

British Cattle Conference

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“The Herd of the Future”

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British Cattle Conference

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The British Cattle Breeders Club

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Message from the Chair

‘The Herd of the Future’



Looking back to our roots, the British Cattle Breeders Club was founded by the late Sir John Hammond in 1946. Its aim then, as now, was to provide a forum for exchange between scientists and breeders of beef and dairy cattle. This was superbly brought to life by the contribution from this year's presenters at our annual conference held in Telford. The importance of cattle breeding and farming to ensure food security whilst treading ever more lightly in the environment, posed the question: what is required from the herd of the future?

The scene was set by Professor Nigel Scollan from Queens University Belfast outlining the task ahead of us, with farmers needing to feed the ever-increasing world population, against the backdrop of geopolitical instability and environmental concern. 'Food production must step up with substantial increases in output and not just incremental increases for food and nutrition security'.

Delegates highlighted the key needs for efficiency, sustainability and profitability in producing cattle with a lower carbon footprint. During the

conferences two and a half days, both beef and dairy sectors were examined in detail with regard to how well equipped we are to meet the challenges of producing more from less.

There were some inspiring papers showing on-farm practices and systems from diverse locations stretching from the Shetland Isles, Central Scotland through to Somerset where the key genetic and breed traits were harnessed in farm efficient systems.

A common thread was to look at the need to safeguard the diversity of our genes. In doing this we have the opportunity to consider the future gene pool traits that may be needed as tools for our livestock in the future production systems, such as breeding for increased feed efficiency and disease resistance.

We were also reminded of the global nature of commercial genetic supply and the possible dangers of narrowing this offering too much, both in terms of potential inbreeding and reducing the breeding farms opportunities to provide the bulls of the future through onerous contractual obligations. It was encouraging to hear from Professor Mike Coffey that geneticists have more potential for breeding for efficiency, but he states, 'the whole supply chain must share the benefits of this work'.

Other key elements of this future thinking looked at cattle health monitoring with technology, including the role of artificial intelligence to enable early detection of disease challenge through cattle behavioural changes.

The conference final session ended on a high with presentations on the needs to rear our future heifers better, understand our future staff better and most importantly select our herd in a way that it is most suited to the farm and farming system we manage.

I would like to finish by thanking the club and the committee for the opportunity to Chair during this last 12 months. It has been a great honour to be a part of the team that delivers this now renowned conference event. I would like to wish next year's Chair, Dr Alex Brown and Vice Chair, Matt Gue all the very best and know the early seeds have already been sown for next year's conference theme: ***Joining the Dots: From Blue Skies to Green Fields***

Andy King
BCBC Chair 2024/2025

The British Cattle Breeders Club

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Food security, animal sourced foods and One Health

L.S. Perkins and N.D. Scollan

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Introduction

The challenges surrounding food security are heavily influenced by population trends. The global population is projected to reach nearly 10 billion by 2050 before plateauing at 10.4 billion (United Nations, 2025). This places unprecedented strain on food production systems and the environment. Within this evolving context, animal sourced foods (ASF) present both opportunities and challenges, by providing essential nutrients while presenting animal welfare and environmental concerns. The One Health approach recognises the interconnection between human, animal, and environmental health and provides a vital framework for building resilient food systems that can meet the needs of today while preparing for a food secure future. This brief paper explores the grand challenges at the intersection of food security, One Health, and ASF, identifying key priorities for policy, industry, academia and innovation in an era of shifting demographic and ecological realities.

Food Security

Food security, the challenge of providing the world's growing population with access to safe, affordable and nutritious food at all times and in ways our planet can sustain against backdrop of climate change and biodiversity loss, continues to be a major challenge for society (Barrett, 2021). Food security is a complex, multi-dimensional issue that extends from global food availability to household-level access.

It is estimated that food production needs to increase by 60–110% to meet growing population and planetary needs (FAO, 2009; Tilman, 2011; Alexandratos and Bruinsma, 2012; van Dijk et al, 2021). This expansion is challenged primarily by the nutritional demands of the growing population but also by limited arable land, biodiversity loss, and increasing climate related disruptions such as droughts, floods, and shifting weather patterns. The resilience and sustainability of the food system can be separated into six key themes.

The six main themes of food security each contribute to how food is produced, distributed and accessed (DEFRA, 2024a; Figure 1). Global food availability is reliant on the balance between supply and demand including distribution, sustainability

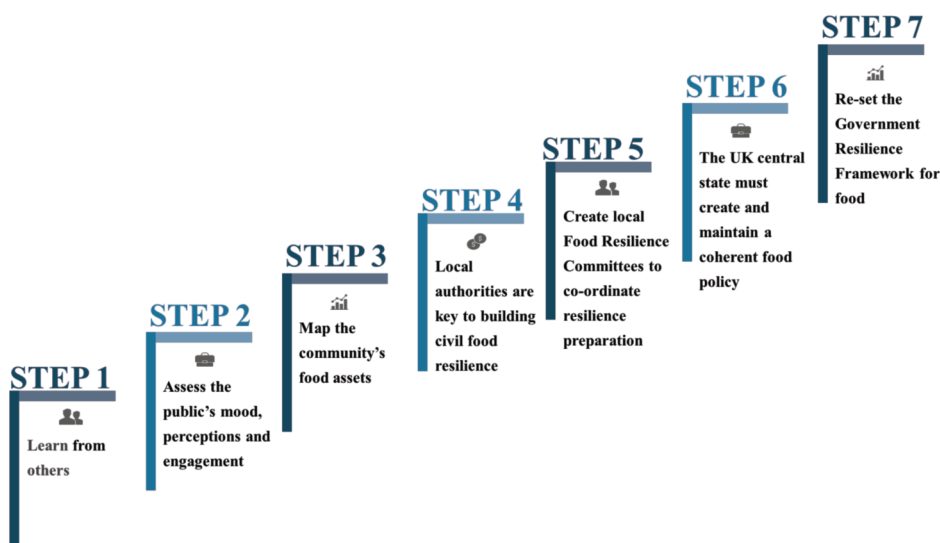
and dietary value of food. The resilience of the food supply chain relies on physical and human infrastructure, a skilled workforce, and stable economic conditions, all of which determine how effectively the UK can respond to global challenges and supply interruptions. At the household level, food security is shaped by the ability of individuals and families to access sufficient, healthy, and affordable food. The sources of the UK's domestic and imported food supply play a crucial role in determining the country's vulnerability to external pressures. Public trust in food safety and authenticity is essential and supported by rigorous monitoring systems and transparent communication. Finally, agency and sustainability reflect the capacity of individuals to make informed, culturally appropriate food choices within an environmentally responsible system. Together, these interconnected areas form the foundation for a robust, future-facing food system.

A main report to the National Preparedness Commission (Lang et al, 2025) outlines seven strategic steps to civil food resilience to enhance the UK's preparedness for food-related crises (see Figure 2 on page 6). These steps focus on addressing the fragility of the current food system, which is heavily reliant on global supply chains, and transitioning from a "just-in-time" approach to a more robust "just-in-case" model. This shift aims to build a food system that is more adaptive and resilient in the face of disruptions such as climate change, economic

Figure 1: UK Food Security in Society 2024 (DEFRA, 2024a).



Figure 2: The seven steps to civil food resilience (Lang et al, 2025).



uncertainty, and geopolitical instability. The goal is to create a sustainable, responsive food system that ensures long-term food security and the ability to withstand future challenges.

Self-sufficiency in the UK

While food security is underpinned by access, availability, and nutritional quality, the concept of food self-sufficiency identifies nation's capacity to meet its own food needs through domestic production. In the UK, food self-sufficiency has seen a decrease from ~75% in 1990 to ~60% in 2025 (DEFRA, 2024b). The remaining 40% is fulfilled through imports from the EU but also from global markets (UK Food Security Index, 2024). In recent years, international trade has remained relatively stable, however geopolitical events such as Ukrainian Russian war and more recently evolving trade dynamics and policy shifts with countries such as the USA has presented uncertainty. In addition, extreme weather events have questioned the sustainability of both domestic and imported sources. Climate change, declining natural capital, and environmental pressures continue to affect food production capacity. These challenges are compounded by labour and skills shortages, particularly in agriculture and food processing, which threaten the continuity and efficiency of the supply chain.

