages for communicating to industry

Breeders

Key messages include:

- Where available, make use of selection indexes that have penalties applied to breeding female mature weight EBVs; this controls the increase in mature weight,

associated with selection for early growth,
  - The availability of these indexes is clearly at the discretion of the breeding society and genetic evaluation service provider
- Record sire of all calves (especially those that go on to be herd replacements), record mature weight and include that data in the genetic evaluation system
- Engage breed societies and genetic evaluation service providers about the need for selection tools, which account for the non-linear nature of value from increases in carcase weight and the cost associated with breeding female mature weight, and
- Communicate with commercial farmers to understand the needs in the context of breeding female mature weight, with an understanding that bigger is not always better.

Commercial farmers

Key messages include:

- Buy sires where it is possible assess the size/weight of the breeding females and gather more intelligence about the genetic merit of the males for growth, mature weight and other genetic merit estimates
- Work to build a relationship, and communicate, with a breeder(s) that is/are producing the types of sires you need for your farming business
- Where possible, use an index to select sires for use in commercial herds (needs to be made available by the breeder)
- Make use of maternal genetics and terminal genetics in combination within herds to capture the benefits of hybrid vigour, while controlling breeding female mature weight
- Engage breeders and breed societies about the need for selection tools, which account for the non-linear nature of value from increases in carcase weight and the cost associated with breeding female mature weight, and
- Weigh breeding females regularly and be informed about the right mature weight for the farming system.

Developmental programming and alternative heifer development

Dr Bart Lardner PhD
Department of Animal and Poultry Science,
University of Saskatchewan, Saskatchewan, Canada

Summary

This paper will explore the effects of maternal nutrition during gestation on progeny performance. Another focus will be alternative heifer development programs, where the goal is to not grow too fast in confinement, but create functional cows required to perform in a similar environment.

Developmental programming in beef cattle

Maternal nutritional stimuli or insult during gestation can lead to genetic and phenotypic changes in the developing foetus that may also affect post-natal growth of the calf (Reynolds et al. 2010). Research has demonstrated that prenatal nutrition in beef cattle can affect foetal gene expression and, in some instances, visible measures of foetal growth and development (Gionbelli 2018; Taylor 2018; Paradis 2017). Prenatal diet can also affect postnatal gene expression and performance in bovine offspring in several areas, e.g. growth, reproduction, and carcass characteristics, with varying degrees of affected phenotypes and penetrance (Añez-Osuna 2019; Paradis 2017; Funston 2010).

In early pregnancy, the foetus is particularly susceptible to nutrient insults since this period corresponds to placental growth and vascularization, and organogenesis (Funston 2010; Long 2009; Vonnahme 2007). This can impact nutrient transfer to the foetus altering its growth and nutrient repartitioning toward the essential organs (i.e. brain, heart, etc), rather than skeletal muscle development, and therefore can have long term detrimental consequences upon carcass and meat quality. Nutrient insults during pregnancy are known to affect muscle development, metabolism, tissue composition, health status and incidence of disease, and female productivity and reproductive longevity (Fungston 2010; Du 2010), all of which will have important consequences on profit for producers. Previous work in cattle and other ruminants have often focused on nutritional insults in early-to-mid gestation (Funston et al. 2010). However, during mid-to-late gestation the foetus undergoes rapid growth, representing a more significant metabolic toll on the dam (Ferrell et al. 1976). Understanding the molecular mechanisms underlying the phenotypic and epigenetic differences observed due to pre-natal nutrition is therefore of considerable practical significance.

Since growth predominates during the latter half of gestation, and is of a lower priority for nutrient partitioning in the foetus, sub-optimal maternal nutrition at this stage could be detrimental for foetal growth and muscle development (Du et al. 2010). Previous research has shown that heifers born from cows receiving supplementation in the last trimester of gestation were heavier at weaning, pre-breeding and at pregnancy confirmation compared to unsupplemented cows (Martin et al. 2007). As well, steers born from dams managed on a higher plane of nutrition (improved pasture) as compared to a low plane of nutrition (native range), had improved meat tenderness characteristics, animal growth, and carcass composition (Underwood et al. 2010). Therefore, proper late gestation nutrition can support foetal programming events towards improved growth and meat quality traits.

Profit in the beef cattle industry is largely dependent on carcass yield and muscle mass. The number, type and size of muscle fibres are the main determinant of muscle mass and total fibre number is positively correlated to growth potential (Oksjberg 2004). While hypertrophy of muscle fibres occurs mostly after birth, muscle fibre number and type is determined in utero. In cattle, by day 240 of foetal life, the total number of muscle fibres has been fixed, consequently predetermining the lifetime potential of an animal (Oksjberg 2004). Moreover, other meat characteristics such as marbling can be determined prenatally (Du 2010). Therefore, any environmental stresses imposed on the cow during gestation, such as nutritional restriction, as the potential to hamper the performance of its offspring.

In cattle, protein and/or energy supplementation during different stages of pregnancy have been shown to have effects upon marbling, quality grade, final BW and HCW, and increased the value of calves at weaning, postnatal liveweight and carcass weight, and even pre-pubertal reproductive development of bulls (Larson 2009; Sullivan 2010). Early and mid-gestational nutrient restriction in cattle altered calf birth weight, muscle fibre area and growth of the lungs, and gene expression in adipose tissue (Long 2010, Micke 2010b). Inclusion of fat in the prenatal diets of cattle in previous studies have shown associations with calf birth weight and increased cold tolerance (Lammoglia 1999). Linoleic supplementation of pregnant ewes has shown to increase survivability of lambs (Encinias 2004).

Anez et al. (2019a; 2019b) reported that fat level and source in gestating beef cow diets during the second and third trimester, did not affect cow body weight from calving to weaning. However, feeding a flax diet during gestation increased the total concentration (mg/g) of PUFA, CLnA and CLA during the first 42 days of lactation. Pregnancy rate of cows fed the high fat diets over gestation tended to be greater compared to cows fed a low-fat diet.

Compared to the low diet, feeding high fat diets over gestation resulted in heavier calves at birth, greater calf performance from birth to slaughter and superior shrunk-final body weight and hot carcass weight of the progeny at slaughter. The reason for this difference in performance between the progeny of high fat and low-fat cows is likely due to a developmental programming effect as the result of a possible greater placenta nutrient uptake and transport.

Finally, our goal is to provide information to cattle producers of the relative importance early pre-natal nutrition has on post-natal growth and development of cattle, and what the economic consequences upon health, fertility, and meat quality can be.

Heifer development – alternative systems

Development of heifers is a critical component of a beef cow-calf production enterprise. Current recommendations indicate a heifer should reach approximately 65% of mature BW by the first breeding for successful reproduction (Patterson et al., 1992).

In recent years, researchers and producers have questioned if 65% of mature weight by breeding to ‘TOO BIG’. The replacement heifer must receive substantial supplementation on the farm in a pasture-based development system to meet the 65% target body weight.

Question then is – Can heifers be developed to lower weights and what are the reproductive impacts on the heifer and system cost? Previous studies have reported that developing heifers to reach 55% of mature weight by the start of breeding season does not impact percentage of heifers becoming pregnant in first 21 days of the breeding season compared to heifer fed to a greater target weight (Funston, 2004; Roberts et al., 2009; Larson et al., 2009).

In contrast, heifers developed to a 55% target weight had a 15% reduction in heifers pregnant during the first 21 days compared to heifers developed to 64% target weight (Eborn et al., 2013). There was an 11% reduction in heifers calving in the first 45 days of the calving season for heifers developed to 50% compared to 56% target weights (Martin et al., 2008). Most studies reported that cost of heifer development was reduced.

However, to ensure acceptable pregnancy rates and adequate size for calving, heifer MUST gain weight during the breeding season on good quality pasture, and continue to gain during the post-breeding season. Heifers should also weigh 85% to 90% of mature weight at calving as 2-year-olds to minimize calving difficulties. Altering the harvested feed inputs into the replacement heifer program can affect the cost of raising a heifer from weaning to breeding.

Rising input costs have increased interest in reduced-cost heifer development systems. Feeding replacement heifers to traditional target BW increased development costs relative to development systems where heifers were developed to lighter target BW ranging from 51 to 57% of mature BW (Funston and Deutscher, 2004; Roberts et al., 2007, 2009; Martin et al., 2008; Larson et al., 2009). Feeding to prebreeding BW as light as 51% of mature BW was shown to be more cost effective than development to 57% of mature BW (Martin et al., 2008). Previous research on decreased ADG heifer development has been conducted completely in the dry lot, under controlled conditions. Much of the recent research in Canada and US has been conducted in extensive, resource-limited environments with adapted cattle. Producers should know their mature body weight of >5-year cows, know their genetics and breeding pasture quality when altering target weight decisions.

Popular recommendations indicate heifers should reach 65% of mature BW prior to the first breeding season (Patterson et al., 1992). Winter range offers a similar source of standing winter forage for heifer development, but the effects are not well characterized. Recent data indicate heifers reaching <55% of mature BW by breeding have similar reproductive ability to heavier counterparts (Funston and Deutscher, 2004; Martin et al., 2008). Previous data also demonstrate moving heifer development from the drylot in favour of grazing corn residue does not negatively influence pregnancy rate (Funston and Larson, 2010); however, BW at breeding is reduced and puberty is delayed. However, recent research has demonstrated heifers reaching less than 58% of mature BW by breeding do not display impaired reproductive performance (Funston and Deutscher, 2004; Martin et al., 2008; Funston et al., 2012). In today’s beef industry, meeting heifer maintenance and gestation nutrient requirements can increase overall development costs for beef producers. Therefore, in response, beef producers in western Canada are moving from conventional drylot wintering systems, where cattle are housed in pens to the adoption of extensive wintering systems (Van De Kerckhove et al., 2011). Advantages of extensive winter grazing are decreased stored feed requirements, direct deposition of nutrients from urine and manure in field, and reduced yardage costs (Jungnitsch et al., 2011). One of the most commonly used extensive wintering systems is bale grazing.

A recent study (Lardner et al. 2014), evaluated replacement heifer development using an extensive winter grazing system utilizing a combination of bale grazing and supplement compared with traditional confined feeding to generate different target BW at breeding. Developing heifers to 55% of mature BW, can save nearly $60 per heifer compared with developing to 62% in confinement without negatively affecting reproductive performance and herd retention. This study further suggests developing heifers in an extensive grazing system can be a viable alternative to reduce development costs. Finally, considerations in development of replacement heifers depend on individual farm goals, available feedstuffs, environmental conditions, management level, grazing program, ability to supplement, as well as marketing options for open heifers.

Research Highlights

Developmental Programming

Recent data suggest that feeding beef cows a high-fat (300 g/d) diet over gestation results in a heavier progeny, superior postnatal performance and greater carcass weight at slaughter, which indicates the possibility of improving the performance of beef cattle through a developmental programming effect.

However, more research is needed in order to establish the physiological mechanisms involved. Using developmental programming as a management tool for beef producers may provide opportunities for improvements for growth and production traits in cattle.

Heifer Development – Alternatives

Western Canadian research provides additional evidence post-weaning development of heifers to achieve 55% of mature BW before breeding does not affect reproductive performance during first and second calving compared with developing heifers to achieve 62% of mature body weight.

Finally, select heifers born early in calving season, then determine an appropriate target weight for heifers. Knowledge of mature body weight of breeding herd and adequate pasture quality during breeding season is primary when developing heifers in pasture systems.

References

Anez-Osuna, F., Penner, G.B., Campbell, J., Dugan, M.E.R., Fitzsimmons, C.J., Jefferson, P.G., Lardner, H.A. and McKinnon, J.J. (2019a). Level and source of fat in the diet of gestating beef cows: I. Effects on the pre-partum performance of the dam and birth weight of the progeny. *J. Anim. Sci.* 97: 3103–3119.

Anez-Osuna, F., Penner, G.B., Campbell, J., Dugan, M.E.R., Fitzsimmons, C.J., Jefferson, P.G., Lardner, H.A. and McKinnon, J.J. (2019b). Level and source of fat in the diet of gestating beef cows: II. Effect on the postpartum performance of the dam and the progeny. *J. Anim. Sci.* 97: 3120–3141.

Bagley, C.P. (1993). Nutritional management of replacement beef heifers: a review. *J. Anim. Sci.* 71: 3155–3163.

Du, M., Tong, J., Zhao, J., Underwood, K.R., Zhu, M., Ford, S.P., Nathanielsz, P.W. (2010). Fetal programming of skeletal muscle development in ruminant animals. *J. Anim Sci.* 88: E51–60.

Encinias, H.B., Lardy, G.P., Encinias, A.M., Bauer, M.L. (2004). High linoleic acid safflower seed supplementation for gestating ewes: Effects on ewe performance, lamb survival and brown fat stores. *J. Anim. Sci.* 82: 3654–3661.

Ferrell, C.L., Garrett, W.N., Hinman, N. (1976). Growth, development and composition of the udder and gravid uterus of beef heifers during pregnancy. *J Anim Sci.* 42: 1477–89.

Funston, R.N. and Deutscher, G.H. (2004). Comparison of target breeding weight and breeding date for replacement beef heifers and effects on subsequent reproduction and calf performance. *J. Anim. Sci.* 82: 3094–3099.

Funston, R.N., Larson, D.M., Vonnahme, K.A. (2010). Effects of maternal nutrition on conceptus growth and offspring performance: Implications for beef cattle production. *J. Anim. Sci.* 88 (13 Suppl): E205–15.

Gionbelli, T.R.S., Veloso, C.M., Rotta, P.P., Filho, S.C.V., Carvalho, B.C., Marcondes, M.I., Cunha, C.S., Novaes, M.A.S., Prezotto, L.D. and Duarte, M.S. (2018). Foetal development of skeletal muscle in bovines as a function of maternal nutrition, foetal sex and gestational age. *J. Anim. Physiology and Anim. Nut.* 102 (2): 545–556.

Lammoglia, M.A., Bellows, R., Grings, E.E, Bergman, J.W., Short, R.E. and MacNeil, M.D. (1999). Effects of feeding beef females supplemental fat during gestation on cold tolerance in newborn calves. *J. Anim. Sci.* 77: 824–834.

Lardner, H.A., Damiran, D., Hendrick, S., Larson, K. and Funston, R. (2014). Effect of development system on growth and reproductive performance of beef heifers. *J. Anim. Sci.* 92: 3116–3126.

Larson, D.M., Martin, J.L., Adams, D.C. and Funston, R.N. (2009). Winter grazing system and supplementation during late gestation influence performance of beef cows and steer progeny. *J. Anim. Sci.* 87: 1147–1155.

Long, N.M., Vonnahme, K.A., Hess, B.W., Nathanielsz, P.W. and Ford, S.P. (2009). Effects of early gestational undernutrition on fetal growth, organ development, and placentomal composition in the bovine. *J Anim Sci.* 87: 1950–1959.

Martin, J.L., Vonnahme, K.A., Adams, D.C., Lardy, G.P. and Funston, R.N. (2007). Effects of dam nutrition on growth and reproductive performance of heifer calves. *J. Anim. Sci.* 85 (3): 841–847.

Micke, G.C., Sullivan, T.M., McMillen, I.C., Gentili, S. and Perry, V.E. (2011). Protein intake during gestation affects postnatal bovine skeletal muscle growth and relative expression of IGF1, IGF1R, IGF2 and IGF2R. *Mol Cell Endocrinol.* 332: 234–241.

Oksbjerg, N., Gondret, F. and Vestergaard, M. (2004). Basic principles of muscle development and growth in meat-producing mammals as affected by the insulin-like growth factor (IGF) system. *Domest Anim Endocrin.* 27(3): 219–240.

Paradis, F., Wood, K.M., Swanson, K.C., Miller, S.P., McBride, B.W. and Fitzsimmons, C. (2017). Maternal nutrient restriction in mid-to-late gestation influences fetal mRNA expression in muscle tissues in beef cattle. *BMC Genomics* 18 (1): 632.

Patterson, D.J., Perry, R.C., Kiracofe, G.H., Bellows, R.A., Staigmiller, R.B. and Corah, L.R. (1992). Management considerations in heifer development and puberty. *J. Anim. Sci.* 70: 4018–4035.

Reynolds L.P., Borowicz, P.P., Caton, J.S., Vonnahme, K.A., Luther, J.S., Hammer, C.J., Maddock, C., Grazul-Bilska, A.T. and Redmer, D.A. (2010). Developmental programming: The concept, large animal models, and the key role of uteroplacental vascular development. *J Anim. Sci.* 88 (13 suppl): E61–72.

Roberts, A.J., Paisley, S.I., Geary, T.W., Grings, E.E., Waterman, R.C. and MacNeil, M.D. (2007).

Effects of restricted feeding of beef heifers during the postweaning period on growth, efficiency and ultrasound carcass characteristics. *J. Anim. Sci.* 85: 2740–2745.

Roberts, A.J., Geary, T.W., Grings, E.E., Waterman, R.C. and MacNeil, M.D. (2009). Reproductive performance of heifers offered ad libitum or restricted access to feed for a one hundred forty-day period after weaning. *J. Anim. Sci.* 87: 3043–3052.

Taylor, R.K., LeMaster, C.T., Mangrum, K.S., Ricks, R.E., Long, N.M. (2018). Effects of maternal nutrient restriction during early or mid-gestation without realimentation on maternal physiology and foetal growth and development in beef cattle. *Animal.* 12: 312–321.