At the same time, the UK has experienced major supply disruptions, a sharp rise in input costs, and the highest food inflation in ~45 years, all of which have contributed to growing levels of household food insecurity (Das, 2023). Many people are finding it more difficult to consistently have access to healthy, affordable food, further highlighting the need for a more resilient and equitable food system. Alongside these economic and logistical challenges, there remains a national imperative to improve the nutritional quality and food safety. Strengthening food system resilience will need to address promoting sustainable domestic production, addressing labour gaps, investing in infrastructure, and embedding climate adaptation into future planning.

The challenges to the UK's food self-sufficiency and security include declining domestic production and rising import dependency to climate change impacts, supply chain disruptions, and escalating food prices. These challenges have been highlighted in the "Food, Diet and Health Committee's report, Recipe for Health: A Plan to Fix Our Broken Food System", which discusses comprehensive and integrated food strategy to address current system failures (House of Lords, 2023). The importance of tackling issues such as food insecurity, public health, sustainability, and economic

efficiency are discussed. The UK needs to build a food system that is resilient and produces healthy, more sustainable and equitable food by working with sectors such as agriculture, public health and policy.

ASF and Global Protein Demand

ASF play an important role in the human diet helping to promote optimal health and wellbeing (Beal et al, 2023). Products such as meat, dairy, eggs and fish contain a diverse matrix of bioavailable macro- and micronutrients including iron, zinc, B complex vitamins and omega-3 polyunsaturated fatty acids (Beal et al, 2023). These nutrients play a pivotal role in bone and muscle growth, repair and maintenance, brain development and immune response (Mann, 2018). Without careful planning, human diets devoid of ASF can result in sub-optimal or deficient levels nutrients which can result in a negative impact on human health and well-being.

Micronutrient deficiencies remain a global challenge, particularly in iron, vitamin A and zinc (Passarelli et al., 2024). The blood status of other nutrients such as omega-3 and vitamin D are reported to be sub-optimal. Iron deficiency is associated with anaemia, while vitamin A and zinc deficiency is associated with poor eye health and impaired immune function, respectively (Iolascon et al, 2024; Marley et al, 2021). Micro-nutrient deficiency from ASF is impacted by socioeconomic status, geographic location, and cultural barriers and exacerbated by economic barriers, limited access to diverse foods, and poor food distribution systems. Given the complex challenges surrounding food security, micronutrient efficiency, and sustainable protein production, the agriculture and livestock industry must adapt and address these concerns through innovation, research and collaboration. This includes improving production efficiency, reducing waste, and adopting sustainable farming practices to meet the nutritional needs of a growing global population while reducing environmental impact.

Meat is a valuable source of high

biological value protein which is essential for growth, maintenance and repair of body tissues, muscle and bone health. Requirements vary across life stages, but adequate levels are particularly recognised in infants and the elderly (Lee et al, 2021). As meat consumption increases, the prevalence of stunted growth in children decreases (Adesogan et al, 2020). Due to increasing global population, urbanisation and change in dietary trends, global protein demand is predicted to rise (Duluins and Baret, 2024). In recent years in western nations, dietary trends have shifted towards increasing protein consumption, due to health and exercise regimes, but also on a more general level. The movement from animal protein intake to plant-based products is recognised and known as protein transition (Duluins and Baret, 2024). Increases in numbers of people adopting vegetarian and vegan diets have resulted in a larger scale of alternative proteins including plant-based and synthetic based. These alternatives can contribute to meeting the rising demand, however the socioeconomic cost and accessibility of these products and nutrient bioavailability when consumed are still being investigated.

Figure 3: Estimated stunting rate relative to meat consumption across different countries (Adesogan et al, 2020).

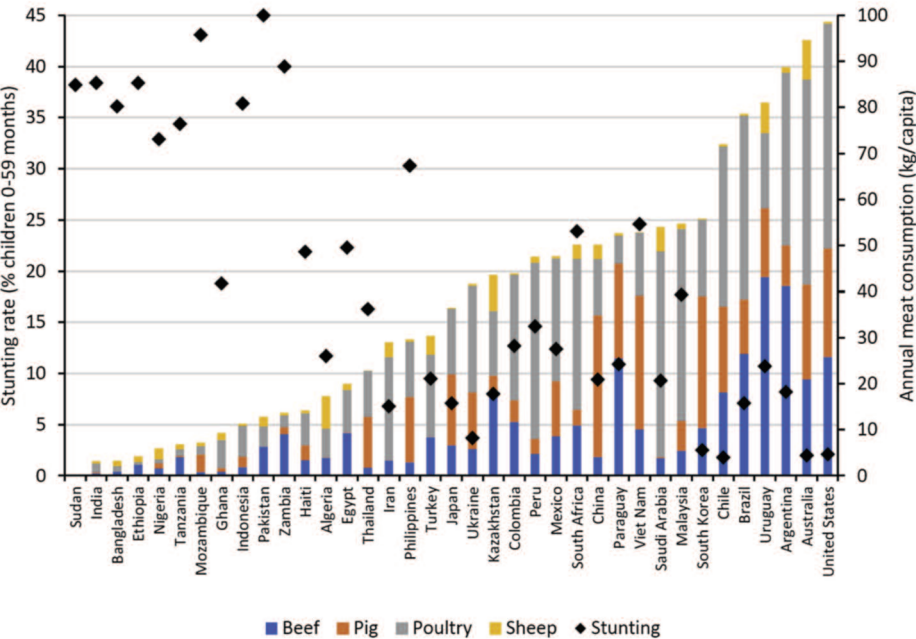


Figure 4: One Health principles (adapted from ISGlobal, 2025).



One Health

The intricate connection between animals, humans and the wider planetary environment is known as One Health (Zinsstag et al., 2024). The One Health approach is receiving increased political attention

as a solution to some of the greatest global health threats including increasing zoonotic disease emergence (e.g., Bovine TB, Avian Influenza H5N1 and swine flu), antimicrobial resistance (AMR), food safety and security (Figure 4). These pillars of One Health directly impact Global Food Security and safety by threatening productivity of livestock, reducing biodiversity, and compromising human health, while increasing the risk of disease transmission through the food chain. The inextricable links between Global Food Security and One Health are evident and need for enhanced and accelerated innovation, investment and partnership are required. Intensive farming and global trade increase the risk of disease, while livestock losses, trade restrictions, and declining public confidence in food safety. Integrating One Health into food system planning is complex but also supports prevention, resilience, and long-term food security.

Rapid Innovation, Investment and Partnership

To overcome the challenges in ensuring a food secure planet while

addressing One Health concerns is a multifaceted task. Previous trajectories for food security are not sufficient to satisfy the complex food needs of the global population. In January 2025, over 150 Nobel and World Food Prize laureates signed an open letter urging world leaders to invest in new innovations driven by scientific data and supported by strategic collaboration to ensure global food security for the future (World Food Prize Foundation, 2025). This will aide food and nutrition security while addressing concerns surrounding health livelihoods and economic development. Collaboration between governments, research and industry will be key to building resilient food systems that not only ensure access to safe and nutritious food but also promotes public health, increases biodiversity, and benefits economic development. The production of high quality ASF which follow One Health principles, coupled with innovation, investment, strategic partnership will contribute significantly to the future of a robust, resilient, adaptable, equitable and healthier Global Food System for humans, animals and the planet.

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The UK national livestock biobank: for farming and food security

Tullis Matson (Co-Founder, UK National Livestock Biobank)

Abstract produced by Lydia Keeping (BSc Hons)¹
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(Co-Founder and Biobank Lead)

(¹Equal contribution from both authors)

Introduction

75% of the world's food comes from just twelve plants and five animal species (United Nations, 2019). Globally, 26% of livestock breeds are at risk of extinction (FAO, 2019), with figures rising to 80% for native breeds within countries including the UK (DEFRA, 2019). This alarming risk of extinction, of animals vital to the human food chain, is the result of factors including farming intensification, increasing monoculture, decoupling of livestock production, inbreeding and use of fewer but higher performing breeds in selective breeding programs (FAO, 2019). Rising inbreeding within commercial breeds has been associated with reduced long-term production efficiency and fertility (Wiggans et al, 2016), while loss of native breeds is considered a significant risk for future adaptability and reliance of the livestock sector (DEFRA 2021). Within this paper and accompanying presentation, regenerative cryo-genetic biobanking is proposed as a vital action to preserve and protect our livestock sector for future generations.

What is a Biobank?

A biobank is a collection of biological and genetic material (see Figure 1). The UK National Livestock Biobank (UKNLB) is a farm animal biobank

Figure 1: Biobanking – a collection of preserved biological and genetic material.



established to ensure national livestock preservation and long-term food security. The biobank is based on gamete preservation (sperm, egg and embryo), alongside collection and cryopreservation of skin samples for fibroblast cell line generation (UKNLB, 2024). The collection of skin samples alongside gametes is unique within the UK farming cryopreservation sector, and has numerous applications and opportunities, including preservation of the whole genetic profile of farm species and the regenerative genetic capture of female lines (UKNLB, 2024). Biobanking permits the indefinite storage of genetics beyond the lifespan of the original animal, ensuring the availability of resources for future applications (ERFP, 2023).

Why is the UKNLB Needed?

Gene banks have been recognised as important by the United Nations (UN) in the 2030 agenda, more specifically 'Sustainable Development Goal 2' (Zero Hunger). This indicator shows only 152 local breeds and 61 transboundary breeds in Europe have sufficient material to allow breed reconstruction in the case of extinction. This represents less than 1% of EU breeds (FAO, 2019).

The preservation of livestock genetic and reproductive resources for future use is vital to adaptability of this sector to future challenges. The farming sector has many known and unknown challenges for the future, including climate change, heightened disease risk, reduced farming numbers, reduced land availability, increased production pressure for a growing global human population and changes to trade and consumer preferences (FAO, 2019; DEFRA, 2021).

In the case of climate change alone, there is a significant risk of insufficient time to adapt to a more challenging global environment using current production systems (UKFSR, 2021). Capitalising on positive natural mutations in certain breeds could aid in developing 'future proof' livestock. Subpopulations of cattle, for example Hereford, have been found to have

significant differences in allele frequencies for single nucleotide polymorphisms (SNPs) associated with the breed's ability to deal with environmental stressors (Blackburn et al, 2017). Bos taurus cattle are commonly used in tropical climates due to increased heat tolerance derived from a 'slick hair gene' and improved metabolic rate. This gene has been successfully transplanted into Holstien cattle to improve their thermoregulatory ability (Dikmen et al, 2014). These variations in sub-populations offer a valuable range of genetics that could prove vital to future adaptability to environmental conditions.

Several diseases already pose a significant threat to UK farming, with climate change only serving to increase these threats (UKFSR, 2021). The impact of these diseases can be far-reaching, affecting not only individual farmers but also the wider agricultural industry and consumers. These impacts include economic losses, reduced food production, animal welfare concerns and environmental costs from chemicals and other means that may be needed to control disease outbreaks (Whatford et al., 2022). A biobank of livestock samples may not only allow for animal restoration after significant disease outbreak, but it may also allow for the discovery of genetic traits that confer resilience to disease threats and so future adaptability to diseases challenge.

As summarised by Koyun et al., 2016, a food system that has higher agrobiodiversity provides more variety and therefore resilience against climate change, and other challenges to the sector, including heightened disease risk. To provide opportunities for diversity in the future, biobanking is of paramount importance (Bolton et al., 2022). To secure what is available to the sector today, to allow for use and adaptability for the future known (Revive & Restore 2024).

Looking ahead into future technologies such as gene editing, it is also becoming increasing apparent that a repository representing

unedited animals from an original population will be required (BSAS, 2024). Gene banks may be needed to 'un-edit' populations after CRISPR-Cas9 generated gene editing. This was a major point identified at the recent BSAS Gene Editing Farm Animals: The Facts conference 2024.

Existing Agricultural Biobanks

Seed repositories, such as the Millenium Seed Bank and Svalbard Global Seed Vault, are well established and provide crop production security (Kew Gardens, 2024; Svalbard, 2024). Unlike the crop sector, designated biobanks for livestock species indefinite genetic protection do not exist. Most livestock genetic resources are held as living populations, preserved semen samples and frozen embryos, for short to medium term use in production breeding programmes. Repositories specifically for future conservation, adaptability and resilience of the breeds and species are not present. The UKNLB is therefore the first of its kind, to promote preservation of gametes, alongside skin samples, specifically to provide future reproductive and genetic resources to ensure long term livestock breed security.

A pro-active group, outside the UK, to recognise the need for and

potential of farm animal biobanking is NordGen. The Nordic Genetic Resource Centre recognises the unique but highly threatened assemblage of local and regional transboundary farm animal breeds and subspecies, that its member countries represent. In response, NordGen has been actively working alongside the UKNLB since 2022, to produce a co-written white paper that will be submitted in 2025 to appeal for government funding to establish a Nordic Farm Animal Biobank (White et al., in progress).

What samples are banked and their uses

The UKNLB is based on skin and gamete cryopreservation. Skin can be taken whilst ear tagging or specifically for biobanking purposes upon veterinary discretion.

In the laboratory, the skin sample is sterilised and cryogenically preserved in liquid nitrogen (a similar procedure to freezing semen). Samples can be thawed out and cultured to produce viable cells lines that can be used for further breeding technologies such as induced pluripotent stem cell technologies (IPSCs) (see Figure 2 below) and somatic cell nuclear transfer (see Figure 3 on page 11) (Cowl et al, 2024). Benefits of cultured cell lines include the provision of an infinite

Figure 2: IPSCs for gamete production (UK National Livestock Biobank, 2024).

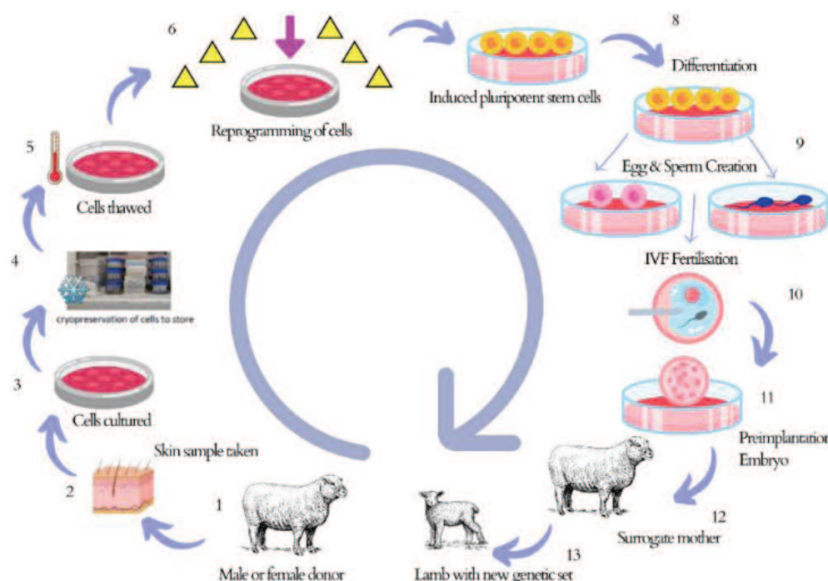
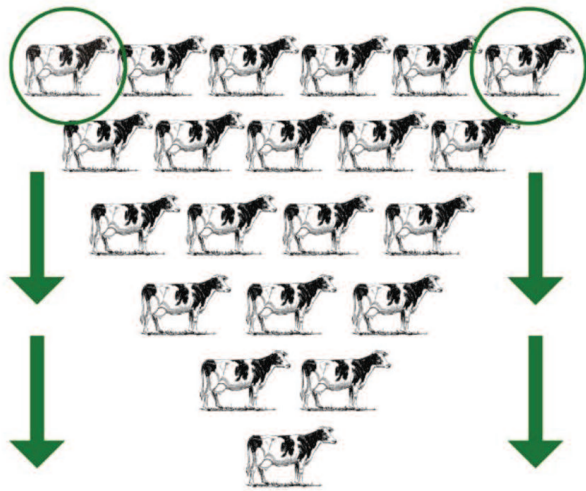


Figure 3: Genetic replication from skin samples following animal loss or genetic bottleneck (UK National Livestock Biobank, 2024).



resource (versus the finite resource of gametes), preservation of the whole genetic profile of the donor animal (versus 50% DNA capture via sperm and egg), and preservation of female lines and neutered animals.

Gamete preservation must continue alongside the skin sample banking, providing for reproductive resources that can be readily used in both short- and long-term production systems (DEFRA 2021). With regards to animals selected for biobanking, of both skin and gametes, it is important that maximum production output is not the only deciding factor.