Underwood, K.R., Tong, J.F., Price, P.L., Roberts, A.J., Grings, E.E., Hess, B.W., Means, W.J., Du, M. (2010). Nutrition during mid to late gestation affects growth, adipose tissue deposition, and tenderness in cross-bred beef steers. *Meat Sci.* 86: 588–93.

Vonnahme, K.A., Zhu, M.J., Borowicz, P.P., Geary, T.W., Hess, B.W., Reynolds, L.P., Caton, J.S., Means, W.J. and Ford, S.P. (2007). Effect of early gestational undernutrition on angiogenic factor expression and vascularity in the bovine placentome. *J. Anim. Sci.* 85: 2464–2472.

Breeding for superior beef meat eating quality

Michelle Judge[1], Stephen Conroy[2], Thierry Pabiou[2], Andrew Cromie[2], P. J. Hegarty[2], Emily Crofton[3], Donagh Berry[1]

[1]Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork; [2]Irish Cattle Breeding Federation, Highfield House, Bandon, Co. Cork, [3]Teagasc, Ashtown, Food Research Centre, Dublin 15

Introduction

In recent years there has been an increase in the interest and awareness surrounding the quality of meat products. The term ‘meat quality’ encompasses a range of different metrics including food safety, nutritional value, lipid content and composition, and organoleptic properties (such as tenderness and flavour). Consumer studies have highlighted taste as the primary reason for selecting beef meat over other types of meat and a bad eating experience is known to turn consumers off beef for up to 3 months. With pork and chicken being the major competitor to beef meat consumption, it is paramount that beef is consistently of the highest quality. Major advancements in meat eating quality have been made in recent years through processes within the farm gate as well as within the abattoir, including animal handling, slow chilling, hip hanging and the dry aging process. Despite these extremely controlled conditions in abattoirs, large variability in meat quality persists; genetics undoubtedly contributes to this variation.

The potential of breeding to improve meat quality

Performance differences in any trait are due to both management (e.g. nutrition) and underlying genetic effects. The contribution of breeding to improving animal performance has been well recognised across a range of different species. Using a controlled experimental study in broilers, it was reported that up to 90% of the gains in performance in recent decades could be attributable to genetic improvement (Havenstein et al., 2003). Genetic improvement is both cumulative and permanent implying that the performance of the animal is a function of the past decades of breeding, and improvements made in one generation can be further compounded in successive generations.

Once genetic variation in a trait exists, then there is scope to improve that trait through breeding. Whether improvement is justified, or will occur, depends on the breeding strategy adopted. The perils of single trait selection are now well documented in many species and thus selection should be practiced within the framework of a total merit index or breeding objective. Three criteria need to be fulfilled for a trait to be considered in a breeding objective; the trait:

1. must be either economically, socially, or environmentally important,
2. must exhibit genetic variation, and
3. sufficient information must exist to differentiate between genetically elite and inferior animals for the trait of interest

Whether genetic gain is actually achieved in the trait will be a function of the aforementioned criteria as well as the heritability of a trait, the correlations between the trait and the other traits comprising the breeding objective, its relative weight, extent of genetic variability and its respective accuracy of selection. The heritability of a trait is the proportion of the difference between individuals that is attributable to genetics. It is often construed that a low heritability results in slow genetic gain. The rate of genetic gain cannot be deduced from heritability but instead heritability simply reflects how many records need to be collected on the trait of interest to generate accurate estimates of genetic merit. This accuracy of genetic evaluations, in turn, impacts the rate of genetic gain. Relative to many other traits, there is a general paucity of documented genetic correlations between meat quality traits and other performance traits, and those that exist generally suffer from a lack of precision owing to the cost of procuring meat quality data in a sufficient quantity to achieve narrow confidence interval flanking the correlation estimates. Ireland has access to the largest database globally of genotyped cattle with trained sensory analysis of meat thus facilitating more precise estimates of the correlations.

Irish data on meat eating quality

Over the past 5 years The Irish Cattle Breeding Federation and Teagasc have collected sensory data on several thousand Irish cattle representing the germplasm used in Ireland in recent years. Meat sensory-based assessments for tenderness, flavour and juiciness are now available on 5,310 young bulls, steers and heifers slaughtered between the years 2010 to 2019, inclusive. Approximately 2,000 of these animals also have information on performance traits such as growth rate, feed intake and therefore feed efficiency providing knowledge of the relationships among all these traits. The goal is to have 8,000 meat sensory results by the end of 2020 ensuring that the dataset held in Ireland is three times larger than the next largest international dataset on meat sensory results generated from a trained panel (Figure 1). The animals included in the dataset are from a wide mixture of sires lines and crossbreds with the latter enabling the prediction of breed differences. A total of 737 different sire lines are represented in the dataset; such diversity is crucial when generating accurate genetic evaluations and identifying superior (and inferior) sire lines.

Forty-eight hours after slaughter, 2.54 cm steaks were obtained from each animal from the *longissimus thoracis* muscle. The steaks were aged for 14 days and then frozen prior to sensory analysis. Sensory analysis was undertaken by trained panellists. Samples were ranked on a 1 to 10 scale point where a score of 1 represented a very tough, not juicy and not flavoursome sample, while a score of 10 represented a very tender, very juicy and very flavoursome sample.

The results so far

Eleven to fifteen per cent of the variability between animals in meat eating quality is due to genetics (Table 1 on page 18), thus implying the potential for breeding to improve the meat quality of the entire Irish cattle population. Genetic correlations among the meat sensory traits in Ireland are in Table 2 on page 18; a correlation of 1 means the two traits being compared are the same trait and therefore correlations close to one means that both traits are very similar. In breeding, a positive correlation, especially a strongly positive correlation, means that selecting in a positive direction for one trait will also have a positive impact on the second trait; the opposite is also true in that selection for a negative value in one trait will cause a negative response to selection in the other correlated trait. The correlations in Table 2 signify that all meat quality traits are strong genetically correlated with each other implying that selection for more tender meat will, on average, result in more juicy meat with a stronger beef flavour. The correlation between beef flavour and juiciness is almost one implying that they are almost identical traits; more juicy meat tends to, on average, be more flavoursome while less juicy meat tends to, on average, have less flavour. The implications of these strong correlations is that it is really only necessary to measure one of these traits thereby increasing the speed at which the assessments can be done and, by extension, reducing the cost per sample.

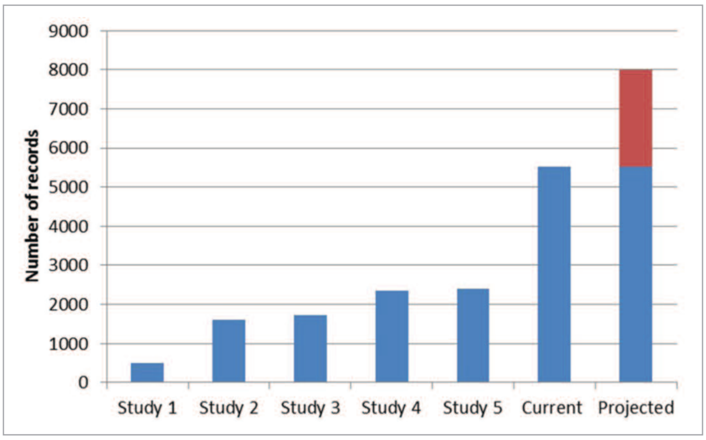
Table 1: Heritability estimates for the three meat quality traits.

	Heritability
Tenderness	0.15
Beef flavour	0.12
Juiciness	0.11

Table 2: Genetic correlations between the different eating quality traits; a correlation of 1 means they are the same trait.

Trait	*Tenderness*	*Beef flavour*
Beef flavour	0.81 (0.09)	
Juiciness	0.65 (0.11)	0.96 (0.05)

Figure 1: Number of animal sensory measures for the published scientific studies alongside those currently available in Ireland and projected to be available by the end of 2020.

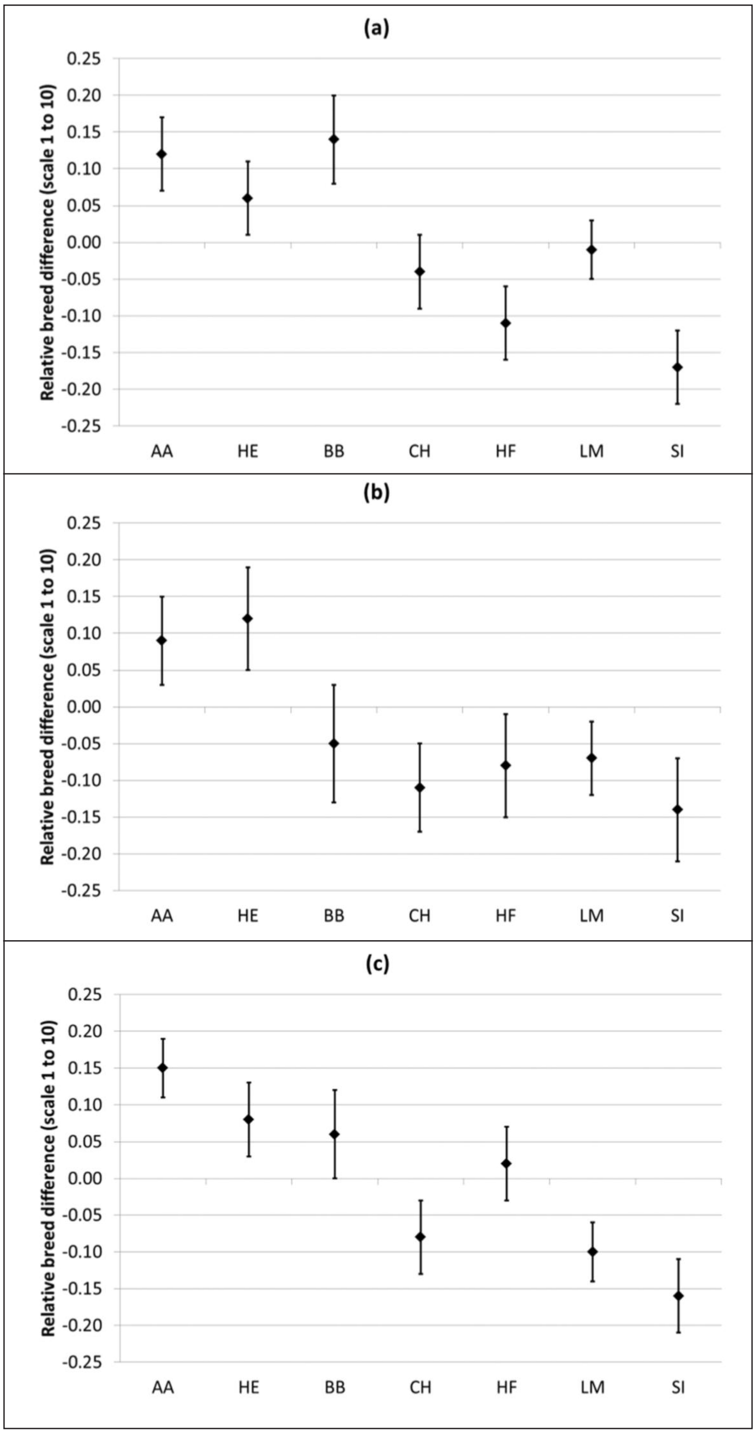


Genetic correlations between the sensory traits and other performance traits are in Table 3 on page 19. The correlations with carcass weight are near zero for tenderness and flavour suggesting that within-breed selection for heavier carcasses will not impact either tenderness or flavour although, on average, it will result in less juicy meat; if not properly addressed, selection for improved conformation and greater fat cover will also lead to reduced tenderness. Similarly, selection for increased fat cover is associated with a reduction in meat tenderness.

Table 3: Genetic correlations between the meat sensory traits and carcass weight, formation and fat score.

Trait	*Tenderness*	*Beef flavour*	*Juiciness*
Weight	-0.03 (0.12)	0.05 (0.14)	-0.25 (0.13)
Conformation	-0.10 (0.12)	-0.16 (0.13)	-0.42 (0.13)
Fat	-0.36 (0.12)	-0.08 (0.14)	-0.20 (0.14)

Figure 2: Mean relative breed differences (on a scale of 1 to 10) for (a) meat tenderness and (b) flavour and (c) juiciness based on the 4,913 Irish animals; also included are one standard error each side of the predicted mean.

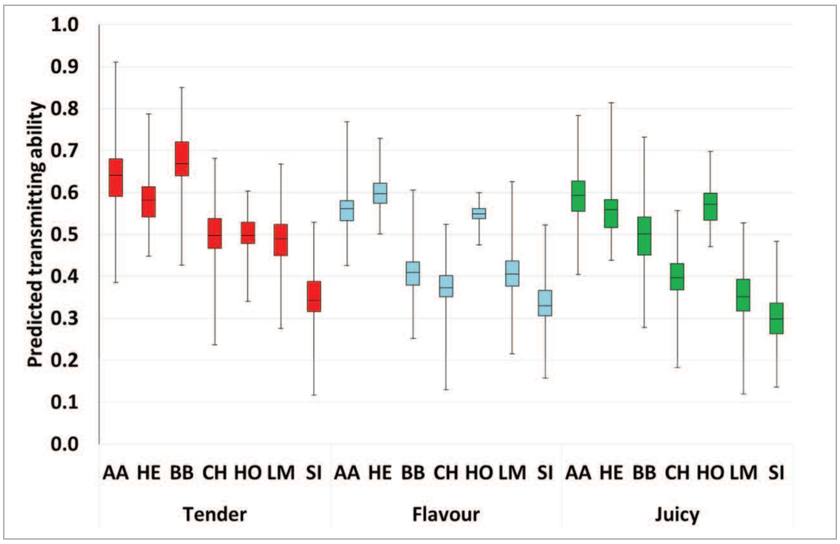


Breed differences for tenderness, flavour and juiciness are illustrated in Figure 2. The Angus, Hereford and Belgian Blue breeds had the most tender meat (although the biological mechanism as to why the Belgian Blue has superior tenderness is likely to differ to that of both British breeds). The meat of the Simmental breed is, on average, the least tender although it is not worse than the average Holstein-Friesian. Both British breeds are the most flavoursome with all other breeds being relatively similar; both British breeds also tend to be the most juicy.

While differences among breeds exists, of real interest to breeders is the extent of the within breed differences and how these can be exploited. Figure 3 on page 20 illustrates the extent of within breed variability among sires that exists in the sensory traits. While mean breed differences clearly exist, there are Simmental bulls who have a superior genetic merit for tenderness compared to Angus, Hereford and Belgian Blue bulls; the same is true of the extent of within breed variability in the other sensory metrics. Genetic evaluations attempt to exploit this within breed variability and, in doing so, achieve genetic gain without necessarily a breed substitution.

National genetic evaluations for meat tenderness, flavour and juiciness are currently being developed in Ireland. The first step will be to publish these evaluations so stakeholders can visualise and get used to the figures, as well as possibly test their efficacy. The next step will be to introduce them into the national breeding indexes. It is hoped that these genetic and genomic evaluations will be publicly available in 2020. Validation of the genetic evaluations has, however, been undertaken. Validation involves estimating the genetic merit of animals that are still alive and then correlating this estimate of genetic merit with their actual tenderness score several months later. The validation clearly shows that the meat tenderness of the animals predicted to be genetically elite for meat tenderness was, on average, superior to that of the animals predicted to be

Figure 3: Box and whisker plot of the variability that exists in meat sensory characteristics per sire for a selection of breeds.



genetically inferior for meat tenderness; the estimate of genetic difference between groups matched very well with the actual observed differences.

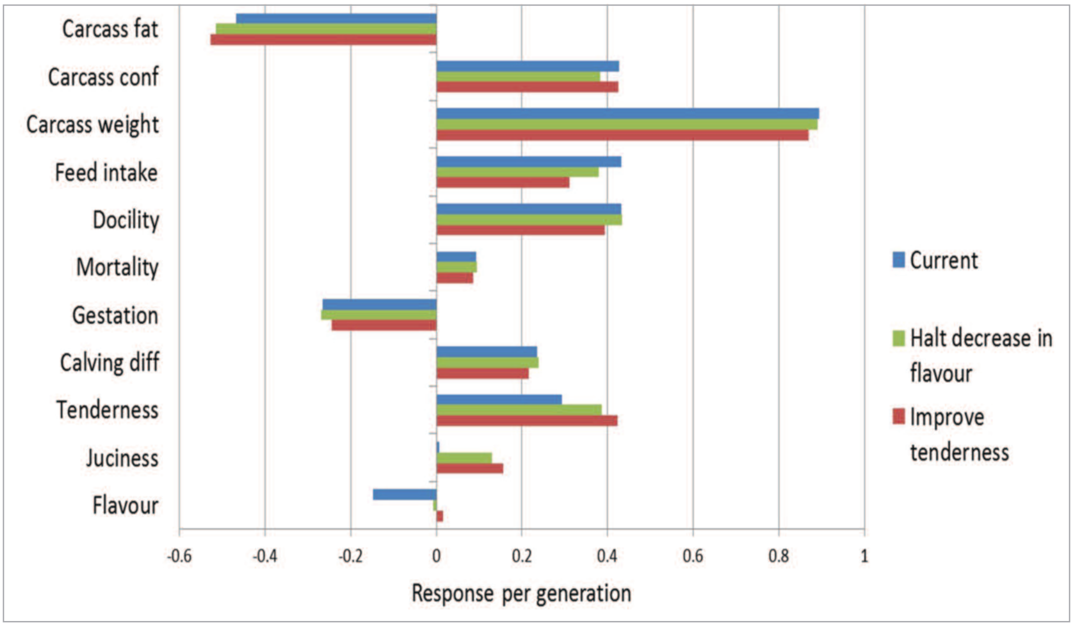
Weighting on meat quality within a breeding objective

Few producers are rewarded on meat quality other than through a standard supplement per kg for animals of certain breeds. Therefore, determining the weight to be apportioned to meat quality within an overall breeding objective is not trivial. Nonetheless, strategies do exist to generate such weighting factors even if no direct economic value exists for the trait. The most simplest approach is a desired gains approach which places sufficient weighting on the trait to achieve a desired genetic gain (e.g. 1% gain per generation); a special type of desired gains approach is a restriction selection index where the desired genetic gain is set to zero (i.e. no deterioration in quality). Irrespective of the strategy taken, the impact on genetic gain in profit accruing from altering the breeding objective should be quantified and the impact reconciled. Figure 2 depicts the expected response to selection based on the current terminal index as well as two modifications of the current terminal index to achieve desired gains in meat sensory. The current terminal index is improving meat tenderness with minimal expected genetic change in juiciness; it is however expected to reduce the beef flavour of meat. Using mathematics, placing sufficient weight on flavour to halt deterioration will marginally slow down the rate of genetic gain in carcass conformation and weight. Placing sufficient weight on tenderness to achieve a genetic gain of 1% per generation will slow down the rate of genetic gain in most of the traits.