Characteristics considered suitable for the diversity of UK production systems and national adaptability to future conditions must be included in the biobanking animal selection strategy. This differs to current gamete banks for livestock, where maximum production output and efficiency, sometimes in environments different to those on farm, commonly predominates in animal selection, due to the immediate commercial pressures on the sector. The biobank, by contract, allows genetics to be captured for future use, with adaptability, resilience and sustainability suggested as vital

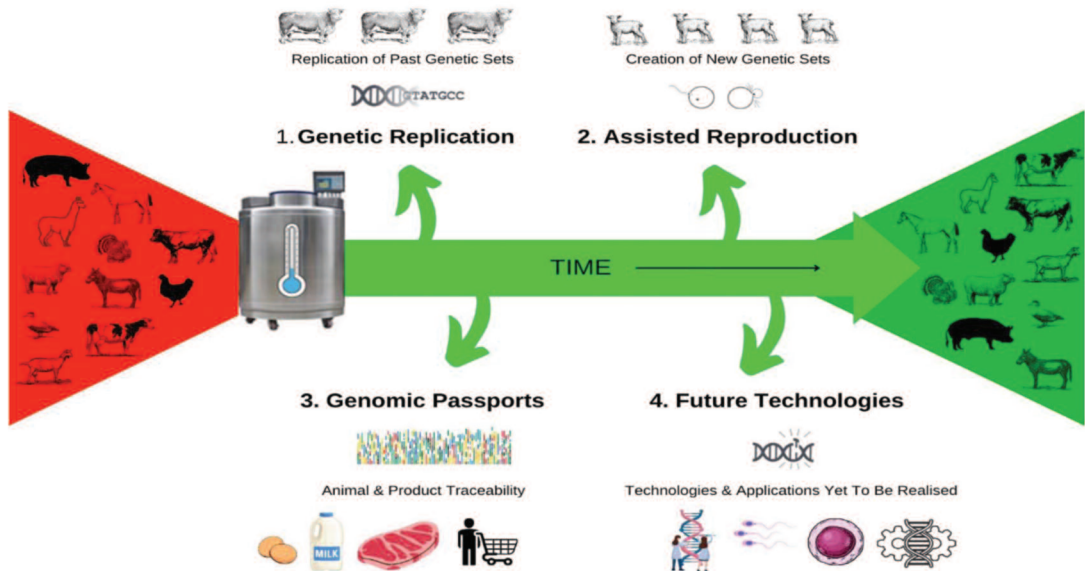
animal selection criteria, alongside production output and efficiency.

Further Applications of Biobanked Genetic Material

In addition to animal regeneration via skin and gametes, the genetic material captured whilst biobanking could also be utilised for genomic passports. This will aid animal and animal product traceability which may be a future requirement for the food production sector. Some larger food companies are already using animal genetic data to confirm animal identification (Tripoli and Schmidhuber, 2020). Samples that are submitted to the UKNLB could also be used for DNA profiling and genomic passports.

There are also reasons that we are yet to know or understand, where a livestock biobank will aid in overall UK food security. There is a large gap between the usage of state-of-the-art technology available to the livestock sector and applying these to local breeds (Bruford et al, 2015). This reduces the amount of genomic data available to determine genetic diversity or erosion within sub-populations. Therefore, it is paramount that as many samples as possible from as wide a range of species are taken and stored now. By increasing knowledge and information gained on livestock gene

Figure 4: Banking of genetic and reproductive material for future technologies and applications (UK National Livestock Biobank, 2024, adapted from Revive & Restore, 2024).



pools, this improves the adaptability of livestock species to overcome further global issues of population growth, consumer and farmer income and climate change (see Figure 4 on page 11).

Lessons from wild animals

A sector to increasingly recognise the need for biobanking, is the wild and endangered species community. A pioneer in this area is San Diego Frozen Zoo, who started to preserve skin samples and semen from captive-wild animals as far back as 1975 (San Diego Zoo, 2023). These samples, that were banked without knowledge of what future needs and resources would be, are now being actively used to restore threatened species genetic diversity, including the Przewalski horse and Black Footed Ferret (Cowl et al., 2023). The UKNLB is also a sister establishment to a leading conservation charity, Nature's SAFE, which provides a comparable living biobank model for wild and endangered species in the UK (Nature's SAFE, 2024).

Current Barriers and Recommendations

Whilst the need for biobanking in the livestock sector is clear, and will likely become increasingly so, the implementation of biobanking is not without barriers that will require navigation, on the individual, regional, national and international level.

By far and large, funding is perhaps the biggest barrier for national livestock biobanking (ERFP, 2023). The costs of setting up biobanking facilities, training staff and funding are significant obstacles identified by the FAO on a global scale.

Where facilities already exist, as in the case of the UKNLB, the ongoing costs of sample submission and processing, sample storage, upscaling of facilities to meet demand, facility requirements for future resource utilisation etc. are further hurdles.

From engagement with farming stakeholders, it is unlikely that the

farming community itself will be able to cover the cost of biobanking samples as a complete biobanking model. An issue over sample ownership may also arise if banked samples are farmer owned. The bio banked samples are predominately collected for future use, to ensure national food security. If ownership is via independent farmers, this may restrict future use, where the original owner may have passed away, for example, and relatives do not wish to take over responsibility for the samples and their use.

An alternative to this situation would be government funded biobanking, as is already in place for national seed repositories. This would allow overall costs to be more realistically met and reduce the potential for ownership issues and actual utilisation of the samples upon breed/species/ national need.

As present for seed banks, a private arm to the biobank could still exist, to enable individual farmers to utilise resources offered where they have funding for their own animal genetic conservation and advanced breeding tools. Native breed societies could also use the biobank for their own breed security for the future, alongside feeding into the national biobank for likely benefits of their breeds to long term food security.

Livestock producers must remember that a genetic bank is only as good as the material being stored. Therefore, farmers must ensure good genetic health of the current population via responsible breeding practices alongside preserving DNA for future use. The biobank is not an 'either/or' technology, but one that must be used synergistically. It should be considered how current populations are bred, maintained and used. For certain breeds and species, optimum mate selection tools in terms of genetic diversity are available, to assist in mate selection within the living population (Dell, et al., 2021).

An open and active dialogue with livestock gene banks that are already established in Europe and further

across the world would be beneficial to share best practices, protocols and eventually genetic data. This would aid good quality control practices and management efficiency from the first instance (Zomerdijk et al, 2020). The UKNLB has already established a working relationship with NordGen biobanking task force, as previously described.

Conclusions

In the event of a national level climate or disease challenge, gene banks may be summoned to reconstitute affected livestock populations on a large scale. For this reason, it is paramount that producers and governing bodies recognise the need for livestock biobanking, with the UKNLB already proactively working and campaigning for assistance in this area. While the funding and operational mechanisms of livestock biobanking on a national scale are yet to be determined, an open mindedness to new breeding technologies offered through gene banking will improve genetic diversity and resilience in our livestock breeds both in the present and the future.

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Return of the native: how cattle breeds from the past may hold the key to the future

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The UK is a nation of livestock breeders – we have more breeds than any other country in the world. However, over the last 100 years, the fortunes of our native breeds have fluctuated in response to government policy, changing markets for livestock products, and farming fashions. Today, 20 of the 26 native UK beef breeds are classed as “at risk” by Defra. In this paper, I outline how, and why, some British breeds have seen a dramatic revival over the last few decades and describe how small populations of pedigree breeds can recover using the right tools.

There are now over 160 native livestock breeds in the UK, down from more than 180 native breeds in the early 1900s, but the concept of a “breed” was only really developed with the work of Robert Bakewell in the 1760s. When he developed the English Longhorn, Bakewell was the first person to focus effort on selectively breeding for meat – before then, cattle of distinct regional types were kept predominantly for milk, or draught purposes, and eaten only when the animal was of no further use. With the growing population in the 18th century, and a growing demand for meat in people’s diets, Bakewell saw the opportunities in breeding selectively for beef production, mating closely related animals together to fix the characteristics he wanted. Breeds, as we think of them today, were therefore created by selective inbreeding.

Before Bakewell got to work, the huge climatic and geological variation

within the British Isles had already produced a great range of regional types of cattle – small, hardy double-coated animals to withstand the wet and windy conditions of the north west, fine-coated red cattle to tolerate the hot summers of the south, and large, rangy beasts in the east of Britain to provide draught power and cope with the bitterly cold winters. Bakewell’s principles of improvement by selective breeding led to the defining of distinct local breeds with shared characteristics, and breed societies sprung up to record and support them.

So, could we just do as Bakewell did, and recreate breeds at will, meaning that their preservation is unnecessary? Although a handful of modern composite breeds, such as the Luing and the Stabiliser, have been developed from existing breeds, and therefore could arguably be recreated relatively easily, many of our native breeds derive from long-extinct ancestors with regional specialities and unique genetic characteristics. The genetics they hold therefore represent a diverse and resilient range of traits which may prove essential to deal with future environmental or disease challenges.