Conclusion

Ensuring consumers achieve a satisfactory eating experience is a prerequisite for repeat purchase. Although consumer eating experience is governed by a whole plethora of factors, genetic and genomic tools

Figure 4: Expected response per generation in genetic standard deviation units (enables response rate per trait to be compared on the same sale) based on the current terminal index (blue), a terminal index that restricts the deterioration in flavour (green) and a terminal index constructed to improve meat tenderness by 1% per year (red).



can also contribute to achieving this end goal. Under controlled conditions, for example, up to 15% of the remaining variability in meat quality attributes in Irish cattle can, on average, be attributable to genetic merit transmissible from one generation to the next. One of the main benefits of breeding is that it is cumulative and permanent; moreover, many breeding schemes have (a form of) pyramid structure with few breeders making the breeding decision (at the top of the pyramid), the effects of which trickle down to the commercial population; therefore, because commercial producers are generally limited by the germplasm available to them, selection decisions made at the top of the pyramid can change the entire population, in a way by default. More details on breeding for meat quality can be found at Berry et al. (2017).

References

Berry, D.P., Conroy, S., Pabiou, T. and Cromie, A.R. (2017) Animal breeding strategies can improve meat quality attributes within entire populations. *Meat Science*, 6–18.

Havenstein, G.B., Ferket, P.R. and Qureshi, M.A. (2003) Growth, livability, and feed conversion of 1957 versus 2001 broilers when fed representative 1957 and 2001 broiler diets. *Poultry Science*, 82, 1500–1509.

Limousin to Hereford, change for change sake?

David & Maggie Kelly
Beef Farmer, Nether Hall, Kirkby Lonsdale, Cumbria

About us

We farm in the beautiful Lune Valley, three miles north of Kirkby Lonsdale. We live in Cumbria, have a Lancashire postcode, covered by South Lakeland District Council and have just joined the Yorkshire Dales National Park.

Team Netherhall consists of David, Maggie, daughter Harriet and Patrick Booth. We farm 900 acres and at the moment are running 840 cattle.

When David and I married in 2003 we were running a commercial herd of 240 mainly Limousin x cows put to Limousin Bulls and had 2 pedigree Limousin heifers Sarkely Tanya and Tracey. By 2006 we had grown to 50 pedigree Limousins in the herd. We decided that rather than buying in Limousin bulls we would breed them. We wanted really good bulls. We set about buying some fabulous Limousin heifers as the basis for our elite herd. Cloughhead Ainsi, Parkhouse Angel and Castleview Versace to name three (Figure 1).

Fieldson Alfy was our first top bull, followed by Haltcliffe DJ and Anside Flint. We used all these bulls extensively through the herd and sold semen from them all through Genus and Cogent (Figure 2).

Netherhall bulls at Carlisle regularly made in the tens of thousands of guineas, including Netherhall DoubleOseven at 20,000 gns. We also had females up to £25,000.

Netherhall Jackpot was our home-bred stock bull out of Cloughhead Ainsi by Requin and he has been one of the best selling Limousin bulls at Cogent (Figure 3).

Great stuff! Why would we change?

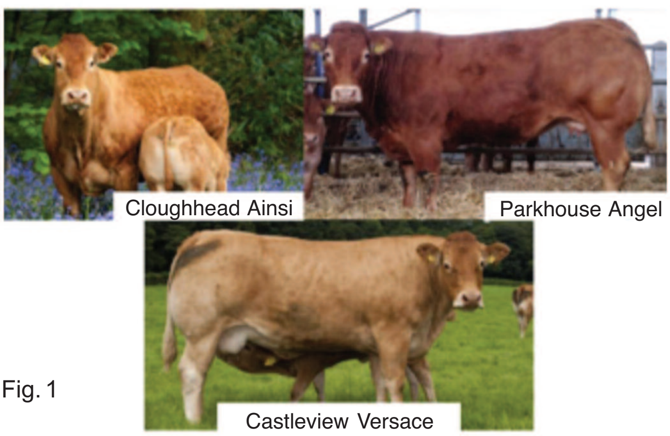
Our system was high input so these cattle were expensive to keep, calves on creep feed practically from birth, the feed wagon was in the yard every week (see Figure 4 on page 23).

We had pens of bulls eating their heads off on really expensive cake.

Fig. 3

Then, 'Joe is no good his feet are starting to go, Jonny is no good he walks wide, Jimmy had got a bad personality'. So off to the fat pen. The others then went to the auction and that became a big stress, they also needed halter training and they didn't always like that.

We found we didn't have a ready home market, lots of people liked the bulls but were only prepared to pay £2,000, which left us dependant on the bull sales.



Cloughhead Ainsi

Parkhouse Angel

Castleview Versace

Fig. 1

Fig. 2

Fieldson ALFY

Haltcliffe DJ

Anside FLINT

Fig. 4

We do not believe that a bull should have to be fed to within an inch of its life to sell as a working bull. But at the bull sales we found that if they were not fed they would not sell.

BREEDERS NOT FEEDERS

Canadian research shows fat bulls had backfat thickness of 10mm and lean bulls had a back fat of 4mm. The fat bulls produced 60% fewer sperm cells than the lean bulls, but they also had poorer quality semen. They had much higher percentage of inactive abnormal sperm cells than the leaner bulls. The detrimental effects of overfeeding are believed to be related to excessive fat deposits in the scrotum, which interfere with normal temperature regulation, causing overheating and possibly testicular degeneration.

For example: Netherhall Gameboy who had bulled 30 heifers before the sale and they were all in calf, they just could not see past the condition, he wasn't lean but he wasn't rolling fat, actually we thought he was in good working order, we could not sell him at the auction. We did sell him at home and he is fit and well doing what he is supposed to do, he has bred some excellent progeny, he is fertile and his feet are still very good.

Bullocks are a lot less trouble, and David took the view that if in doubt castrate. We had some fabulous bullocks.

Between 2006 and 2013 we worked really hard with our cattle and we bought in other bulls. One in particular was really hard calving, we had put him on some of our best cows which resulted in caesareans, dead calves and cows ruined, so he went for slaughter. Another bull had a really long gestation, giving us big calves which the cows were able to calve.

At home it became hard to find an easy enough calving bull for the heifers that didn't require assistance, and some of the heifer's temperament meant they could be really protective of their calves. It started to be really hard work.

In spring 2013 we went to New Zealand on holiday and a friend sent us to visit Haldon Station in the South Island. Here Paddy Boyd calved 700 Herefords block calving on his own – a light bulb moment – What were we doing? These were good cattle with not too much bone, milk and great carcase (Figure 5).

At the February bull sales in Carlisle after our holiday we were told we were ruined and we were, why were we producing bulls for a market which was influenced by the show calves. Why were we producing bulls with big behinds when actually this is mince and the value is in the loin and it is not necessarily a good calf if you have had a hard pull.

That summer we bought the autumn calving portion from Ervie Herefords, and they calved, they didn't need us, in fact they didn't want us fussing about. It was very hard to leave them alone. They calved they grazed and they milked. They were so easy calving we decided to put a L1 Hereford bull on to our Limousin heifers just to calve them and avoid doing damage. The Limford was born.

We liked our Herefords, they were L1's (Line One cattle which were developed in America and have been at the forefront of beef cattle breeding research since the 1930s) we searched the internet to find the best. Holden Herefords have arguably the best L1 Herefords and Jack Holden was happy to flush cows for us.

Going back to when we were in New Zealand Paddy at Haldon Station, had told us that he thought the best Hereford cattle were in Australia, so again we searched the internet and

Fig. 5

found Ian and Diana Locke who had Wirruna Poll Hereford Stud NSW.

The Locke's were happy to flush cows for us and this is the sire of our first embryos Wirruna Daffy. We liked his conformation, fabulous length and loin, meat where it is worth the most (Figure 6).

Fig. 6

Netherhall Herefords

We have 200 pedigree Hereford cows to calve in March to May. Our Herefords are run very commercially on grass in the summer, silage and straw in the winter. They calve at two years old, we tried this with our Limousins but two and a half was the soonest we could manage. By block calving the Herefords in March to May we calve them outside and there is lots of good spring grass to milk on. As the calves grow, we have creep gates on the fields so the calves can forward graze, they are not fed creep feed. The calves are weaned in autumn and get 2 kg feed per day for a month just to get them over the transition period. That is the only cake they have; from there it is good silage and grass through the summer. They are such good converters, that the challenge isn't to put weight on it is to keep it off for calving.

Our farm land ranges from 360 ft river bottoms to 800 ft steep hills above sea level and we get over 1160 mm of rainfall. We apply 44 units of nitrogen on the silage ground and 25 units on the grazing ground annually. Our Herefords are not as big, they do not eat as much and they make better use of the grass and eat less silage. Two big square bales a day for 84 in calf Herefords for 3 months on a diet and we keep 80 cows and calves plus stock bulls on 120 acres. We rotational graze all the cattle and use electric fences to divide fields. We are keeping more stock on the same amount of land, but have reduced our fertiliser costs by 30%. They are so much cheaper to keep.

What are we looking for in our herd? What do our customers want for their herd? What are they getting from our herd?

- High herd health
- Fertility
- Easy calving
- Short Gestation
- Carcase
- Docility
- Sales

Health

Netherhall has been a member of the SAC Premium health scheme since 2005. All Calves are tested for BVD at birth using Dalton tags, for 5 years all have tested negative, accredited since 2011. We annually test for Johnes and have been Accredited since 2012, Johnes risk level 1 and routinely vaccinate for Lepto and BVD. We are in a 4 year TB testing area and have never had a case.

This isn't new practice our Limousin herd had this too, and goes without saying we are passionate about health, any animal coming on is quarantined and tested. We have also doubled fenced against the neighbours.

Fig. 7

Carcase	Other
Eye Muscle Area Fat Depth Retail Beef Yield Intramuscular Fat Carcase Weight Shear Force	Docility Net Feed Intake Structural Soundness Flight Time

Weight	Fertility/Calving
Birth Weight Milk 200 Day Growth 400 Day Weight 600 Day Weight Mature Cow Weight	Scrotal Size Days to Calving Gestation Length Calving Ease

EBVS

We use EBV's to select our cattle and to prove our claims. We want our clients to get the perfect bull for their herd and EBVs give the best information on how an animal will perform (Figure 7).

Fertility

Size really does matter. All Bulls have their scrotal size measured and recorded into Breedplan. It has been proved that the bigger the balls the more fertile the bull is. Our Hereford bulls have bigger balls than our Limousin bulls did. Research shows that double-muscling in beef bulls results in reduced testicular development.

Also proven that the Scrotal circumference links to female fertility making the bulls siblings and daughters more fertile and reach puberty sooner. It is estimated that for every extra 1 cm increase in scrotal size is a 4 day decrease in the time it takes a heifer to reach puberty. Our Hereford heifers happily calve at two.

Easy Calving

Every calf is weighed at birth, recorded, and BVD tagged. We have found that our Herefords tend to calve themselves resulting in:

- A more relaxed calving period; no night calving's and we only calve them if there is a problem, for example if the calf is backwards
- Reduced labour
- Reduced mortality rate
- Reduced use of antibiotics and painkillers
- Reduced number of prolapses and caesareans – to date none of our pedigree Herefords have had either on the farm
- Longevity (see Figure 8 on page 25)

Short Gestation

We record gestation length from Insemination date or seen bulled to the birth date. We can only record gestation if we have the dates, no guestimates, it is a true recording.

EASY CALVING

Top 1% for low birth weights & calving ease.

BIRTH WEIGHTS
(July 2019 BREEDPLAN)

NO.	BIRTH WEIGHT AVG
78 HEIFER CALVES 2019	37.5KG
68 BULL CALVES 2019	40.6KG

Fig. 8

Last year 147 cows were recorded they had all calved before the due date, heifer calves average 278 and bull calves 280. Some cattle have longer or shorter gestation, and this is a big factor in calving ease. Cattle with long gestation lengths generally give birth to large calves, since the foetus is growing fastest at the end of gestation. One study showed that each extra day of gestation adds a pound or more in size of the calf.

SHORT GESTATION BENEFITS

HEREFORD GESTATION	280 day (avg)
MILK PRICE	29p (approx.)
MILK PER DAY	32L (approx.)

COWS CALVES 10 DAYS EARLY

10 Days x 32 Litres x 29p=£92.80

1 Bull x 60 Cows=60 x 92.80

=£5568

EXTRA MILK NO EXTRA COST

Milk

Herefords are great milkers, this means the calves do not need any creep feed. We measure milk by weighing the calves at birth and at 200 days.

Carcase Traits

We have all our bulls and heifers carcase scanned at 14 months. This is how we measure the trait; we are in the top 1% for eye muscle and retail beef yield.

Because of inter muscular fat Hereford beef is some of the best in the world and consistently wins competitions for eating quality. Without a doubt Limousins are the carcase breed and they do kill out really well but the F94L gene which most Limousins have, has been found to cause a 20% reduction in inter muscular fat. Many Herefords kill out at R4L which is what the slaughter houses want and the size of the carcase is ideal for the supermarket packaging.

Our stock bull Netherhall Daffy 22, when we scanned his progeny it came apparent that he was putting an extra half a rib of length into his progeny. His figures show he is +6 for eye muscle and the UK average is +1.9 also +66 for carcase weight and again UK average down at +40.

Docility

Our Herefords are more docile than our Limousins were and the benefits we have seen are:

- Handling and movement of stock is easier faster and safer
- Less risk of stampedes break outs and broken fences
- Grazing stock is easily checked
- Cows are quieter at calving enabling the calf to easily suckle so higher intake of colostrum
- Quiet cattle have higher daily live weight gains
- Docile cattle suffer less from stress, therefore reducing the potential risk of phenomena
- Easily loaded and the calmer the cattle are at slaughter the more tender the meat they produce

AI Sires

We are importing semen selected on fantastic EBVs and great carcase. We bought Wirruna Lennon in Australia and we are using his semen and selling it through Cogent.

Hereford Beef

We send all our Hereford cattle that do not make the cut through Dunbia on the Hereford scheme and we have a Coop contract. Hereford beef is sold in Waitrose, Lidl and Coop.

Bulls

We have now sold 7 Hereford bulls into AI studs in the UK and Ireland. We are selling bulls to various beef and dairy clients.

We always have bulls for sale and clients can come and take their pick. In the last year we have sold 40 at home and we are finding we are getting a lot of repeat customers.

All our stock is branded with the Netherhall N logo so if you see this it is a sign of quality and has the Netherhall guarantee.

Visitors are always welcome! We had lots of visits and trips last year including the National Hereford open day and the National Beef Association Beef Expo Farm Tour. We are looking forward to welcoming more visitors this year and we always finish with a BBQ and Hereford burgers.

References

https://agnr.osu.edu/sites/agnr/files/imce/pdfs/Beef/TheBull.pdf

http://agriculture.vic.gov.au/agriculture/livestock/beef/breeding/soundness-of-testicles-in-beefbulls

Repeatable quality beef – Chagyu, right every time

Ben Harman
Beef Farmer, Grove Farm, Chesham, Buckinghamshire

Summary

I am a third generation Charolais breeder, farming 274 ha of mostly marginal land at about 550ft on top of the Chiltern Hills on the Buckinghamshire/Hertfordshire border. In 2007 the first Wagyu cross Charolais was born mostly out of curiosity. That initial experiment coupled with as much learning as possible from the likes of Meat and Livestock Australia, Temple Grandin, AHDB and other sources too numerous to mention grew into the enterprise that is a small but important part of my business, Chagyu™.

Introduction

The disconnect between beef producers and consumers is a major factor in the variability of beef presented for sale, whereby it is very unusual for a producer to get quality feedback from the end user. This is compounded by the often disjointed nature of beef rearing and finishing, where it is not uncommon for an animal to move through 3 different systems (suckler, store and finisher) over its lifetime. Furthermore, even when the best intentions are followed there is a high likelihood of a degree of stress around slaughter. All of these factors will play a major role in the variability of the product reaching the shelves. At a time where beef is under such scrutiny from the green lobby, the vegan/vegetarian lobby, and under enormous price pressure from lower cost sources of protein such as chicken and pork it is essential that when a relatively high price cut of beef is bought that the consumer has a positive experience. Work from AHDB has shown that after a negative experience with chicken a customer will buy chicken again the following week. Following a negative experience with beef it will be up to 3 months before more beef is bought. It is incumbent upon all sectors of the beef industry, but especially those producers who place meat directly into a customer's hand, to ensure that the product is the best we can achieve.

The Chagyu™ Concept

Attending Beef Australia in 2009 I was lucky enough to hear a presentation from Meat and Livestock Australia (MLA) who had spent four million dollars researching repeatable meat quality. The findings were many and varied but the most salient points were:

- 80% of meat quality comes about in the last 42 days before slaughter and the first 28 days after
- There is a correlation between the speed a beef animal leaves a crush and the tenderness of the meat
- Mixing groups of cattle causes stress
- Transport causes stress
- Stress is a key component of reduced meat quality

Temple Grandin (Grandin, 1980) cites that:

- Hierarchical fighting is a major cause of dark cutting meat in cattle
- Calves lose less weight the second time they are transported
- Sheep would display less signs of stress during transport if they were used to human contact
- Pigs trained to handling procedures had better meat quality than untrained pigs

Temple also has a phrase 'It is incumbent upon us to give these animals the best life possible and the best death possible'.

AHDB Live to dead demonstration

Disruption to the growth curve not only has a negative effect on days to slaughter but also potentially to meat quality through the increase in elastin (gristle).

The concept was born primarily out of these 3 sources of research information with a bit of thought, a great deal of love for my cattle and a nugget of wisdom from Sir Clive Woodward – try to do 100 things 1% better than anyone else.

My needs as a producer, my animals needs and my customers requirements are closely related. By minimising stress at all points my life is easier, my cattle are happier, the meat is better, my customers are satisfied.

The steps

This is not meant to be 'preachy' its just an explanation of what I do and why I think it helps. Everything is done with a mind to maintain consistency of process and therefore product, to minimise stress and to maintain a smooth growth curve, with the aim of maximising output and meat quality.

Replacement Charolais heifers are selected not only on phenotypic characteristics, with temperament given a veto status. No cattle are retained that show any aggression, fear or tendencies to disrupt. Wagyu semen is bought selecting solely for Eye Muscle Area (EMA) and Marbling score and as the Wagyu is a far smaller animal than the Charolais this leads to a (so far) 100% unassisted parturition for Chagyu calves. The heifers 'learn' to calve without help which I believe has a knock-on effect through their life.

Every handling experience is positive. By installing and correctly using a well-designed handling system the cattle flow through quietly and calmly. If handling becomes stressful for the cattle there will be a 'stress memory' when it is handled in the future. Ultimately this will be in the slaughterhouse.

Pull don't push. When cattle are brought in from pasture (potentially for handling) it is always with a reward. Chasing will mimic the actions of a predator, by walking ahead I'm just one of the herd.

Sticks are never used, but wands are allowed. If I needed a stick to defend myself then I'd be keeping the wrong cattle. No hitting, no prodding. Wands (which are for all purposes identical to sticks but work like magic) when needed are used for extending reach, scratching and pointing.

Travelling – The farm is spread over three sites so the cattle get used to travelling early. They load at their own pace and rewards are always given to incentivise the process.

Spring born Chagyu will spend their entire growing phase on pasture, Autumn born spend their first winter indoors.

Creep feed is introduced gradually to ease transition through weaning and onward through the growth phase. Availability of high fibre where there is supplementary feeding – grass silage and beef nuts. The aim is to maintain as smooth a growth curve with no rapid changes in diet across the seasons.

Pre-weaning – Some high fibre is introduced pre-weaning. This has been shown to ease transition and aid growth rates (Campistol, 2010).

Fenceline weaning – It has been shown that fenceline separated calves spend more time eating and lying down and less time walking than total separated calves (Price, 2003).

While all Chagyu are outwintered, they have access to a dry lying area with silage and nuts to maintain around 1 kg dlwg.

Finishing – Around 120 days pre slaughter a pair will be separated from the group. Over a period of a month a higher energy feed will be introduced. It will be fed until I am comfortable with the condition. This tends to be reached at around 650 kg at 21 months.

The last journey – The slaughtering is done at a nearby farm which is also a small independent abattoir that opens one day a week. The cattle are handled by the farm's stockmen, it smells and sounds like a farm.

The sides weigh around 200 kg, they are hung for 28 days at 85% relative humidity and 2°C. No two carcasses have ever been butchered the same.

Take home message

Build your brand, shout about it and be proud of it!

Succession and running a successful family business

Martin Thatcher
Fourth generation cidermaker
Thatchers Cider Company Ltd, Myrtle Farm, Sandford, Somerset

Be under no illusions, running a business is hard work. Running a family business is exceptionally hard work. But when done right, the results are most definitely worth it.

Thatchers Cider is currently a fourth generation cidermaker, but it won't be long before we officially change that to fifth as the next generation begins to make its mark within the business. That is surely something to be proud of.

A 2016 PwC Family Business Survey said that 43% of family firms do not have a succession plan in place, and only 12% reach a third generation.

So, with that in mind, why are we at Thatchers bucking the trend as we enter our fifth successful generation?

Succession planning plays an important part of course. As a family we are tight knit, and we regularly sit around the kitchen table and discuss the matters of the day. With my father now retired, but still a familiar face around Myrtle Farm, and my daughter now 19 and beginning to play her own individual role within the business, that succession is playing out in front of us.

Family members can be your harshest critics, but they can also be your strongest advocates. The dedication over four generations to maintain our business as a family is something to be very proud of. The enthusiasm and interest from the fifth generation in continuing this heritage is very special.

Understandably then, creating a sustainable business for future generations is one of the core values of Thatchers. The family business message features prominently in our marketing and when new recruits join us within the business, we introduce them to the whole family – what's gone before and what we are planning ahead. No one can be in any doubt the role that family plays in the business.

It was my great grandfather William who first started making cider on the farm back in 1904. Second generation Stan, continued creating the legacy and really pioneered the art of traditional cider making, in fact we still use some of his recipes today. When my father John took the helm, he moved the cider business forward once again, and although when I left school, I had my heart set on becoming a cattle farmer, a shortage of hands at the cider farm brought me into the business sooner than I had ever imagined. Before I became managing director over 25 years ago, I had worked my way around all the functions of the business, from cidermaking through to sales and marketing.

Gaining this experience across every aspect of the company is now instilled into our ethos and our fifth generation are already gaining valuable experience before they join us full time. Encouraging the next generation is a principle we hold throughout the company. We must continue looking forward. Our recently established Apprenticeship Programme, Thatchers Young Talent, sees our young people learn and gain knowledge within the wider food and drink industry. In fact, that's no different for the fifth generation – my children have been on their own extended apprenticeship programme since the day they were born!

We're committed to training and development. Over recent years as the company has grown and we've looked to expand our work force, it's become increasingly apparent that school and college leavers just weren't yet equipped for a career in the cider industry. So, we took matters into our own hands with Thatchers Young Talent, and by working closely with our local education providers, we've created a programme that is now in its second year and is winning awards for its innovation and quality. We've opened the programme up to existing employees too, just one element of individual development within the company. Having a motivated workforce is crucial to success.

As a family run company, we're able to invest in growth, and that's what sets us apart from many of our competitors who are beholden to shareholder profit. And its investment in skills and technology that enables us to produce world class cider.

That focus on producing the world's best cider through always striving for better, came as a result of my Nuffield Scholarship. What I realised through those studies, was that to succeed in a competitive environment, our sole purpose had to be to make Thatchers Cider the best we possibly could. So, over a relatively short period we streamlined out all our activities that were not directly related to building a great cider brand.

We have taken some enormous risks, some have paid off, some have not, but during all this time we have kept this focus. We keep our eye firmly on the future.

Heritage is important, but with those eyes on the future, we place innovation at our core. From our 150-year-old giant oak vats, to our state-of-the-art fermentation, we don't shy away from embracing technology to create the best product in the most sustainable way.

Sustainability comes naturally to us as a rurally based company. As farmers, we're always in tune with the environment around us, and with over 500 acres of our own orchard, as well as orchards run by our contracted growers, we're guardians of natural carbon sinks.

We're taking that one step further by investing in a new energy centre at Myrtle Farm that will in future enable us to run our cidermaking on energy we've created ourselves. We're determined to reduce our plastic usage – working with our trade customers on how we bulk supply to them, as well as on a consumer level. We were the first cidermaker to take away the plastic rings on our four-packs of cans and replace them with recyclable cardboard outer packs.

We work hard to reduce our waste throughout the business – and in particular recycle, and reuse – not send to landfill. We're thinking big on sustainability.

We operate in a competitive environment. Customers have a choice – if they don't like what we do, they won't buy from us. So, it's up to all of us to be the best we can, every day. As a family business, we're in a great position to change, to evolve – and to move quickly if we need to. At the end of the day it's my family's name on the label so it has to be right.

We're a product of our surroundings. We are so lucky to be situated in the heart of Somerset, nestled at the foot of the Mendip Hills. We live and work in a rural environment which of course has its challenges, but also has so many benefits. We can step outside our office door and be walking through the most beautiful orchards. We're very lucky to have this as our back garden, and most certainly adds to the character of our business. We're fiercely proud that the South West remains our heartland.

So, with our local community at heart we have established The Thatchers Foundation with trustees from the wider community as well as family members. Our aim for the Foundation is help and support the community in which we live and work, and we invite applications for grants from individuals or groups. Over the last few years, we've been able to donate to a wide range of organisations run by inspiring volunteers. From the Avon and Somerset Search and Rescue, to the Appleshed inclusive theatre group; from a local community hall fundraising for a children's play area, to the Reach centre that supports young adults with learning disabilities, giving them opportunities to develop life-skills for living independently.

We keep moving forward and continue to develop new ciders to reach new audiences; we invest in our people to make them the best they can be at their jobs; we invest in our cidermaking facilities to ensure we're in a position to produce an exceptionally and consistently high-quality product in the most sustainable way. We're very proud that Myrtle Farm remains our family home.

Going green – How do we communicate our cattle industry's environmental advantages?

Dr Jude L Capper
Livestock Sustainability Consultancy, Harwell, UK

We are at a crossroads in livestock production, with opposing governmental, market and consumer forces working upon farming systems so that new challenges are an inevitable component of modern food production. Ultimately, a sustainable system has to balance environmental responsibility, economic viability and social acceptability (de Wit et al., 1995), yet it is clear that there are as many concepts of what might constitute sustainable food production, as there are people in the UK. To some, the bucolic idyll of agrarian literature provides the foundation for farming that, in many ways, resembles the countryside of the 18th or 19th century, with small mixed farms, reduced technology use and a return to a perceived simpler existence. To others, efficiency is the key to sustainability, focusing on producing sufficient food in the most efficient manner possible, despite potential conflicts with consumers uncomfortable with modern practices. The conflict between these two extremes ensures that the debate will continue for some time.

Although sustainability discussions tend to focus on environmental issues, specifically greenhouse gas (GHG) emissions, it is important to note both that environmental impacts go beyond GHGs to include a range of different issues, including water use, air pollution, soil erosion and biodiversity. All foods, whether animal or plant-based, have an environmental impact and although cattle are often cited as being environmentally undesirable, according to Gerber et al. (2013), beef production in Western Europe has a lower carbon footprint at 18 kg CO_2 per kg carcass weight than Oceania (26 kg CO_2 per kg carcass weight), North America (29 kg CO_2 per kg carcass weight) or Latin American countries (72 kg CO_2 per kg carcass weight). British beef and lamb also have reduced water footprints compared to other regional production systems – up to 96.4% lower per kg of beef than United States beef production (Beckett and Oltjen, 1993, Chatterton, 2010).

The English beef industry has cut its carbon footprint per kg of beef by 37% since 1970 (AHDB, 2012) through improved animal nutrition, genetics, health and husbandry, although the carbon footprints of English beef and lamb still vary considerably (EBLEX, 2009). In contrast to monogastric production systems, methane is the predominant GHG emitted from ruminant production, however, a new study from Oxford University has reported that it has a far lower impact on climate change than was first suggested, with a new global warming potential (GWP*) at approximately 25% of the originally calculated value (Allen et al., 2016, Allen et al., 2018). That means that the carbon footprint per kg of beef or lamb could be reduced by up to 50% compared to previous calculations. Obviously this does not mean that GHG emissions have intentionally been reduced or that producers should cease trying to achieve this goal, but, if adopted by the Intergovernmental Panel on Climate Change (IPCC) who assess the science as it relates to GHG emissions, this would level the playing field with other meat choices generally considered to have lower environmental impacts, i.e. pork and poultry.

The British cattle industry also has a positive story to communicate to consumers in that livestock systems don't simply produce milk and meat, but myriad by-products (leather, fertiliser, pharmaceuticals, etc) which cut environmental costs compared to synthetic sources. Cattle's ability to convert waste products from human food and fibre production that we cannot or will not eat (e.g. maize gluten, sugar beet pulp, surplus vegetables, bakery waste, etc), into high-quality protein is also a significant positive PR story. Ruminant livestock are often cited as being less efficient than pork and poultry, but because forage and human-inedible by-products make up a considerable part of their diet, they produce more human-edible protein than they consume and use very little arable land per tonne of protein output (Wilkinson, 2011, Wilkinson and Lee, 2018).

The average Briton spends only 8.2% of their total income on food (World Economic Forum, 2016), thus our demand for affordable food is often cited as a driver of improved on-farm efficiency (Morris et al., 2016). As with any industry or business, efficiencies of scale are present on large livestock operations that should allow for reduced economic costs of production, improved specialisation and technical expertise, and the provision of a uniform quality product. However, in contrast to automotive or computing industries where we tend to celebrate efficiency, the ‘factory farm’ label carries negative connotations. Compassion in World Farming (2017) produced a map of ‘factory farm hotspots’ ostensibly intended to educate consumers about the comparative intensity of livestock production. Labelled with statistics such as ‘*Somerset has the seventh highest number of indoor-reared dairy cows with over 2,660 animals confined inside, restricted in their ability to express their natural behaviours*’ the map does not provide data on health or welfare measures, the proportion of the herd/flock that was housed or the extent of behavioural restriction. In the absence of this data, it does not inform the debate, but simply adds to overall consumer concern regarding farming practices. Bucolic agricultural imagery is often used in food advertising, with dairy cattle portrayed grazing lush pasture, beef or pigs in deep straw bedding and poultry in sunlit conditions. The discrepancy between these pictures and the ‘factory farm’ images promoted by activist organisations is an obvious erosion factor for consumer trust. The influence of the ‘factory farm’ label was also exemplified in a study from the USA, in which identical samples of beef jerky were labelled either ‘factory’ or ‘humane’ (Anderson and Barrett, 2016). Consumer panels consistently rated samples labelled ‘factory’ lower for appearance, taste, smell and overall enjoyment than ‘humane’ samples, despite the absence of any actual differences.

When we purchase foods, we act as both citizens and consumers (Carrington et al., 2010). As citizens, we are concerned about issues perceived to be for the greater good (e.g. ‘I only buy meat from free-range animals’ or ‘I care deeply about animal welfare’), whereas our actual purchasing behaviours often reveal that we choose foods based on quality, price, brand, nutrition and taste (Eurobarometer, 2012). This may explain the perceived popularity of the Veganuary campaign, which encourages people to adopt a vegan lifestyle throughout January and is highly publicised in the mainstream media, yet only attracted 250,310 participants globally in 2019 – equal to the population of Wolverhampton (Veganuary, 2019). Meat-free Mondays are also often promoted in the media, yet British livestock production accounts for only ~6.9% of our national carbon footprint (author’s calculation from DEFRA data). If the entire British population went meat and dairy-free every Monday for an entire year, the carbon footprint would therefore be reduced by less than 1%.