Crucially, most of these breeds were developed before the advent of artificial fertilizers, chemical wormers and readily accessible veterinary skills. The animals therefore needed to thrive on a predominantly forage-based diet, be naturally resistant to parasites, and be fertile, easy-calving and docile. Dual-purpose breeds were popular, providing a decent beef calf

and plentiful milk with good constituents, since most milk was transported in the form of butter and cheese, not as liquid milk.

But by the 1950s, government policy and the availability of cheap feed and fertilizer was incentivising production at all costs – to remain profitable, farmers were forced to move away from mixed farming. They were encouraged to switch to continental beef breeds that finished quickly on grain-based feed and high-yielding dairy cows that maximised volume over longevity and milk constituents. These breeds replaced native breeds or were crossed with them – and hybrid vigour and improved yields lead to the slower-growing breeds falling out of favour. Some, like the Longhorn, were reduced to double figures after the war, with only around 50 registered animals in existence.

Fast forward 70 years, and we are farming in an era of high input costs and reduced support payments, where many beef and sheep farms operate at a loss. Farmers are once again looking for breeds which will thrive in a low-input system, that will finish on grass, and that will make use of the huge tracts of land that are unsuitable for growing other foodstuffs owing to rainfall, soil type or topography.

Appropriate land use is crucial to sustaining food security in the UK. Research by the Sustainable Food Trust (*“Feeding Britain from the Ground Up Report”*, The Sustainable Food Trust, 2022 <https://sustainablefoodtrust.org/our->

work/feeding-britain/) modelled the availability of different foodstuffs from UK production alone, showing that by growing the right things in the right places, the UK could feed itself without imports. This would require some significant dietary shifts – pork and chicken, reliant on grain and protein-based feeds that are edible by humans, would reduce enormously, and beef and lamb, consuming non human-edible grass and forage, would become the primary meat source.

Beef calves from dairy cows, with all the efficiency that comes from the cow producing milk for human consumption as well as producing a calf, are already becoming more important, meaning that a more moderate dairy cow with dual-purpose traits can be an advantage. On marginal land where dairying is more challenging, hardy native hill breeds of cattle and sheep are the best option for converting rough vegetation into nutritional food for people.

We are already seeing this playing out in increasing demand for native breeds, with farmers taking advantage of generous incentive payments in the new Environmental Land Management (ELM) schemes

to support the rarer breeds. The Longhorn, reduced to 50 animals in the 1950s, is now estimated to boast over 4,000 breeding females, and its historical successor the Shorthorn has increased from fewer than 600 breeding females in 2002, to over 13,000 today – making it one of a handful of native breeds not considered by Defra to be rare. Both breeds have demonstrated key commercial qualities and been supported to market their products widely and effectively by large retailers.

Selective breeding for fertile, low-maintenance cows, with good conformation and a docile temperament is key, but this must be accompanied by great advertising. Without telling the story of a breed, backed up with data and figures to show profitability, they will remain a novelty to many. The challenge for many native breed societies is to support their members to tell their stories, shout about their successes, cull hard, and share the impact on their bottom line.

Many of our dual-purpose breeds, even selectively bred towards their beef traits, will retain a level of milkiness and easy-calving that makes them ideal for modern

systems. These cows, overlooked in the modern specialisation to beef or milk, produce calves that grow quickly into beef animals with desirable conformation. They also tend to show a ready marbling from forage that is the envy of most beef breeds, making them ideal for specialist markets.

The diversity of our native breeds may be seen as a disadvantage to some, but with diversity comes opportunity and resilience. Several native breeds are naturally polled, a dominant trait that will be passed on to first-cross offspring. Many are smaller than continental breeds, but bigger is definitely not always better: nowadays a moderate carcass size isn't just desirable on the hook – an increasing interest in outwintering, often utilising bale-grazing and deferred grazing, means that a medium-sized breed, less likely to poach the ground, is the perfect solution to reduce wintering costs and address the challenges of more extreme weather conditions.

In the right system, all native breeds can be profitable, sustainable and pleasurable to keep – bred to thrive without inputs, their future lies in their diverse genetics, and in the hands of those who choose to champion them.



Vaynol Bull



Shetland Cow

Copyright: Ruth Dalton

Back from the brink: Vaynol cattle

Very few breeds are in as perilous a state as the Longhorn once was, but in 2010 our rarest native breed, the Vaynol, was reduced to only a handful of breeding cows in a single location. There are now 6 herds, and over 30 breeding females, thanks to a breeder-led initiative.

The conservation effort has comprised:

- Conservation breeding, using semen collected in the 1990s to breed a range of bulls that were relatively unrelated to the modern population.
- Use of the “SPARKS” mating tool (Dell et al, 2021): originally developed for the critically endangered Cleveland Bay horse, and now increasingly utilised by livestock breeds with small populations, SPARKS identifies the animals with the rarest genes in the living population, allowing them to be selectively bred with unrelated animals which have a similar level of genetic rarity. This increases the proportion of the rarest genes circulating in the breed, conserving vital genetic diversity and reducing inbreeding depression.
- A small and carefully controlled grading programme, now closed, which used White Parks, a related breed already present in the pedigrees of all living Vaynols, crossed back to Vaynol bulls.
- Increased numbers of herds, geographically dispersed, to safeguard against disease outbreak.

The results of this breeder-led initiative have been a 75% increase in estimated breeding females in the last 5 years – from 20 in 2020 to 35 in 2024 – the largest percentage increase of any UK cattle breed.

Dell, A., Curry, M., Hunter, E., Dalton, R., Yarnell, K., Starbuck, G. & Wilson, P.B. (2021). 16 Years of breed management brings substantial improvement in population genetics of the endangered Cleveland Bay Horse. *Ecology and Evolution*, 11, 14555–14572. <https://doi.org/10.1002/ece3.8118>

Feed into beef – a new applied feeding system for beef cattle

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Background

During recent decades, beef production in the UK has been improved significantly, with increased growth rates and carcass quality. These improvements, together with associated changes in feeding management, merited a review and evaluation of the beef feed rationing system recommended by Agricultural and Food Research Council (AFRC, 1993) for use in the UK for rationing beef cattle. Indeed, in a Defra-funded project (Feed into Beef and Sheep) over 15 years ago, a review of the available scientific literature indicated that rationing beef cattle using AFRC (1993) could underestimate their energy and protein requirements (Cottrill et al., 2009). Subsequently, new evidence showed that AFRC (1993) underpredicted metabolizable energy (ME) requirement for maintenance (ME_m) by over 20% for Holstein heifers and steers (Jiao et al., 2015) and suckler cows (Zou et al., 2016). Therefore, the present Feed into Beef (FiB) project aimed to review the impact of the above-mentioned changes and to develop updated feed-rationing models for modern beef cattle.

This FiB project was funded by Agriculture and Horticulture Development Board (AHDB). Scientists at Agri-Food and Biosciences Institute (AFBI) in Northern Ireland and Scotland's Rural College (SRUC) led the research (coordinated by Francis Lively of AFBI) in partnership with the Centre for Innovation Excellence in Livestock (CIEL), who helped manage the project and produce information for use in knowledge exchange with industry through AHDB and other networks.

Research for updating beef feed rationing models

The research aimed to update the tools available for predicting the nutritional requirements of beef cattle or their performance on given rations, as well as ration formulation to achieve a defined level of performance. The research programme was undertaken in the following areas.