Regardless of personal dietary preferences, it is essential to pursue an evidence-based foundation for sustainable food production, which involves confronting the ‘everybody knows’ rhetoric. This is challenging in an era where television, internet and social media have overtaken traditional print media and literature as information sources (Capper and Yancey, 2015, Ofcom, 2019) and arguments against livestock production that appeal to aesthetic or ethical values are sometimes more successful than the science-led information that we tend to rely upon. Rather than trying to combat anthropomorphic or ethical claims with scientific facts, we need to combine the two, acknowledging that we share consumer desires for both excellent animal health and welfare and efficient food production, and demonstrating a clear commitment to systems and management practices that promote these. However, this must occur without compromising economic viability, which may be a crucial tipping point. For example, if, as consumers believe that low-input or small-scale production systems have health and welfare advantages, then we must be prepared to risk potential negative trade-offs, potentially paying an increased economic and environmental cost. For example, the celebrity chef Jamie Oliver recently advocated the production of beef from cull dairy cows in his popular ‘Friday Night Feasts’ television programme. Dairy animals already account for a significant proportion of UK beef and adding weight to cull dairy cows may improve economic viability, especially when the beef price is high. However, the cull cow system that Mr Oliver promoted was based on ‘retiring’ cull dairy cows onto pasture for four years before slaughter. The average UK dairy cow is culled at 6.1 years of age (Hanks and Kossaibati, 2016), by when she will have reached mature weight. Therefore, the majority of extra weight added in ‘retirement’ is fat, and while this would add flavour, most carcase fat isn’t particularly human-edible. Grazing a cull cow for four years to render into tallow a significant proportion of the weight that she gains is remarkably inefficient. A cow will eat 2–2.5% of her body weight in dry matter (DM) each day (NRC, 2001). Four years of feeding a 700 kg cow is equal to 19,856 kg of feed DM, or 82,733 kg of fresh grass at ~24% dry matter, in addition to four-years worth of drinking water, manure, greenhouse gas (GHG) emissions and veterinary care. This has a considerable economic and environmental impact compared, for example, to rearing 5.15 beef steers to slaughter at 24 months of age on the same amount of total DMI from pasture, in addition to culling the dairy cow when she leaves the herd (without the ‘retirement’ period). The latter scenario would provide 5.15 extra carcases (a total of 1,931 kg beef), from the same amount of pasture and with a lesser total quantity of manure and GHG emissions. Neither the cows needed to produce the steers, nor the cost of rearing the dairy cow have been accounted for in this example, yet it highlights the relative efficiencies in differing uses of a unit of pasture and the potential for the aesthetically-appealing choice (retired cull cows) to have negative trade-offs compared to the more efficient (young beef steer) option.

Eliminating some efficiency losses may also have positive social sustainability effects if they relate to animal health or welfare issues that are in the public eye. For example, if every male dairy calf was reared for beef or veal (thus removing the issue of male calves being shot on farm), and better use was made of both beef sire breeds and sexed (dairy) semen, significant gains could be made. However, it should be noted that beef cattle grazing lower-quality grassland play a vital role in British food production, as 65% of British land cannot be used to produce arable crops (DEFRA, 2019). Grazing cattle and sheep also allows farmers to provide other vital ecosystem services and public goods, including sequestering carbon, maintaining wildlife biodiversity, planting trees, preserving landscapes and providing tourism opportunities. A balance therefore has to be sought between utilising all animals resulting from dairy production, and effective use of land that is only useful for grazing.

Despite our demonstrated capacity for independent thought, as consumers, we are more akin to herd animals than we might like to admit. When provided with factual information about controversial issues, including food production, our interpretation of the data; willingness to believe in its validity or relevance; and the likelihood of consequent changes in behaviour are influenced by myriad factors. Given the pace of modern life, we have little free time in which to research issues, therefore we form strong opinions upon them based on limited information – the concept of bounded rationality (Capper and Yancey, 2015). These opinions may be reinforced by bad news bias – the assumption that negative assertions have greater veracity than positive headlines. Therefore, 'Factory Farming: Misery for Animals' is more likely to tempt the casual browser to read the article than 'Better Off on Big Farms'. In short, bad news sells. This is potentially dangerous, as negative pieces of information confer more strongly-held beliefs than positive statements. Indeed, one negative piece of information is sufficient to neutralize five pieces of positive information (Richey et al., 1975).

The fact that we can instantly access food production information via the internet is a major communications opportunity, however, there is little or no regulation of factual accuracy on internet websites or blogs, therefore the spread of misinformation also occurs at a faster rate than was historically possible via printed media. We are pre-programmed to search for and agree with information that reinforces our pre-existing opinions or perceptions ('confirmation bias'), regardless of its veracity (Nickerson, 1998). When faced with a variety of opinions or information sources (e.g. on Twitter or in comments on media articles) we therefore give greater weight to those that concur with our experience and viewpoint. In social media terms, this may give rise to 'tribes', in which we tend to read and respond only to others within our chosen circle of contacts or information providers. This becomes dangerous when we become so focused on communicating within our chosen tribe (e.g. farmers, agricultural industry professionals, fans of a particular sports team) that we dismiss both the validity and impact of opinions outside that tribe. Given that the majority of consumers are unfamiliar with farming systems and production practices, we need to reach outside our tribes in order to communicate with the wider world, understand consumer perceptions and concerns, and respond to them (Capper and Yancey, 2015).

We tend to agree with the opinions of people with whom we identify and share values (Tomasello et al., 2005, Kahan et al., 2011), which is why initiatives like Open Farm Sundays that allow consumers to feel that they 'know their farmer' may prove to be successful in changes perceptions and improving social acceptability. This mechanism, known as cultural cognition, is also the way in which we are influenced by people whom we wish to emulate. This provides our industry with an opportunity to potentially improve the social acceptability of cattle production by promoting greater interaction and discussion with chefs, food critics, sports people and other celebrities who have significant social media influence. For example, a quick Twitter search reveals that although AHDB Beef & Lamb, the Food Standards Agency and DEFRA have 15.4, 53.4 and 150.4 thousand followers respectively; Nigella Lawson (2.6 million), Sir Paul McCartney (4.0 million), Jamie Oliver (6.7 million) and Wayne Rooney (17.1 million) have a significantly greater reach. Thus, any food-related tweet from the latter four may have a far higher impact on consumer perception than those from industry, governmental or scientific associations. The impact of media coverage of English professional rugby player Joe Marler, who attributed a particularly fast recovery from a broken leg to his habit of consuming two pints of milk per day, upon milk consumption by young athletes is unknown, but is presumed to have had a positive influence. However, the recent promotion of vegan lifestyles by celebrities including Lewis Hamilton, Jude Law and Venus Williams may have had the opposite effect. Ultimately, our industry needs better positive publicity and celebrities who are prepared to act as spokespeople and influencers.

As an industry, we must be prepared to enter conversations that we have traditionally avoided, to move outside our comfort zones and communicate the realities of cattle production to the consumer. This is the responsibility of all within cattle production, as the survival of our industry depends on improving the social acceptability of how we breed, feed and care for livestock. Ultimately, a sustainable future for cattle production will be independent of either economic viability or environmental responsibility if the market ceases to exist for milk and meat. However, if we learn from the successful communication methods and mechanisms adopted by both the media and activist groups and continue to improve cattle productivity, health and welfare, we should be able to balance the three pillars of sustainability and ensure that milk and meat are still on the menu in the year 2050 and beyond.

References

AHDB (2012) Long-Term Carbon Footprint Trends – Beef Industry. In AHDB, Stoneleigh, Warwickshire, UK.

Allen, M.R., Fuglestvedt, J.S., Shine, K.P., Reisinger, A., Pierrehumbert, R.T. and Forster, P.M. (2016) New use of global warming potentials to compare cumulative and short-lived climate pollutants. *Nature Climate Change* 6, 773–776.

Allen, M.R., Shine, K.P., Fuglestvedt, J.S., Millar, R.J., Cain, M., Frame, D.J. and Macey, A.H. (2018) A solution to the misrepresentations of CO_2-equivalent emissions of short-lived climate pollutants under ambitious mitigation. *Climate and Atmospheric Science* 1, 16.

Anderson, E.C. and Barrett, L.F. (2016) Affective beliefs influence the experience of eating meat. PLoS ONE, (online-only).

Beckett, J.L. and Oltjen, J.W. (1993) Estimation of the water requirement for beef production in the United States. *Journal of Animal Science* 71, 818–826.

Capper, J.L. and Yancey, J.W. (2015) Communicating animal science to the general public. *Animal Frontiers* 5, 28–35.

Carrington, M.J., Neville, B.A. and Whitwell, G.J. (2010) Why ethical consumers don't walk their talk: Towards a framework for understanding the gap between the ethical purchase intentions and actual buying behaviour of ethically minded consumers. *Journal of Business Ethics* 97, 139–158.

Chatterton, J. (2010) The Water Footprint of English Beef and Lamb Production – A Report for EBLEX. In Cranfield University, Bedfordshire, UK.

Compassion in World Farming (2017) Do You Live in a Factory Farm Hotspot? Retrieved on July 28th 2017 from https://www.ciwf.org.uk/factory-farm-map/.

de Wit, J., Oldenbroek, J.K., van Keulen, H. and Zwart, D. (1995) Criteria for sustainable livestock production: a proposal for implementation. *Agriculture, Ecosystems & Environment* 53, 219–229.

DEFRA (2019) Farming statistics – provisional crop areas, yields and livestock populations at 1 June 2019 – United Kingdom. Retrieved on 2nd January 2020 from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file /837834/structure-jun2019prov-UK-10oct19.pdf

EBLEX (2009) Change in the Air – The English Beef and Sheep Production Roadmap – Phase 3. In EBLEX, Stoneleigh, Warwickshire, UK.

Eurobarometer (2012) European's Attitudes to Food Security, Food Quality and the Countryside. Special Eurobarometer Report 389. In The European Commission, Brussels, Belgium.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. and Tempio, G. (2013) Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. In Food and Agriculture Organization of the United Nations, Rome, Italy.

Hanks, J. and Kossaibati, M. (2016) Key performance indicators for the UK national dairy herd. In University of Reading, Reading, UK.

Kahan, D.M., Jenkins-Smith, H. and Braman, D. (2011) Cultural cognition of scientific consensus. *Journal of Risk Research* 14, 147–174.

Morris, C., Helliwell, R. and Raman, S. (2016) Framing the agricultural use of antibiotics and antimicrobial resistance in UK national newspapers and the farming press. *Journal of Rural Studies* 45, 43–53.

Nickerson, R.S. (1998) Confirmation bias: a ubiquitous phenomenon in many guises. *Review of General Psychology* 2, 175–220.

NRC (2001) Nutrient Requirements of Dairy Cattle. In Natl. Acad. Press, Washington, DC.

Ofcom (2019) News Consumption in the UK: 2018. Retrieved on 2nd January 2020 from https://www.ofcom.org.uk/__data/assets/pdf_file/0024/116529/news-consumption-2018.pdf

Richey, M.H., Koenigs, R.J., Richey, H.W. and Fortin, R. (1975) Negative Salience in-Impressions of Character: Effects of Unequal Proportions of Positive and Negative Information. *Journal of Social Psychology* 97, 233–241.

Tomasello, M., Carpenter, M., Call, J., Behne, T. and Moll, H. (2005) Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences* 28, 675–691.

Veganuary (2019) Veganuary 2019: The Results Are In. Retrieved on 2nd January 2020 from https://uk.veganuary.com/blog/veganuary-2019-the-results-are-in/.

Wilkinson, J.M. (2011) Re-defining efficiency of feed use by livestock. *Animal* 5, 1014–1022.

Wilkinson, J.M. and Lee, M.R.F. (2018) Review: Use of human-edible animal feeds by ruminant livestock. *Animal* 12, 1735–1743.

World Economic Forum (2016) Which countries spend the most on food? Retrieved on July 28th 2017 from https://www.weforum.org/agenda/2016/12/this-map-shows-how-much-each-country-spends-on-food/.

Deep learning and its application in livestock industry

Werner Brand
Geneticist Programmer, SRUC, The Roslin Institute, Easter Bush, Midlothian

Introduction

Deep learning is a relatively new tool in data science, but is already implemented in many areas of our daily lives, without us even knowing it. Our smart phones can convert our speech into text, process and understand them and even return information to us. Google Sheets can understand your questions in human language and return accurate charts and data analysis of your spread sheets. Emails and messages are scanned for dates and venues and automatically create calendar events and notifications. Autocomplete on the internet can predict what you will type next and suggest appropriate phrases. And more commonly, facial recognition allows you to securely log into online banking and authorise financial transactions, tag yourself and friends in social media photos and even lets you securely navigate through an airport without the need for a passport and ticket when boarding. This extraordinary technology is already implemented in every sector of industry and can be used effectively in many agriculture and livestock farming sectors. The presentation will highlight some of these applications in livestock, based on research done at SRUC and showcase results from projects undertaken by researchers and embellish on the future applications of deep learning in agriculture.

What is deep learning?

Deep learning is part of a larger group of statistical methods called machine learning. Both are a scientific study of algorithms that computer systems use to perform specific tasks that relies on finding patterns in raw data to make assumptions and predictions. It does not involve any specific instructions about the data it is analysing. The key difference is that deep learning involves feeding a computer system a lot of data in order to make decisions about other data by creating multiple layers of transformed data structures and connecting the association between the layers (neural networks). This is very much how humans and animals learn. Deep learning can be further divided into supervised and unsupervised learning, where the former is the most popular method. Supervised learning takes large amounts of data that are labelled and will learn how to transform the raw inputs (features) into the labels. This is achieved by progressively extracting higher level features from the raw input to make predictions and then validating the accuracy of these predictions on the labels in an iterative process called training. The training of large neural networks requires high performance computers and can train for days, weeks and months to converge properly, but the trained models can then be applied to new data to make predictions rapidly.

Why use deep learning?

In short: we use deep learning to solve complex problems that we do not know how to model accurately. This can be explained with an example where computer models are used to interpret handwritten text. It is fairly easy to write a program to interpret a single person's hand-writing, but the problem becomes exponentially more complex when trying to write a program to interpret the handwriting of multiple people (Figure 1). The overall shape of a letter or digit (raw input) as written by multiple people is not significant enough as the shape varies between people. The highlighted areas on the digits in Figure 1 are examples of higher level features that are common between specific digits and that may be used to distinguish between letters or digits (e.g. a cross shape within the number 4).

This process is similar to how we learn new skills and how we interpret data – even if we do not consciously realise our own thought processes.

Figure 1: Example of high-level features that can be extracted with deep learning on handwritten digits.

As with humans the neural networks are not immune to bias and their interpretation of data can be confounded by identifying patterns in noise. This is generally the reason why they require vast amounts of accurate data during training.

Research at SRUC in deep learning

Research in deep learning started about two years ago at SRUC and resulted in 3 projects that can be deployed in the agriculture industry. Two projects involved binary classification from milk mid-infrared (MIR) spectroscopy data routinely collected for national milk recording. The MIR spectra data is already used for predicting other economically important traits like fatty acid content, mineral content, body energy status, lactoferrin, feed intake, and methane emissions. The MIR spectra data was converted into grey-scale images (Figure 2) in order to use a pre-trained model in a technique called *transfer learning*.

As mentioned before, the higher level features in raw data are not related to the type of data being analysed and transfer learning exploits this by training a model on millions of images to learn how to extract these features and then applying the model to other data in another feature space – even if the original images were of cars, buildings or faces and target images are of MIR spectra images.

In general, models are evaluated by their accuracy (ratio of correct predictions to all predictions) and their loss (average sum of squared differences between the predicted label and the real label where a loss of zero is a perfectly score) during training. Furthermore, an inference dataset (a dataset seen by the model) is used to measure the robustness of the model to make real world predictions.

Project 1 – Predicting pregnancy status from milk MIR spectra

Pregnancy status of dairy cattle is essential to ensure the reproductive and subsequent production performance of the herd. The longer it takes to determine if the cow has not maintained the pregnancy the greater the financial implications. This study converted 10,000 milk MIR spectra records into grey-scale images to retrain the DenseNet neural network. The model showed a validation accuracy of 0.97 and loss of 0.08 during training. On inference, the model showed an accuracy of 0.877. There were clear distinctions in the probabilities between correct and incorrect predictions of the model. After adjusting for this, the model showed an accuracy of 0.9125. This model will be trialled soon to test its accuracy in the industry and to further optimise the model.

Project 2 – Predicting TB status from milk MIR spectra

This study predicted bovine tuberculosis (bTB) status of UK dairy cows using their MIR spectral profiles collected as part of routine milk recording. Bovine tuberculosis is a zoonotic disease of cattle that is transmissible to humans, is distributed worldwide, and considered endemic throughout much of England and Wales. It is a chronic disease of great economic, welfare and societal importance, having severe conse-quences for the dairy cattle sector. The prevalence of bTB infected animals in dairy herds is low and resulted in an unbalanced dataset (ratio of responders to non-

Figure 2: Example conversion of a raw MIR spectra record into a grey-scale image.

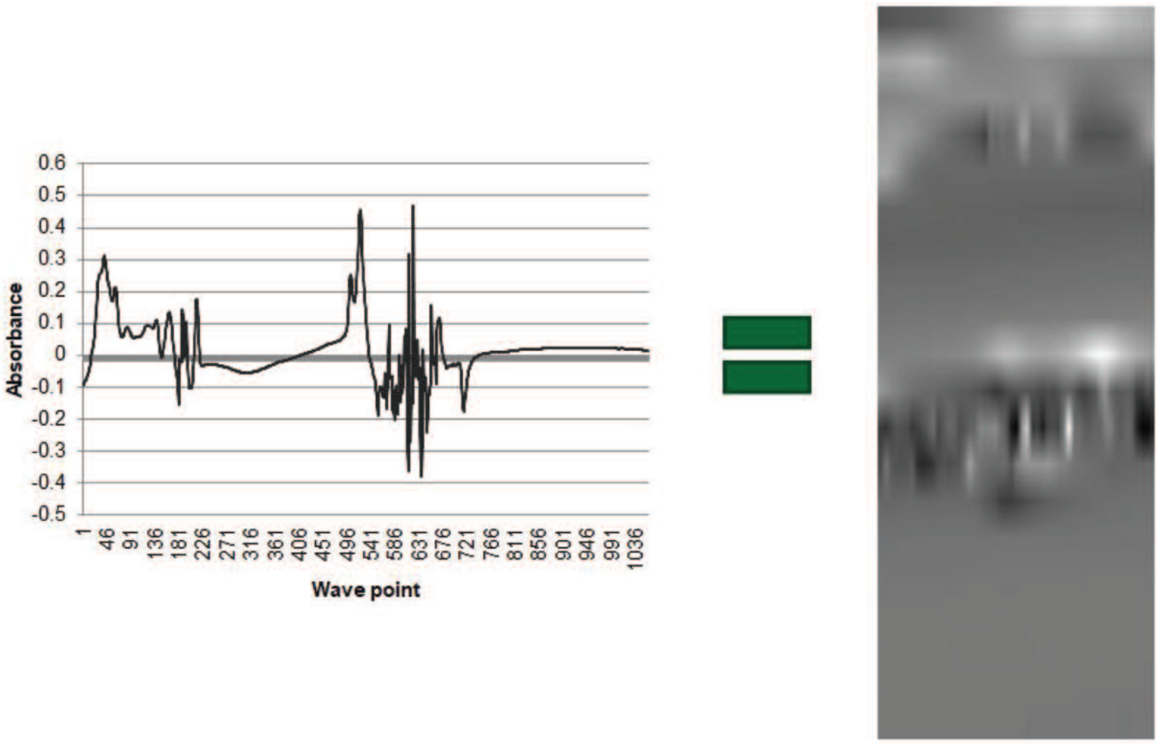


Figure 3: Example of digital image received for dairy goats during milking with the highlighted isolation margin of the udder.

responders) which is not ideal for binary classification. For example, if you have 93% non-responders in the data, then a deep learning model can predict everything as non-responders and will still be 93% accurate!
A machine learning technique was used to synthesize milk MIR records for responders to balance the dataset. As with project 1, the milk MIR spectra data was converted into images and used with transfer learning. The model showed validation accuracy and loss of 0.95 and 0.26, respectively, and a true positive rate (TPR) of 0.96 and true negative rate (TNR) of 0.94. Results from this project will too start a field trial soon.

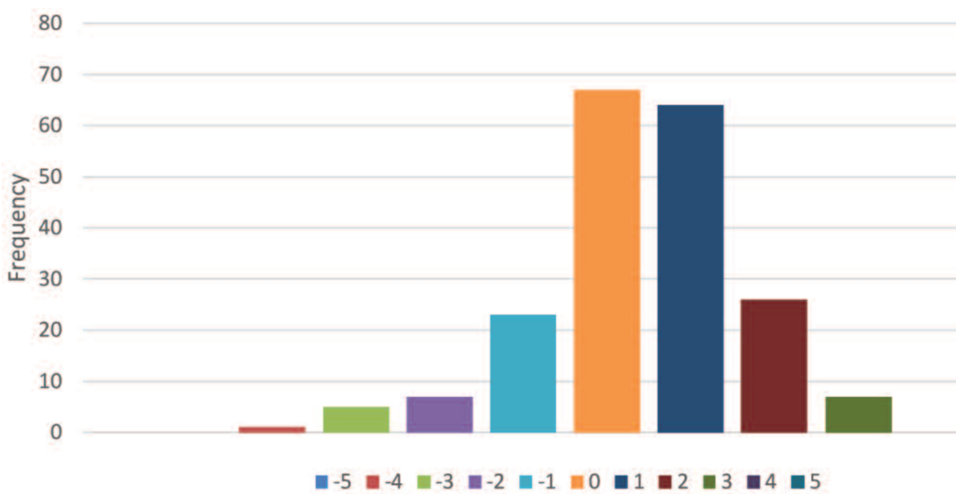
Project 3 – Predicting udder furrow score in dairy goat udders from digital images

As part of an honours project, digital images of dairy goat udders were used to predict the udder furrow score in a range between 3 and 8. The digital images received included a large amount of noise required additional cropping to isolate the goat and its udder (Figure 3).

A transfer learning model was used to train a neural network to predict udder furrow. The model showed validation accuracy of 0.99 and loss of 0.04 during training. The student classified a number of images these were used for inference. Figure 4 shows the cross-validation results of the predictions on the inference dataset.

The results from Figure 4 show that the model was able to predict a large proportion of udder furrow images correctly within a single point of difference. The results from this project are promising and will be further optimised for accuracy and to include more udder traits.

Figure 4: Cross-validation of predictions by the neural network on the inference dataset as compared to predictions by the student.



Conclusions

Data is currently collected in gigabytes on farms and hold key insights into the very nature of farming enterprises. Sources of valuable information can be recorded with specialised sensors like mid-infrared spectrometers, but also with the most simplest of equipment like smart phones, digital cameras or GPS devices. Deep learning can significantly enhance the prediction capability of economic important traits in agriculture and assist farmers in their daily tasks by automating repetitive tasks and giving insights into complex data structures. Both the technology and the means of data recording already exist today and new management tools are just waiting to be deployed. Best practices for accurate data recording and storage are imperative in a digitised world and investment in these best practices will benefit the farming community greatly.

Future-proofing your herd through the use of genomics

Neil Eastham BVSc DBR NSch MRCVS
Partner, Bishopton Veterinary Group & RAFT Solutions, Ripon, North Yorkshire

Introduction

Good genetics are fundamental when considering the profitability of any dairy enterprise. A structured approach to breeding can be a highly cost-effective way of improving herd performance. Genetics directly influence a number of key areas of management including: production, milk quality, health, fertility and feed efficiency.

Genomic testing has transformed the dairy industry's understanding of genetics. Genomic test results are significantly more reliable than traditional parent average values as they reveal more about the genetic potential an animal actually inherited. Using genomic testing, an animal's genetic potential can be revealed early in life, and genetic progress can be accelerated with confidence.

The rate of genetic gain in the genomic era has doubled. Early on, the major focus of genomic testing was the benefit in identifying high quality young bulls early. Now farmers can use exactly the same power of prediction for females as a cost-effective tool to make more precise management, selection and breeding decisions on-farm.

Whilst the adoption of genomics on the male side is high, the number of UK dairy farmers genomic-testing their females is low. In 2018 I set out on a Nuffield Farming Scholarship to explore why this might be by visiting producers who are benefiting, as well as meeting with other stakeholders. I wanted to understand more about how producers are using genomics in practice, consider the potential returns that can be realised, and learn more about the role the vet can play.

The genomic revolution

Around the turn of the century research in the field of genetics moved at pace from the study of individual genes to that of the whole genome. The developments that would ensue have changed the field of animal breeding for evermore.

Genomics is the study of the whole genome of an organism. Whole genome selection, more commonly known as genomic selection, was proposed by Meuwissen in 2001.[1] However, it wasn't until the Bovine Genome Project (BGP) was initiated in 2003 that the DNA tools became available to bring earlier postulations to fruition. In 2009 the BGP group published the first bovine genome for a Hereford cow named L1 Dominette 01449.[2]

Meuwissen demonstrated that estimated breeding values could be calculated from genetic markers along the genome. A successful marker would be abundant and show variation between individuals. Single Nucleotide Polymorphisms (SNP's) refer to variation between individuals at single nucleotides (A, C, G, and T) along the genome.

The work of the BGP group along with Dominette's sequenced genome provided the framework from which over 2 million SNP markers were identified. After genotyping it would now be possible to examine SNP differences between individuals and associate these differences with traits of interest.

Rather than use whole genome sequencing which would be costly and time consuming, the first commercially available SNP-based genotyping chip was released in December 2007 and provided genotype data for 54,609 SNP markers.[3] At a cost of $225 this signalled a 1000-fold decrease in the cost of genotyping and paved the way for many bulls (dead and alive) to be genotyped.[3] Their genotypes, together with millions of daughter records, would provide the early reference population and prediction equations needed to incorporate genomics into the traditional genetic evaluation processes.

Official genomic predicted transmitting abilities (gPTA's) were first released in 2009 in the US. Initially the number of males tested outnumbered females. The artificial insemination (AI) industry immediately benefited as the cost of testing bulls was subsidised to recognise their early contribution of bull genotypes. The costs associated with genomic testing later decreased as cheaper low density SNP chips were made available.

Genotype imputation is the process whereby SNP sites not covered by a lower density SNP chip can be inferred.[4] Statistical techniques are used to estimate genotypes at loci not directly genotyped by the SNP chip.[4] This can be achieved with high accuracy and, as a result, genotype imputation is celebrated as a break-through in the evolution of genomic testing.[4] This has made whole-herd genotyping more common and females now account for over 90% of the genotyped population.

Using genomics to predict the future with confidence

The rate of genetic gain in the genomic era has doubled.[3] Early adopters of genomics have long accepted a genomic proof as an accurate indication of a bull's eventual daughter's proven proof and many are now practising whole herd genomic testing to further expedite genetic gain.[3]

The 'breeder's equation' is central to realising genetic progress. The rate of genetic gain can be measured as per the following equation:

$$\frac{\text{GENETIC PROGRESS}}{\text{YEAR}} = \frac{\text{ACCURACY X SELECTION INTENSITY X GENETIC VARIATION}}{\text{GENERATION INTERVAL}}$$

The role of genomic testing on each of the variables included in this equation is now considered:

1. Accuracy

Reliability is used to indicate how accurate an estimate of genetic merit is. The reliability figure for a PTA varies dependent on the amount and source of information used in its calculation. In the pre genomic era the most accurate way of predicting the genetic merit of a young male or female was to use the parent average (PA) assumption. This assumes that the animals genetic merit lies exactly intermediate between that of its dam and sire. By revealing more about the genetics an animal actually inherited genomic testing has significantly increased the reliability of PTA predictions.

The jump in reliability (typically from 15–35% to 55–75% dependent on the trait) is greatest for low heritability traits. Heritability describes the extent of variation for a trait that is attributable to genetics. In the traditional evaluation process a trait with low heritability (e.g. fertility) requires more information (e.g. daughter records) to produce a breeding value with the same reliability as a high heritability trait (e.g. protein yield).

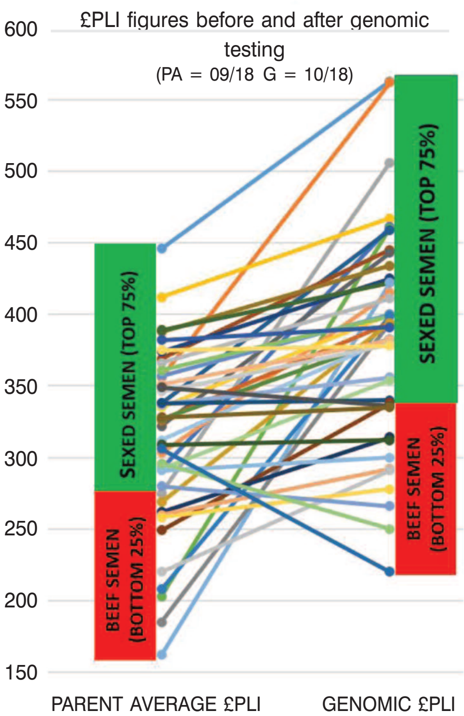
Genomic testing provides more information for low heritability traits. For protein yield the extra information provided after genomic testing equates to 34 additional daughter records: whereas a genotype is worth the equivalent of an additional 131 daughter records for fertility.

2. Selection Intensity

The selection differential is a measure of the difference between the average genetic merit of the animals selected for breeding and the average genetic merit of all animals in the population from which they were selected. The higher the selection differential the greater the selection intensity.

After genomic testing a group of animals re-ranking for a given PTA will occur when PA PTA and gPTA values are examined. Figure 1 on page 40 illustrates this for a group of forty tested heifers.

Figure 1: Re-ranking effect after genomic testing.



Use of the selection index Profitable Lifetime Index (£PLI published by AHDB) enables us to explore the opportunity cost of this re-ranking effect. In this example the breeding decision for 13 of the 40 heifers is changed after testing. The opportunity cost of using PA PTA's in this example is over £1000 across this group of heifers (one generation). Given the cumulative effect of genetics across multiple generations the actual figure is far higher.

3. Genetic variation

Genetic variation plays a vital role in realising genetic gains through selection. Heritability can be used as a measure of genetic variation. Whilst traits with high heritability are thought to be easier to improve through breeding, even traits of low heritability (e.g. fertility) can be improved as sufficient genetic variation exists to apply selection pressure. This is especially important when one considers the significant economic cost of some low heritability traits such as fertility and longevity.

4. Generation interval

Generation interval is defined as the average age of parents when their progeny are born. As the divisor in the breeder's equation a decrease in the generation interval has the effect of increasing the rate of genetic gain. The widescale use of young genomic proven bulls has dramatically reduced the age of both the sire of bulls and sire of cows across the national herd.

The average age of the dam of bulls has also decreased because genomic tested virgin heifers are now more commonly used as bull dams. The ability to collect more frequently from a younger age, use reverse sorted semen, less semen, and collect during the first trimester of pregnancy has meant that ovum pick up (OPU) in-vitro fertilisation (IVF) has superseded embryo transfer as the advanced breeding technique of choice in many territories around the world.

Applications for breeding and beyond

Genomic testing can be used for parentage verification as well to provide valuable information relating to the animals status for genetic recessives and haplotypes (e.g Holstein fertility haplotypes 1–6), genetic characteristics (e.g. horned/polled status) and milk protein traits (e.g kappa casein).

Practical use of genomics on farm

The widescale availability of genomic evaluations now spans both males and females across multiple dairy breeds.

Genomic-proven sires now account for 70% of inseminations on UK milk recorded dairy farms (source AHDB). Since the introduction of UK genomic evaluations by AHDB in 2012 there has been a marked shift in the UK from using daughter-proven sires to genomic-proven sires. Similar trends were observed in other countries visited, with genomic-proven sires accounting for 60% of inseminations in The Netherlands, 65% in Canada, 70% in the US and 80% in Ireland.

In the US, 12% of eligible heifers are genomic tested per year (source: The Council of Dairy Cattle Breeding). In Canada it is estimated that 7% of eligible heifers are tested (source: Canadian Dairy Network), markedly higher than the 2% currently tested in the UK. Testing on the farms I visited was almost exclusively carried out on young heifers, thereby capitalising on the largest possible increases in reliability.

The motivation to test differed between dairy farms visited. Some were embarking on a race to the top, elbow to elbow with the breeding companies. Others looked to find value at the bottom by more accurately identifying and deselecting the heifers with the lowest genetic merit. Regardless of their motivation to test all the farms visited had a clear understanding of their breeding objectives.

To determine their breeding objectives the farms visited had done a full review of their current and future needs based on their farming system, milk contract, herd health challenges, current performance and current genetic base. Following this review they were in a position to identify the traits that they wished to improve through breeding. These selection criteria were then used to carry out bull selection and rank the females once they had been genomic tested. After ranking female animals were aligned with a breeding strategy and this was deployed with ruthless precision.

Breeding strategies to maximise genetic progress

For those farmers who were genomic testing, having a clear set of breeding strategies was deemed crucial. These strategies were tailored to the individual farm and often included; the use of sexed dairy semen, use of beef semen, negligible or zero use of conventional dairy semen, the sale of low genetic merit animals and use of advanced breeding techniques (OPU–IVF and/or conventional Embryo Transfer).

The combination of breeding strategies to use alongside genomic testing is an important consideration when looking to realise a return on an investment in female genomic testing. Modelling in the US has demonstrated additional value in generating more dairy heifers than are needed.[5] This leads to a higher selection intensity as a greater number of heifers to choose replacements from results in an increase in the selection differential and a greater rate of genetic gain.

The adage that data is only as good as what you do with it is wholly relevant to genomic test results. Many breeding strategies can be deployed and these will vary dependent on the individual farms needs and situation. An ideal combination would result in increased income and decrease costs whilst maximising the rate of genetic gain. The use of sexed dairy and conventional beef semen, together with the sale of surplus low genetic merit heifers, is likely to yield the greatest short and long term financial return on many farms.

A testing solution – a role for the vet?

The amount of information returned after genomic testing can be overwhelming and there is a huge amount to consider before, during and after genomic testing. As farmers look to realise the maximum return from investment, they must have confidence in those who are advising them. Advice in this field appears to be mainly derived from three sectors: breeding advisor, test provider and the vet.

It is imperative that vets have an understanding of the genetic potential of the herds that they are working with. This is vital when looking to set realistic targets and recognise when failures to harness genetic potential are occurring. Mindful that an element of health, welfare and productivity is directly related to the breeding decisions made on farm, vets must equip themselves with all the skills necessary to successfully advise their clients on breeding and genetics.

On-farm observations and data analysis provide vets with an appreciation of those herd health challenges that can be, at least in part, addressed through breeding. With an understanding of the statistical nature of breeding and the science behind genomics, vets are well placed to provide advice in a field where independence is a rarity.

The role of the evaluation body – when industry collaboration meets big business

The success of the genetic evaluation process relies largely on volume and quality of data collected from appropriate representative populations, which must then be processed accurately through the use of evidenced evaluation procedures.

In many of the countries visited it was clear that the evaluation body had no commercial interest in the animals being evaluated, and these bodies have forged close working relationships within the industry to access and process data into meaningful evaluations for the benefit of all farmers.

Through transparent methods their work looked to promote best practice with regard to: methodology, exploring and correcting for potential errors (e.g. bias), identifying emerging threats (e.g. recessives and haplotypes) and preserving genetic variation whilst realising significant genetic gain.

In the UK, AHDB have continued to partition producer levy and funding towards improvements to the genetic evaluation process. These improvements will benefit all dairy farmers, not just those who can access PTA or gPTA data for females. The online herd genetic report (HGR) is also continually improving. This is used by farmers and authorised third parties to access herd genetic PTA and gPTA data.