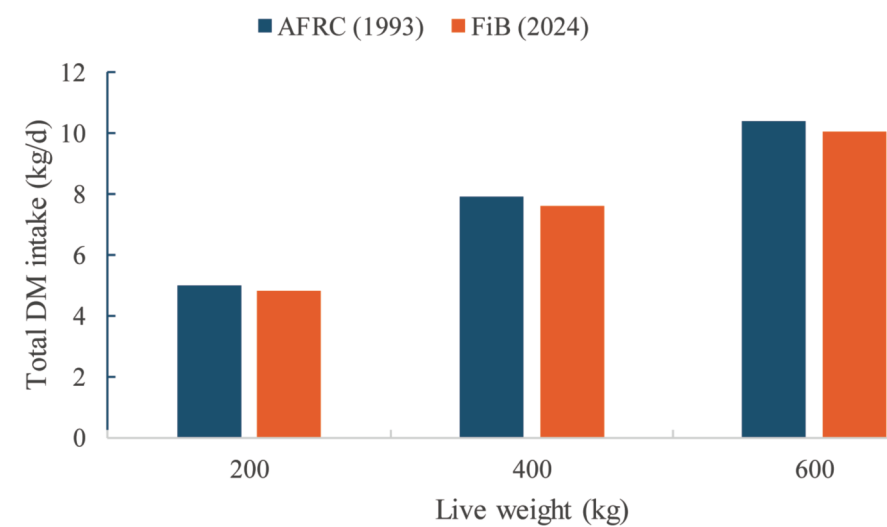
Updating feed intake models

The prediction of feed intake requires the nutritive value of the feed. The measurement of nutritive values of conserved forages (e.g., grass silage) was made breakthrough over

20 years ago with the development of the Near Infra-Red Spectroscopy technique (NIRS). This technique has now been widely adopted in the UK for rapid and robust prediction of the feed intake potential and nutritive value of grass silage. The NIRS silage intake potential (SIP) was used in this FiB project to develop new updated feed intake models for grass silage-based beef feeding systems. The dataset used for the modelling was collected from long-term feeding studies undertaken in AFBI over last 10 years. The new models are more applicable to the commercial farms when compared to the silage intake models of AFRC (1993) which are based on silage toluene dry matter (DM) and ammonia concentrations and digestible organic matter in total DM. A comparison example in total feed intake (grass silage and concentrate) presented in Figure 1 on page 18 reported a similar feed intake prediction between FiB (2024) and AFRC (1993) for beef cattle with live weight from 200 to 600 kg offered an average UK grass silage and 2 kg DM/d of concentrate feed.

Because there were little data available for maize silage intake of

Figure 1: The comparison of total feed intake (silage and concentrate) of growing-finishing beef cattle using models of FiB (2024) vs AFRC (1993) – assuming average grass silage offered and 2kg DM concentrate fed per day.



growing/finishing beef cattle or feed intake data for suckler cows, we suggested to retain the models of AFRC (1993) for prediction feed intake for maize silage-fed beef cattle and suckler cows.

Updating metabolizable energy requirement and supply models

Based on the available data, we updated: (1) prediction models of ME_m, (2) adjustment factors for correction of the effect of sex (bull vs heifer vs steers) and maturity (early vs medium vs late) on energy concentration in live weight gain, and (3) the adjustment factor for correction of the effect of the level of feeding on dietary ME concentration from maintenance feeding level to production feeding level. However, we suggested to retain the models of AFRC (1993) for prediction of (1) ME requirement for live weight gain for growing/finishing beef cattle, (2) ME requirement for pregnancy and lactation for suckler cows and (3) ME requirement for live weight gain or ME support from live weight loss for suckler cows.

The ME_m accounts for a significant proportion of total ME requirement in beef cattle. The model for prediction of ME_m for beef cattle was updated in the FiB project with data used collected from respiration calorimeter

studies with heifers, steers and suckler cows undertaken at AFBI and the University of Reading from 1993 to 2015. The output indicated that the new FiB models increased ME_m by 24% when compared to that calculated from the models of AFRC (1993). The increase might reflect the high metabolic rate of modern beef cattle with increased growth rates and carcass quality (more lean tissue).

Another major work was the revision of adjustment factors for correction of the effect of sex (bull vs heifer vs steers) and maturity (early vs medium vs late) on energy concentration in live weight gain of growing and finishing beef cattle. This was based on the research of Dewhurst and Miller (2023) who used the statistical modelling technique of

extrapolating data back for 40 years and found that carcass fat contents for modern British breeds (Aberdeen Angus, Hereford, Beef Shorthorn) were reduced, while for large continental breeds (Charolais and British Blue) it increased, with little change for some breeds (Limousin, Simmental and Stabiliser).

The FiB models increased total ME requirements of beef cattle when compared to those of AFRC (1993). An example of comparison is presented in Table 1 below. For a given live weight of 400 kg steer of late maturity breed, with live weight gains from 0 to 1.5 kg/d, FiB models increased total ME requirement by 24%–16%.

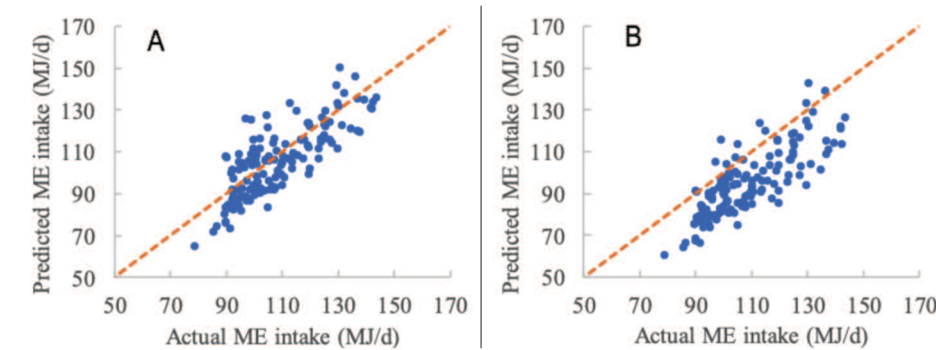
The FiB ME requirement models were validated using data collected from long-term feeding studies with growing/finishing beef cattle undertaken in AFBI over the last 10 years. The outputs are presented in Figure 2 on page 19.

The FiB models had a marginal underprediction of ME intake (2%), while AFRC (1993) underestimated ME intake by 13%. Most predicted ME intake data using AFRC (1993) are below the x=y line (under-prediction), while FiB predictions are clustered around the x=y line. AFRC (1993) had a much higher prediction error than the FiB model in terms of mean square prediction error (MSPE) and mean prediction error. The majority of MSPE for FiB models was from the random error (72%), while this value was smaller for AFRC (1993) (28%). This validation indicates that the FiB models can predict ME

Table 1: The comparison of prediction of ME requirement for late maturity steers between FiB (2024) and AFRC (1993).

Live weight gain		Total ME requirement (MJ/d)		
Live weight (kg)	(kg/d)	FiB (2024)	AFRC (1993)	FiB/AFRC
400	0.0	52.7	42.5	124%
400	0.5	68.7	57.3	120%
400	1.0	87.6	74.6	117%
400	1.5	110.0	95.2	116%

Figure 2: Relationships between actual ME intake and predicted ME intake using models of FiB (2024, A) and AFRC (1993, B).



requirements of beef cattle more accurately than the models of AFRC (1993).

Updating metabolizable protein requirement and supply models

The metabolizable protein (MP) rationing system used in the UK for feeding beef cattle was lastly updated in 1993 by AFRC (1992 and 1993). Sixteen years later, Cottrill et al. (2009) reviewed international MP systems and observed that MP requirement for maintenance (MP_m) in AFRC (1993) was significantly lower than in other MP systems. Since there were little published data available for us to validate and update MP requirement and supply models of AFRC (1993), we conducted a number of activities to review these models, including: literature review of published information, consultation with industrial consortium of this FiB project and comparison of MP requirement and supply models of AFRC (1993) with those published by Feed into Milk (2004), National Academies of Science, Engineering and Medicine in USA (NASEM, 2016) and Institut National de la Recherche Agronomique in France (INRA, 2018). Based on the output of these activities, we proposed the following approaches to ration modern beef cattle in the UK.

MP requirement

We suggested to (1) adopt the model of NASEM (2016) to calculate MP_m, and (2) reduce the adjustment factors of AFRC (1993) for correction of the effect of sex (bull, heifer and steer)

and maturity (early, medium and late) on net protein (NP) requirement of live weight gain for growing/finishing beef cattle. However, we proposed to remain MP requirement models of AFRC (1993) to predict: (1) NP requirement of live weight gain for growing/finishing beef cattle and the efficiency of utilization of NP for live weight gain, (2) MP requirements for pregnancy and lactation of suckler cows, (3) MP requirement for live weight gain or MP supply from live weight loss of suckler cows.

An example of comparison is presented in Table 2 below. For a given live weight of 400 kg steer of late maturity breed, with live weight gains from 0 to 1.5 kg/d, FiB models increased total MP requirement by 90%–36%.

MP supply from feed intake

We recommended to use models of Feed into Milk (2004) to estimate the supply of (1) digestible undegradable rumen protein (DUP), and (2) digestible microbial true protein through calculating rumen fractional

outflow rates of liquid, forage and concentrate, and then effective rumen degradable protein and adenosine triphosphate (ATP) supply.