A growing number of proprietary genomic evaluations are now available. In the absence of an overseeing governing body, there is no official validation process in place to approve proprietary predictions. It is largely therefore down to the farmer and/or their advisor to evaluate their credibility. This should include a review of the methodology used to calculate the prediction. Only once this is performed should a decision be made as to whether the proprietary index is utilised.

Future applications of genomic testing

We are still very much in the early stages of adopting genomic technology. Since the advent of genomic testing the focus for many has been the genotype. Focus is now shifting back to the phenotype as we increasingly realise that existing and new data sources from the farm combined, represent great potential for further genetic improvement.

Small populations of deeply phenotyped animals can be used to develop gPTA's for new traits. When deciding which new traits should be targeted, two factors should be considered. Firstly, new traits should have low phenotypic and genetic correlations with existing traits; they should bring new information. Secondly, they should have value to farmers. Where the cost of measuring is high because specialised equipment is required, it is important that the resulting predictions are of high value to the farmer (see Figure 2).

Figure 2: Device used to measure methane emissions at the Elora Research Station – University of Guelph.

The importance of data has never been greater. Existing and new data sources on-farm represent an exciting opportunity for further genetic improvement. Through sensor technology and on-farm recording procedures, farmers should be encouraged to record as much high quality data as possible. In return, stakeholders should be prepared to reward farmers with financial remuneration or access to improved services.

Summary

Genetics play a fundamental role in herd health. Genetic improvement is permanent and cumulative over generations. At a time when dairy farmers must continue to modernise and specialise in order to maintain competitiveness, genetic improvement represents a cost-effective way for farmers to meet the growing demands of their consumer.

Every dairy farm should have a set of breeding objectives to reflect their current and future needs. Only once the breeding objectives are set should the selection criteria be determined. Selection should focus on those traits where an improvement through breeding will help achieve the breeding objectives.

Faster genetic progress can be realised through the use of genomics. Dairy farmers should look to capitalise on the superior genetic merit of genomic-proven bulls versus their older daughter-proven counterparts. Female genomic testing should be added to the list of tools available that dairy farmers consider when looking to increase the productivity and profitability of their farm.

If an investment in female genomic testing is made maximal value must be returned. Tested females should be ranked according to their suitability for the farm and its breeding objectives. Along with other breeding females, tested females should then be aligned to a defined breeding strategy that looks to optimise returns.

Genetics alone though is not the whole answer: to complement focused-enhanced breeding it is essential good herd health management is practised. The combination of genetics and excellent management will yield the best results.

References

[1] Meuwissen, T.H., Hayes, B.J. and Goddard, M.E. (2001 Apr) Prediction of total genetic value using genome-wide dense marker maps. *Genetics* 157(4): 1819–29.

[2] Christine, G., Elsik, Ross., Tellam, L. and Kim C. Worley (2009 Apr) The Genome sequence of Taurine Cattle: A window to ruminant biology and evolution, The Bovine genome sequencing and analysis consortium. *Science* 324: 522–528.

[3] Wiggans, G.R., Cole, J.B., Hubbard, S.M. and Sonstegard, T.S. (2017) Genomic selection in dairy cattle: The USDA Experience. *Annual Review of Animal Biosciences* 5: 309–27.

[4] Weigel, K.A. (2017) Genomic selection of dairy cattle: A review of methods, strategies, impact. *Journal of Animal Breeding and Genomics* 1(1): 1–15.

[5] https://www.progressivedairy.com/topics/a-i-breeding/looking-for-greater-economic-value-from-genomic-testing

In vitro embryo production for cattle breeders

Gavin Tait BVMS, MRCVS
Veterinary Surgeon, Animal Breeding Europe, Westruther, Scotland

In vitro embryo production (IVP) has been trialled in the UK numerous times over the last 30 or so years and has always struggled to compete with conventional MOET (Multiple Ovulation and Embryo Transfer) flushing in terms of cost, reliability and consistency. In the last decade however, it has become more popular around the world and numerous large scale breed improvement programmes are using this technology with great success.

In my presentation we will look at what we have learned during our transition from traditional MOET flushing into IVP and how we can use our experiences to shape our future.

Introduction

ABEurope was established in 2014 when ABS New Zealand and Innovis Breeding Services formed a new partnership with the intent to establish an IVP system in the UK. ABS NZ (Animal Breeding Services New Zealand) had a fully functioning and very successful system in New Zealand which was producing around 4,000–5,000 in vitro embryos annually, predominantly in the flourishing dairy industry and often under contract with larger companies such as LIC and CRV.

Worldwide IVP was gaining significant market share from traditional MOET flushing and we could see a market opportunity within the UK for a successful IVP system. This would complement the sheep breeding business which was already well established; ABEurope is the largest provider for Artificial Sheep Breeding services in the UK.

IVP/Bovine business staff

We started with 2 full time staff on the bovine side but in 2020 now have 5/6 full time staff:

1 Laboratory Manager (Embryologist)
2 Embryologists
2 Cow side Technicians
1 full time vet + 1 part time vet
(Also, some extra staff support from ovine side of business when available)

Services provided (Bovine)

- IVP production of embryos
- Embryo implantation
- MOET flushing
- Embryo storage
- Embryo import/export
- Semen collection
- On farm service **and** livery service

The advantages offered by IVP over MOET were fairly clear as shown below (Table 1).

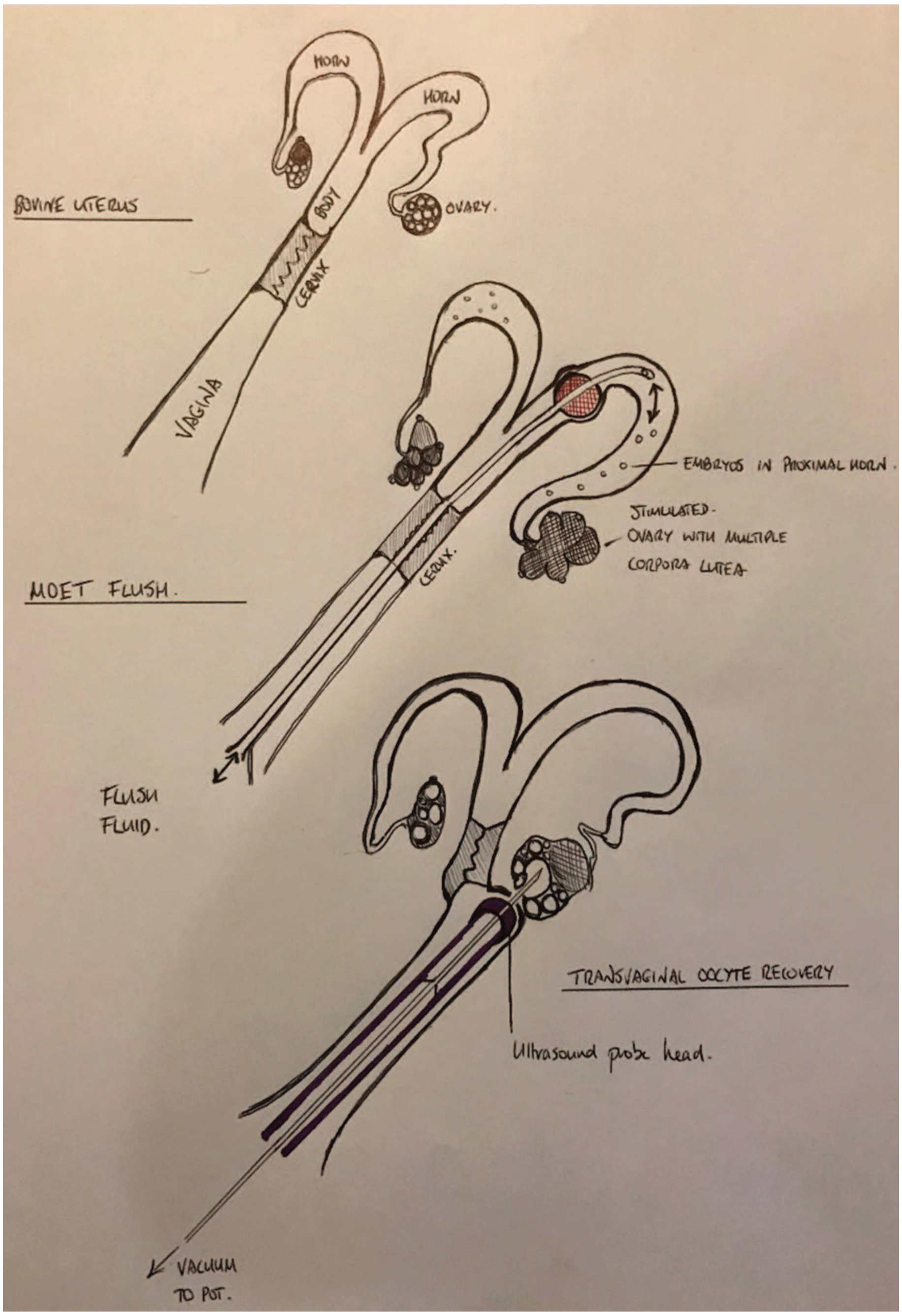
The MOET flush is relatively invasive in that we pass a catheter into the horn of the uterus and flush the embryos from the horn by flushing fluid in and out of the horn through that catheter.

With IVP we don't go through the cervix of the cow so the lining of

Table 1: Advantages offered by IVP over MOET. *Explanation: stimulation (stim) is where cows receive FSH injections to stimulate follicles, and hopefully increase the competence of the oocytes we collect.*

	IVP (no stim)	*IVP (stim)*	*MOET*
No. collections per month	4	2	1
No. semen straws per donor	1 (or less!)	1 (or less)	3–5
Average no. embryos per collection	2–3	4–6	4–6
Average no. of embryos per month/donor	8–12	8–12	4–5
Collect from **pregnant** cows	Yes	Yes	No
How soon after calving can we collect	4 weeks	4 weeks	8 weeks
Interval between collections	1 weeks	2 weeks	4 weeks
Handlings per collection	1	7	13
Vet/Drugs cost to programme donor	£0	£50	£100+
Pregnancy hold rate (fresh embryos)	60%	60%	60%
Pregnancy hold rate (frozen embryos)	45%	45%	50%

Figure 1: An anatomical description of the process illustrates the less invasive nature of TVR/IVP when compared to MOET.



the uterus and cervix remains undisturbed. We simply collect the unfertilised eggs directly from the follicles on the ovary using an ultrasound guided needle which passes through the vaginal wall straight into the ovary.

A new wave of follicles is produced every 7 days or so, and so there is a continuous supply of oocytes available for collections every 5–7 days (or every 14 days where we are using stimulation).

Including preparation, a TVR/OPU collection can be performed in around 15 minutes – the part where the operator is working inside the cow takes only 3–4 minutes in a normal donor (with an experienced operator). It is possible to collect from around 10+ cows in a morning to 20+ in a day.

It is commonplace to collect from pregnant cows **up to around 12 weeks of gestation;** this offers a tremendous advantage where clients are attempting to keep a tight breeding/calving period.

From a welfare and 'on farm labour' point of view the advantages of IVP are remarkable:

- 13 handling episodes and 9–10 injections of hormone for a standard MOET programme
- 7 handling episodes and 4 injections of hormone for a stimulated IVP programme
- 1 single handling episode and no injections of hormone for unstimulated IVP programmes

We are collecting unfertilised oocytes directly from the ovaries – these are collected and matured (IVM) for 24 hours before being put into a fertilisation media (IVF) with semen, and then a day later into culture media (IVC) where they are grown on for 7 days. So, 8 days after a collection we should have blastocyst stage embryos which are suitable for either implantation into recipients or freezing for later use (see Figure 2 on page 45)

Costs

We have various schedules for charging but generally works out at around £150–£220 per embryo.

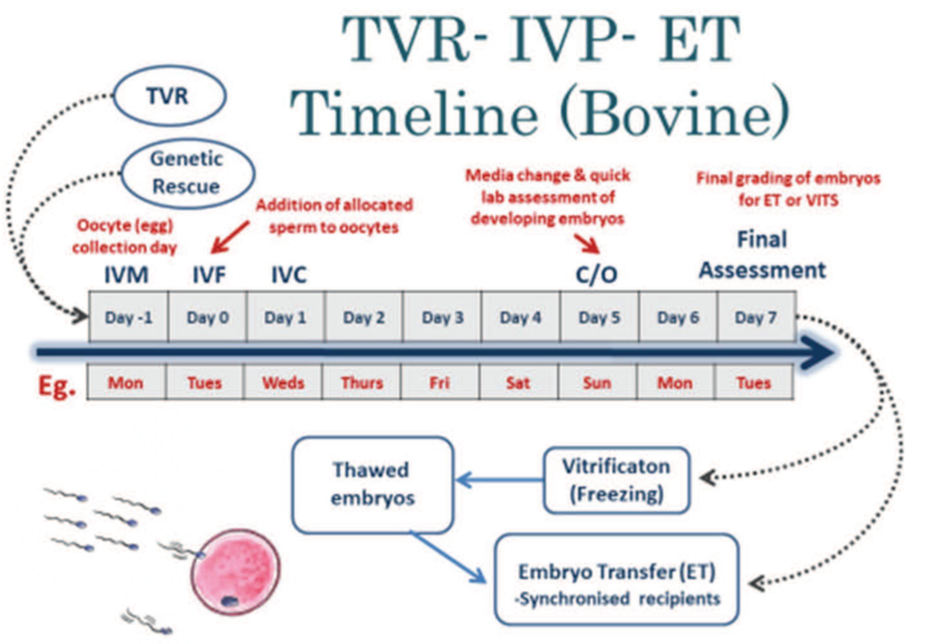
Our early experiences

We didn't set out thinking that it was going to be plain sailing and easy, and we were right. We had to overcome numerous obstacles and although we were able to produce embryos within a relatively short timeframe from our outset, we had numerous periods where we had to troubleshoot. The problem is often that identifying the actual problem within such a complex system is like looking for a needle in a haystack.

After a period of setting up a laboratory and system with trialling and verification in late 2014/early 2015, our first semi-commercial runs began in 2015. We began to produce good numbers of embryos and indeed pregnancies followed with good hold rates.

This was against a general negative murmur from some people within the

Figure 2: Timeline.



industry towards the technology (partly based on previous experiences); this was the first hurdle we had to overcome. Our most obvious problem was that although ABS New Zealand had several thousand calves on the ground, we had none in the UK, so we had no proof of concept in the UK. Our second problem was that in New Zealand they were breeding dairy cattle whereas in the UK we found ourselves at the more 'extreme' end of the Pedigree Beef market. Trying to assure our elite beef breeders that IVP embryo calves from double muscled show cattle would pop out of recipients with no calving difficulty, was fraught with obvious difficulty.

From speaking to clients about previous bad experiences with IVP calves we realised that many of the calves were oversized largely because they had gone well over their normal gestation period. Some were suffering from foetal oversize but often they were suffering badly from lactic acidosis as a result of prolonged dystocia and stress during calving/caesarean.

We quickly decided to strongly encourage all clients (and particularly those with 'large' genetics) to induce (at/around day 284 of gestation), and this seemed to very quickly resolve most of the issues we were having.

It is conceivable that a foetus in utero with a good placental supply and a well-nourished cow might be growing at 1+ kg per day, and so instead of a 65 kg calf with lactic acidosis born on day 294, we were inducing a (still large) but healthy 55 kg calf on day 284. We found farmers would naturally keep a very close eye on the recipient after induction and the calves were born fit and healthy and far more likely to get up and suckle colostrum without any assistance. Despite our advice some clients were allowing recipients to calve naturally and most were getting on fine (particularly where the genetics weren't too heavily geared for growth etc).

By late 2016 we had 100+ calves on the ground; word was getting around that some clients were having good results; runs with 8–10 IVP calves being born on individual farms with no issues at all, and this largely helped to dispel at least some of the myths that were going around at that time.

2016 was a good year for us and we were producing around 2.5 embryos per donor. At this point we made the move to upscale which caused a few difficulties; we moved from 290 donor collections in 2016 to nearly 600 in 2017. From late 2017 to late 2018 we were having some very good results, but lacked the consistency that we would have liked in some runs; our embryo production dropped to around 1.5 embryos per donor in some months; not commercially viable and damaging for our reputation.

By early 2019 we had done 12 months of intensive troubleshooting and optimisations in our system/ advice on donor management/ laboratory etc and things seemed to turn around significantly. By mid-2019 we were seeing some excellent results. In many weeks we were averaging 4–5 embryos per donor and we were doing this consistently. We were at a level where we knew we could seriously compete with MOET flushing in terms of viability, particularly when bearing in mind that many of the donors which we were being presented with had failed in MOET systems or were 'last chance saloon' cows at the end of the line. We were averaging 4–5 embryos with poor quality donors. Many of our better donors are producing 10+ embryos per collection (every 1–2 weeks).

What have we learned?

We learned very quickly that any break in the long chain of links that make up the process of IVP will lead to frustrating failure. Each link becomes just as important as the next despite the natural inclination to treat some aspects as if they are much more important than others. Attention to detail throughout the whole process is the key.

We also learned that our clients who had good results loved the simplicity and ease of IVF compared to the laborious process and multiple handlings/stress involved with MOET flushing. The quick collections and quick turnaround of donors was a major bonus. The ability to collect from pregnant animals meant it was possible to keep a tight calving interval which was also very attractive.