Other works

The quality of beef feed ingredients has been changed considerably during the last 3 decades. For example, the implementation of the Nitrate Directive programme over 10 years ago restricts the nitrogen input for grassland production which could reduce grass protein concentration, while the improvement in ensiling techniques during the last 3 decades could improve silage quality. Therefore, we reviewed the literature and feed databases of AFRC (1993) and Feed into Milk (2024) and updated feed composition tables.

The project also delivered predictions of methane production for beef cattle fed different rations. It can be used to inform carbon foot-printing and allow farmers to choose feeds that deliver a lower carbon footprint for the beef that is produced.

Verification and adoption of Feed into Beef models

A key role in this FiB project was played by an Industry Advisory Group, which was presented with preliminary findings during development and had the final set of equations for field testing for one year before they were released to the wider industry. This provided a means to gain feedback on how the equations worked together in real rationing scenarios. In addition, an industry prediction tool, Ultramix (AGM Systems Ltd), was used to

Table 2: The comparison of prediction of MP requirement for late maturity steers between FiB (2024) and AFRC (1993).

Live weight gain		Total MP requirement (g/d)		
Live weight (kg)	(kg/d)	FiB (2024)	AFRC (1993) (g/d)	FiB/AFRC
400	0.0	391	206	190%
400	0.5	524	331	158%
400	1.0	637	441	144%
400	1.5	730	538	136%

optimise the equations when they are used together, based on advice from experienced industry nutritionists.

This last step was needed because no one dataset could inform the development of all equations of interest. Some were better suited to energy requirement, protein requirement, growth rate and carcass or body composition or feed intake. There was also the need to update feed composition tables due to advances in the feeds available for beef rations. Equations were therefore based on different, often overlapping sets of data, necessitating the optimisation of these equations through use of a tool designed for doing this, in this case Ultramix.

This project provides new information to the UK beef industry, with which it can increase the efficiency of beef production, reduce its carbon footprint and better meet market requirements through more precise feeding of beef cattle and better knowledge of feed quality.

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Feed into Beef project management and delivery

Industry Advisory Group – Chaired by Malcolm Crabtree.

Contractors: AFBI – Dr Francis Lively and Professor Tianhai Yan; SRUC – Professor Richard Dewhurst, Dr Jenna Bowen and Dr Gemma Miller; CIEL – Dr Mark Young and Nikki Dalby.

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Feed efficiency in pasture-based beef production: a data-driven approach

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1. Introduction – The Herd of the Future

Agriculture is undergoing a transformative period, driven by innovations in data analytics, biotechnology, and a growing imperative to address environmental sustainability. By 2035, beef production systems will rely heavily on real-time data, artificial intelligence (AI), and genetic advancements to optimise feed efficiency, reduce costs, and meet consumers' evolving demands for transparency and environmental stewardship. This paper examines how data-driven approaches to feed efficiency in pasture-based beef production will shape the herd of the future and argues that integrating sensors, AI, and gene-editing techniques holds the key to maintaining a profitable, resilient, and sustainable beef industry.

1.1. Overview of Changing Consumer Demands

Modern consumers are increasingly

concerned about the environmental impact of livestock production, animal welfare, and the nutritional quality of their food (McCarthy et al., 2015). By 2035, consumer expectations will likely include transparent supply chains, real-time environmental and welfare metrics, and personalised nutritional information. Such consumer-driven pressures necessitate a data-rich ecosystem wherein producers can document, verify, and communicate their production practices. As a result, the next decade will see a more robust synergy between technology providers, genetic researchers, and livestock producers to ensure that beef production aligns with these heightened expectations (Goldsmith et al., 2021).

1.2 Significance of Feed Efficiency

Feed efficiency – how well an animal converts feed into body mass – is pivotal to profitability and sustainability in beef production (Basarab et al., 2013). Because feed costs can

account for up to 70% of total production expenses in beef operations, even small improvements can have substantial economic effects (Archer et al., 1999). Beyond economic implications, improving feed efficiency is also linked to reducing greenhouse gas emissions, particularly methane (CH₄), a major contributor to agricultural emissions globally (IPCC, 2019). As consumer and regulatory pressures intensify, finding ways to enhance feed efficiency while maintaining animal welfare is a critical goal for the beef industry.

2. The Future of Feed Efficiency in Pasture-Based Beef Production

2.1 Real-Time Data Collection in Pasture Systems

Historically, feed intake measurement in pasture-based systems has been challenging. Precise data on grazing patterns, bite counts, and forage quality were difficult or expensive to obtain, often requiring labour-intensive methods (Rook & Penning, 1991). Recent innovations, however, have transformed this landscape. For example, CERES Tag represents a breakthrough in monitoring cattle in extensive grazing environments. These solar-powered ear tags use accelerometer and satellite technology to measure grass intake per bite, track animal movement, and transmit data in real time. Because they are entirely infrastructure-free, producers can bypass traditional logistical hurdles of installing base stations or towers on large-scale pastures (CERES Tag, 2023).

The significance of such technology extends beyond convenience. High-

resolution data enable farmers to identify variation in individual animals' grazing efficiency, detect early signs of health issues, and make informed decisions about pasture rotation. In practice, producers can receive automated alerts when certain animals are not meeting feed-intake targets, prompting quick interventions that improve welfare and productivity (Johnston et al., 2022). Additionally, the Pasture Feed Intake (PFI) feature in some tags estimates the volume of forage consumed and methane production, providing a more holistic view of the animal's environmental footprint (CERES Tag, 2023).

2.2 CRISPR and Genetic Tools for Enhanced Efficiency

Parallel to sensor-based developments, advances in biotechnology, especially CRISPR gene editing, show immense promise for improving feed efficiency (Carlson et al., 2012). CRISPR allows precision editing of cattle genomes to enhance traits related to feed conversion ratios (FCR) and even reduce methane emissions by targeting genes associated with rumen microbial composition. Some researchers are investigating edits to gut microbes that convert hydrogen into methane, aiming instead to produce acetate that could be used more efficiently by the animal (Broucek, 2018).

Moreover, data gleaned from sensor technologies guide these genetic improvements by pinpointing the most efficient animals in a population. Genome-wide association studies (GWAS), cross-referenced with sensor-based performance data, enable highly precise selection for beneficial traits (Speidel et al., 2015). Instead of waiting multiple generations to confirm the heritability of complex traits, researchers and breeders can rapidly identify and propagate animals that demonstrate superior feed efficiency. This blend of real-time data and genome editing creates a virtuous cycle: sensors highlight top-performing cattle, CRISPR refines traits at the genetic level, and each subsequent generation shows measurable improvements in efficiency (Sharma et al., 2018).

2.3 Economic and Sustainability Implications

Numerous studies suggest that improving feed efficiency by just 10% can boost profits by over 40% (Archer et al., 1999; Basarab et al., 2013). Beyond direct monetary gains, such progress aligns with broader sustainability targets. In the UK, agriculture faces increasing pressure to reduce greenhouse gas emissions and adapt to more stringent environmental regulations. Data-driven feed efficiency strategies, combined with CRISPR-based genetic gains, can reduce methane production, land use, and resource inputs per kilogram of beef (IPCC, 2019). These improvements help position the beef sector as a credible, sustainable protein option, preserving public trust and market access.

3. The Future on the Plate – Evolving Consumer Demands

3.1 Increasing Transparency and Personalised Nutrition

By 2035, consumers are expected to place heightened importance on supply-chain transparency and environmental stewardship (McCarthy et al., 2015). Advances in data analytics will help meet these demands by providing real-time information on an animal's life cycle, from birth to slaughter. Smart packaging, QR codes, and interactive smartphone apps could offer insights into where and how an animal was raised, the carbon footprint of the production, and even welfare indicators tracked through sensor data (Kubiriba et al., 2021).

Alongside this, personalised nutrition – driven by genetic testing, wearable devices, and AI-driven dietary recommendations – promises to shape the types of beef products in demand (Boyle et al., 2019). Health-conscious consumers may request beef from cattle raised on diets that yield specific fatty acid profiles. Such “designer beef” will only be feasible through precise data collection, ensuring animals receive diets optimised for both efficiency and nutrient composition (Smith et al., 2020).

3.2 Leveraging Consumer Data for Targeted Products

Consumer-facing data platforms will increasingly be fed back into production decisions. By tracking consumer preferences in real time – via grocery store purchases, online orders, and health apps – producers can adjust breeding strategies and feeding regimes to deliver niche products. Data from sensors like the CERES Tag on grazing times, daily weight gain, and methane outputs can be combined with consumer analytics to create targeted marketing strategies for premium, eco-friendly, or health-focused beef (Goldsmith et al., 2021). This two-way data exchange, from pasture to plate and back again, forms a feedback loop that aligns production with evolving consumer tastes.