The main factors for success

1. Semen
2. Laboratory
3. Donor Management
4. Collection Process

1. Semen – Choice can be critical. We find that around 80% of semen batches work well, but with the 20% that don't they become 100% of the reason for failure. From the same bull we will find some batches which work and some which don't. We will always try to use proven semen where possible; either batches which have been used before, or have been trialled in a slaughter house run (oocytes collected from slaughter-house ovaries).

2. Laboratory – These are highly specialised processes and staff and protocols are critical; attention to detail and consistency is paramount. We run constant quality control and trials to test equipment/media/ procedures and regular verification and optimisation.

3. Donor Management – Consistency is important in terms of environment/group/housing/feeding. Body condition; not too fat/too thin, a stable/rising plane of nutrition with attention to detail on trace elements and disease control. Livery animals seem to tend to do better after they have been in for around 4–6 weeks on a stable regime.

4. Collection process – We use highly specialised equipment and temperature control is vital most of our kit is electrical and designed to keep oocytes at a stable temperature of 35–38°C at all times. Good restraint of the animal is important and we need to be working in sheltered environment, out of sunlight/shelter from rain/wind.

Where do we go next?

A few things have become very apparent in the last year or so:

1. We can select good donors from a group with initial **ovarian ultrasound screening**
2. From a scan we get an idea of how to manage donors in terms of:
   - Will this be a good donor for weekly collections?
   - Do we **need** to stimulate this Donor, or is she likely to perform well without stimulation?
   - Does this cow need more time (e.g. postpone for a month)?
   - All of this allows us to better manage client expectations
3. **Programming and Stimulation** – can make a huge difference in donors which aren't producing much on weekly collections (various options for drug choice and dosage for tailoring to individual donors)
4. **Donor management** – diet/ stability is all important. Don't rush; plan ahead! At livery we are analysing all silage and keeping separate batches from individual fields to cut down on any inconsistency when feeding donors/recipients. We can select best batches of silage and save these for livery animals; analysis allows us to supplement appropriately with tailor made concentrate rations (including fish oils etc)
5. We need to encourage clients to collect from **better donors** – aim to get away from collections from problem animals/infertile cows/ cows living with chronic pain/ stress/infection/inflammation
   - Ideally look to collect from 2–8 year old cattle with good breeding histories/sound fertility
6. **Freezing** – at the moment we freeze embryos on hooks where they are vitrified and snap frozen. We believe this can lead to better quality freezing, but Direct Transfer (DT) embryos can be more convenient and easily tradeable. If we can get DT's to hold as well as Vitrified embryos, we may make a move in that direction, but if the Vitrified embryos are showing an advantage in terms of results we need to be careful about switching
7. **Dairy** – at the moment most of work is elite pedigree Beef work. As we move forward, we would like to be doing more dairy work
8. **Sexed Semen** – improvements and screening to find batches which work well; we have used sexed semen with some success where batches of semen are good!
9. **Semen** – generally slaughterhouse screening/trials to verify that it's working and care to avoid batches which are sub optimal or introduce infections
10. **Optimisation** of the system leads to improved results which **reduces the cost** per embryo/ pregnancy/calf
11. **Proactive approach** based on experience rather than reactive approach to failures

In November/December 2019 we collected from 55 donors and averaged 13.5 oocytes per donor producing 4 embryos per donor on average. This included a lot of problem donors. The aim has to be to keep up these good results and aim to improve our approach to donor selection and optimising all aspects listed above.

Advice to farmers considering using IVP

- Do it as part of a planned process after consideration/consultation. Avoid rushing in or using it as an emergency/salvage operation. Plan at least 3 months ahead where possible to allow preparation of all aspects and proper pre-management of donors/recipients
- Use a breeding group with an established programme and consistent results: ask for references and speak to people who are using the technology
- Ask questions and learn about the process; do your research – when you are managing the donors and recipients yourself, **YOU** will contribute a large proportion of the potential for success or failure. Work with your vets and nutritionist to attempt to optimise all aspects
- Expect failures as well as success; spread the risk and look to make an average over a number of seasons. Be realistic about what you are likely to achieve and manage your expectations. Look at the averages and work out the statistics.

Delivering succession for farming businesses

Rob Hitch
Partner, Dodd & Co Accountants, Carlisle

Where do we start with succession?

The best place is to agree what it means. Succession is about passing control of businesses from one person to another. In most farming circumstances this is to family members in the generation below the owners.

Succession isn't about the division of a family's assets; after all the capital value doesn't have to be shared in the same proportion as the income. Think of large companies; directors control the business, but shareholders own it.

However, in many farming businesses the two are often heavily interlinked, and families view both succession to the business and the division of assets to be one and the same. I think they should be looked at as two separate issues, although one generally forces discussion of the other.

People are getting better at splitting the two, looking at the business as stock and machinery, and assets as property. Effectively creating a landowner and tenant.

What do I think?

When I googled 'succession planning', I was greeted by many articles and advice about tax! As an accountant I think this seems to be what most people assume to be succession planning. I will cover some tax points later, but these should be incidental to succession planning.

Despite being an accountant, I wish to concentrate on the succession of management, and the potential pitfalls. After all, as my corporate partner often laments, farmers don't get taxed!

Most of the articles I read seem to start from the perspective of the older generation being ready to pass on the business and making the decision to hand it over. I see just as many business succession plans being driven by the younger generation.

After all, many are quite happy to survive on beer and petrol money in their teens and twenties, but by the time they have their own children they want control of their own destiny, to provide for their own family.

Whichever generation is driving the conversation, I think the farmers need to think about who succeeds and who doesn't. To this end are we teaching the next generation the skills they need?

What skills are needed?

If farms operated in a normal market they would simply go out and hire a manager. Most however are trying to recruit from a shortlist of two or three family members rather than a much larger pool. If farmers want their children to run the business, they have the responsibility to give them the necessary skills and training opportunities.

We have to be clear that running a farm business, like many other small businesses, requires the owner to be competent in a range of skills. As farms get bigger these invariably get stretched as people suddenly encounter issues they haven't been prepared for.

Farm managers now need to understand the technical issues in their sector, to deliver good performance, but also need to understand how to apply for grants, employment law, health and safety law, become the 'finance director', and have a comprehension of world agriculture, market prices and competitors cost of production!

Are we being fair expecting people without all of these skills to take over and run farm businesses successfully? How do you choose your successor?

The whole industry is critical of the approach schools careers advice takes to say 'you aren't good enough for this, go and work on a farm'! Agriculture needs better people across the board. I only have one client who doesn't want to pass on their farm to their children as they don't think they could run it!

Do we make too many people partners?

In my business I am one of eleven partners. We are careful about who we make partners! We are looking for people that have the drive to push the business forward. After all a bigger pie to divide is good for everyone, but also who have complementary skill sets, particularly in our business in technical competence.

I see too many farms admit children as partners as a way of reducing the income tax bill. To some extent accountants are complicit in this, and is perhaps something we should be more critical about. I act for several businesses where they have partners who really should not be partners.

They have no interest in managing the business, or making decisions about the running of it, and simply want to do their job. These people should be employees, not partners, however once the genie is out of the bottle it is hard to put back in!

Do you have to make family members partners at all? In some cases, people have non family managers running the business with an equity stake in the trade, with children simply having an interest in the underlying assets. This generally only happens once all children have ruled themselves out of running the business.

Should we insist that those that we want to succeed take the opportunity to upskill themselves? Should we force them to go to agricultural college or university, go and work for someone else or in a different industry for a while? When they come home should they be encouraged to carry on learning? It is good to see Arla, Tesco and First Milk actively engage their suppliers, and particularly their younger members, to engage in more training and learning.

So, what steps can people take to make the process smoother?

I once attended a conference where one of the speakers was lamenting the lack of successors in agricultural businesses and the reasons for it, and a farmer sitting next to me leaned over and said 'Profit'.

At the end of the day, if you want a successor to take on your business it has to be able to reward them for their contribution. If profits are high enough to allow this whilst the older generation take money out then it's fine, but if the business can only provide for one family then the older generation has to have retirement income. Someone starting a pension at age 25 to provide £25,000 of retirement income would need to save £681 each month, assuming a net 2% return after fees and inflation. How many businesses can afford this?

If we wait until retirement age and the next generation are already 40 will they want to, or have the drive to, take on the business, or will they have established a life elsewhere? Is this the fundamental reason that small farms cease at the end of the day? Does a business need to be big enough to support two families to allow the process to start at a younger age?

Being open and honest about these issues with the next generation is key, and probably best done at a much younger age than most people start to think about it. After all it's great having someone leave school at 16 and coming home to work, but if the farm only ever makes £10,000 per year what are we encouraging them to do? Why encourage them home with the 'beer and petrol money' approach to tell them when they are 25 that the farm can't afford to pay them anymore, at the age when they may be starting a family and have much greater cash requirements?

So, we have a successor!

So, you have someone in the family who has the skills to run the business, and the drive to take it on and own the decision making process. This is a big ask, particularly if the business has employees as their decisions now have implications for the employees lives!

The first issue is giving them some share of the trading business. You do not need to transfer property assets at this point but could. In most of the businesses I see these are not insubstantial, but they are often not where the equity is held.

We can often begin to give a large share of the trade, or even all of it, to another generation.

Let's think of a 350 acre, 300 cow dairy business – it might have a balance sheet as Table 1.

In most cases the older generation here could give all of the trade to the younger generation, yet still retain the equity in the farm to allow them a free hand in estate planning, and could, subject to the tax position, simply rent the farm to the next generation to provide for their retirement.

Does who owns the farm matter?

This is the tax bit!

As long as land, and property used for agriculture, has been owned for seven years and farmed by someone, (two years if farmed in hand), then 100% Agricultural Property Relief (APR) is available to exempt the full value of the assets from Inheritance Tax (IHT).

This relief makes planning for business where there is no 'non-agricultural value straightforward. The route suggested earlier of splitting the land from the trade, and even renting back to the business doesn't cause a problem.

If, however there is additional value, perhaps development potential, then any value over agricultural value will not be protected by APR. In this case it may be possible to rely on Business

Table 1

	Total	*Property*	*Trade*
Farm	£3,000,000	£3,000,000	
Cattle	£375,000		£375,000
Machinery	£250,000		£250,000
Assets	£3,625,000	£3,000,000	£625,000
Bank overdraft	£125,000		£125,000
Net assets	£3,500,000	£3,000,000	£500,000

Property Relief (BPR). BPR only has a two-year qualifying period but applies to an interest in a business. To get 100% BPR, agricultural property has to be owned by the business, i.e. owned by the company or partnership farming it! If this land is on the balance sheet then splitting ownership between the property and trade is more difficult.

It is possible to hold the land outside the trade, but you will lose the IHT relief, (50% relief is available if the asset is used in your business, but you must have greater than 50% control). If retaining property on the balance sheet in a partnership then this could be kept in separate property capital accounts, but you need a partnership agreement to specify this is what you are doing and that the property remains vested in the named partners property capital accounts.

Is this enough to guarantee a successful transition?

Giving ownership and control of the trade is the key to succession. Unfortunately for farming businesses the capital value tied up in owned property is substantial and dealing with this becomes the next headache.

The traditional 'One day this will all be yours approach' doesn't work as well anymore. Once the next generation have family of their own, they start to worry about protecting their own children. Having the trading business provides income, but is it stable enough for the long term, and will parents leave it to siblings meaning at some point the farm becomes unviable if family members have to be paid out?

Thinking about how property assets will be divided in future should be discussed at the same time as the succession plan, so that chosen successors don't have the rug pulled from under them in future.

Everyone has a different view of how to divide property assets. I have a few key points that need to be thought about:

1. If you want the business to succeed don't force it to pay out too much to those not in the business.
2. It is difficult to be equal – make sure what you do is fair.
3. Think about gifts to non business members early. What is the value of money when you die?

Can you protect everyone?

Whilst ownership of property remains vested in the older generation there is always a risk that they leave it to someone that makes the successor's life difficult. Many successors recognise this and push for some resolution. This is probably the single biggest issue in farming succession, although it has nothing to do with running the business.

The only way to guarantee the transfer of assets to particular beneficiaries is to make the gift either outright or via trust. I often think a settlor interested trust, where a farm can be settled into trust with income for the settlor, and capital for the successor makes sense. Again, these really only work whilst we have APR. Given the range of views expressed by different political parties in the recent election campaign it is possible there may be changes in future.

Could a gift either outright or via trust, at the age time as raising finance to pay out non farming siblings at an early age, be the best option? If someone is paying interest on a mortgage at 3% for 20 years then a gift on death of £500,000 is the equivalent of £277,000 twenty years earlier!

Summary

I hope that this has given people plenty to consider, and that business succession and estate planning are thought of much earlier. There are plenty of options but remember it is not really about tax!

The conversion to and production of a2 milk

Neale Sadler
Dairy Farmer, Bridge Farm, Edstaton, Shropshire

Introduction

We are a small family dairy farm in North Shropshire where I farm with my wife Claire, an Assistant Primary School Headteacher and my children William 13 and Rebecca 11. The business is run in partnership with my parents Richard and Janet who although retired still help out wherever possible.

The farm is 212 acres, 26 acres of which has been purchased in 2019 growing a variety of crops including grass, maize, lucerne, wheat, and oats. Most operations are carried out with the farms own machinery which includes a small contracting side to the business.

The dairy herd was reintroduced in 2006 following a three-year break, when a new setup including a Lely milking robot was installed. Herd size is currently 75 cows plus replacements but in 2020 we will be installing a second robot and the herd will double to around 140 cows.

The conversion to a2

The business had supplied the Muller dairy since 1993 and following the Muller acquisition of the Robert Wiseman operation all former Muller suppliers were offered the chance to supply a new joint venture with an Australian company called The a2 Milk Company. This involved genetically selecting cows within an existing dairy herd to produce a specialist milk that was suitable to digest by consumers claiming a dairy intolerance. The decision was taken to go with this opportunity.

The science

All cows originated in Africa and the milk produced by these cows contained only one group of beta casein protein variants. This is known as the A2 type.

Around 5,000 years ago cows started to migrate into Europe and within this group a protein mutation took place within the beta casein component to produce a beta-casomorphin known A1 Beta-casomorphin or BCM7.

It is this A1 group of proteins that many people (20% of Western population) are unable to digest. It also presents those who are intolerant with a range of undesirable symptoms including bloating, abdominal discomfort, nausea and constipation/diarrhoea.

Within bovine herds found in Europe, Australia and North America. It is typical that around one third only produce the A1 protein, one third produce the A2 protein and one third of cows will produce both A1 and A2 proteins.

By DNA testing animals it is possible to isolate only those cows which produce exclusively the A2 Beta casein protein.

The majority of those people who report the symptoms of dairy intolerance including Lactose intolerance are able to consume the milk from A2 cows without any symptoms. For people with a true Cows Milk Protein (CMP) allergy unfortunately A2 milk is still not suitable.

By DNA testing breeding bulls as well as cows it is possible to produce calves destined for the dairy herd which are guaranteed to be A2:A2 type.

The herd at Bridge Farm

Following the decision to convert the herd at home to 100% A2 milk, all cows and dairy replacements were DNA tested by taking a small tissue sample from the ear. The results from this test showed that 44% of the dairy cows were of the A2:A2 type and around 35% of replacement heifers were A2:A2 type. This was above average but only as a result of unknowingly selecting more A2:A2 bulls over previous years, purely by chance.

All dairy cows of the A1:A1 and A1:A2, variant type were then sold. As many animals that could be found, including a group of tested Dutch heifers were purchased to replace the herd. Unfortunately, due to low milk prices and having to sell off heifers that were not A2:A2 the recovery of herd numbers back to pre-conversion levels took longer than expected and was only completed during 2018.

Sales of a2 milk

Marketing of a2 milk has been challenging since 2012 mainly due to the dominance and competitive nature of the supermarket industry in the UK, this combined with a generally low retail price for milk throughout the period has made gaining a real foothold on the UK market difficult. Sales of the product however have steadily increased throughout the period as awareness of the product has grown with the consumer mainly through online education and targeting of medical and health care professionals. Over the last few years the product has been launched in liquid form in the USA and as an infant formula powder in China. Both of these markets have seen significant growth particularly China which has seen unprecedented demand.

With the Chinese market forming the vast majority of the company's turnover it was decided in the summer of 2019 to withdraw from the small UK market to concentrate all efforts on China. The last milk to be processed in the UK was collected on the 31st October 2019.

The future

All the remaining a2 milk producers reverted back to their Standard Muller contract on the 1st of November 2019.

From a personal point of view, I have made a big investment in my herd of cows and so have made the decision to continue breeding using a1 free genetics. All of the intellectual property regarding the DNA tests belong to The a2 Milk Company and so I will have to DNA test all herd replacements in the future and probably retest the existing herd.

I have also made the decision to start retailing milk from the farm. This milk will be sold as conventional milk but with the added benefit of being free from the A1 protein.

Contractual obligations mean that it can be described as containing A2 protein but not called “a2 milk”, other farms usually use the term “A1 free”.

While the milk retailing side of the business will start inevitably small and will probably not be the most time efficient part of the business hopefully it will replace some of the lost premium from the a2 sales. I also feel I will be helping many people who have come to rely on a product that can be truly life changing, not all rewards have to be financial!

I would like to thank Laurence Loxam for the invitation to the British Cattle Breeders Conference and for the opportunity to talk about my business, I hope that it has been of interest.