4. Connecting Data and Biotechnology

4.1 A Holistic Data Ecosystem

The convergence of data analytics with biotechnology forms the core of future livestock management. Advanced sensor platforms collect data on feed intake, weight gain, and realtime grazing behaviour. This high-resolution data is integrated into centralised dashboards, where AI algorithms provide predictive analytics and immediate recommendations (Johnston et al., 2022). For instance, if sensor data indicates an uptick in parasite load or a decrease in feed intake efficiency, AI-driven alerts can guide farmers to alter feed composition, administer targeted treatments, or investigate changes in pasture quality.

4.2 Data-Driven Breeding and Microbiome Optimisation

Real-time data on feed intake and animal performance complements genetic selection programmes. Breeders can more swiftly identify top performers, focusing on traits like disease resistance, feed efficiency, and lowered methane emissions (Speidel et al., 2015). The microbiome also plays an increasingly pivotal role. Research into rumen microbiota is revealing how microbial communities impact nutrient



absorption and emission profiles (Tapio et al., 2017). By editing microbial compositions – either genetically or through targeted probiotics – producers can enhance digestive efficiency and reduce environmental impacts. Essentially, the integrated data-biotech model offers a loop of constant improvement: data reveals opportunities for selection and microbiome manipulation, which then yields further performance data, fostering iterative gains over time.

5. Genetic Selection – Data-Driven Breeding

5.1 CRISPR-Focused Advancements

At the heart of next-generation livestock breeding lies CRISPR, enabling rapid genetic improvements. Rather than relying solely on traditional selective breeding, CRISPR allows targeted modifications to genes that control essential traits. Early applications have demonstrated the technology's capacity for increasing muscle mass, improving disease resistance, and potentially reducing methane emissions (Carlson et al., 2012). This precision is critical given that broad genetic modifications risk unintended consequences, whereas CRISPR can specifically address defined gene loci.

5.2 Genome-Wide Association Studies (GWAS)

GWAS have emerged as powerful tools for correlating specific genomic



regions with performance traits (Sharma et al., 2018). Coupling GWAS with real-time data from ear tags accelerates the identification of genetic markers linked to feed efficiency. For instance, the Agriculture and Horticulture Development Board (AHDB) reported that selecting cattle genetically predisposed to more efficient feed conversion ratios can cut daily liveweight gain costs by 10–15p/kg (AHDB, 2022). Farmers adopting these breeding strategies can thus realise sizeable feed cost savings, potentially amounting to thousands of pounds per year in large herds.

5.3 Balancing Efficiency with Other Traits

While improving feed efficiency is paramount, genetic selection must also balance other traits such as calving ease, growth rate, carcass quality, and resilience to climatic

stressors. Data-driven approaches allow multi-trait selection indices that weigh the economic value of each characteristic (Berry & Crowley, 2013). Advanced data integration ensures that efforts to improve feed efficiency do not compromise essential qualities like meat tenderness or overall herd health.

6. Smart Sensors – Measuring Feed Intake

6.1 CERES Tag Innovations

A prime example of emerging sensor technology is CERES Tag, which combines a solar-powered battery system, direct-to-satellite communication, and advanced accelerometer features. The system's infrastructure-free design reduces setup and maintenance costs, appealing to both small-scale and large-scale operations. Updated up to 12 times daily, the tags track grazing intervals, estimate feed intake, and measure methane production, bridging critical information gaps in pasture-based systems (CERES Tag, 2023).

6.2 Indoor Livestock Applications

While CERES Tag has gained attention primarily for outdoor applications, similar sensorbased solutions are transforming indoor beef systems. Integrated weigh scales and electronic identification devices provide continuous data on an animal's feed consumption versus weight gain. AI algorithms overlay this data with environmental parameters – such as barn temperature or feed composition – to generate individualised feeding recommendations (McAloon et al., 2020). These real-time insights reduce overfeeding and wastage while improving uniformity in weight gain across the herd.

6.3 Predictive Analytics

Beyond immediate measurements, sensor data feeds into predictive models for disease outbreak likelihood, breeding success rates, and overall herd performance. If an emerging health issue is detected, farmers can intervene quickly to isolate animals or adjust treatments before an outbreak spreads (Lyons

et al., 2020). By harnessing historical sensor data, producers can also anticipate fluctuations in pasture availability due to seasonal climate changes, optimising grazing rotations and input costs.

7. Implications for Farmers and the Industry

7.1 Farmer Profitability and Competitive Advantage

Adopting sensor and biotechnology tools yields multiple layers of benefit. Improvements in feed efficiency directly enhance profit margins by cutting down the largest single cost in beef operations. Additionally, data-backed evidence of sustainable practices – like lower methane emissions – can fetch premium prices in markets where consumers are willing to pay more for eco-conscious products (Goldsmith et al., 2021). This synergy between sustainability and profitability is a powerful driver for technology adoption.

7.2 Transparency as a Market Differentiator

Increasingly, transparency is becoming a market requirement. Retailers and consumers alike demand verifiable data on environmental footprint, animal welfare, and feed quality. For farmers, this level of transparency is both a challenge and an opportunity. By leveraging realtime sensor data, farmers can provide robust evidence of their practices, thereby building consumer trust and securing access to markets with stricter quality and sustainability standards (McCarthy et al., 2015).

7.3 Competition with Alternative Proteins

The rise of alternative proteins, including lab-grown meat and plant-based substitutes, poses a growing challenge. However, data-driven improvements can position traditional beef as a premium, sustainable choice. Demonstrable gains in feed efficiency and methane reduction weaken the primary criticisms levelled at livestock production. Indeed, producers who can

showcase superior environmental performance, traceability, and welfare standards may stand out even in a saturated protein market (Roosen et al., 2020).

8. Biotechnology in Action

8.1 CRISPR-Based Disease Resistance

Beyond feed efficiency, CRISPR technology has shown promise in conferring disease resistance – for instance, targeting genes related to bovine respiratory disease or mastitis (Carlson et al., 2012). Disease resilience translates directly to economic gains via fewer veterinary expenses, lower mortality rates, and improved overall herd performance. Combined with sensor data that detects early signs of illness, CRISPR-enabled resistance can further reduce the need for broad-spectrum antibiotics, addressing consumer and regulatory concerns about antibiotic resistance.

8.2 Microbiome Management

Ongoing research highlights the importance of the rumen microbiome in shaping feed conversion efficiency and methane output. Certain microbial strains are more efficient at digesting fibres and can reduce methane production by shifting fermentation pathways (Tapio et al., 2017). Biotechnology also includes precision probiotics, which seed the rumen with beneficial strains, and targeted antimicrobial peptides that selectively remove undesirable microbes. As these approaches scale up, they can be tailored to the genetic background of the animal, thereby maximising synergy between genome and microbiome (Sharma et al., 2018).

8.3 Precision Vaccines

Conventional vaccination schedules seldom account for the specific pathogen load or genetic vulnerabilities of each farm. In the future, genomic surveillance combined with big data analytics will enable precision vaccines. Vaccines can be developed or updated rapidly to target emerging or region-specific

strains. By reducing disease outbreaks, farmers improve animal welfare, reduce economic losses, and bolster consumer confidence (Chapman & Hill, 2012). Ultimately, precision vaccines align with the overarching theme of data-driven, tailor-made interventions.

9. Roadmap to 2035 – A Non-Linear Path

9.1 Phased Technological Adoption

Transitioning to data-driven, biotech-enabled beef production will likely be non-linear, characterised by “leapfrog” moments in CRISPR applications and AI breakthroughs. Early adopters who demonstrate significant gains in feed efficiency will encourage widespread uptake, creating a cascading effect. Once new sensor models or genetic editing strategies prove successful in commercial herds, more conservative producers will join the wave to remain competitive (Rogers, 2003).

9.2 Regulatory and Ethical Considerations

Regulations around gene editing, data privacy, and environmental standards will shape the adoption curve. The European Union, for instance, imposes stringent rules on gene editing in livestock, and producers must navigate these frameworks to avoid trade restrictions. Likewise, data privacy legislation demands that farms protect and anonymise data collected from sensor technologies (Kubiriba et al., 2021). Thus, the timeline for achieving a fully integrated system by 2035 may fluctuate based on policymaking and ethical debates.

9.3 Climate Change Adaptation

Climate change may accelerate the adoption of advanced technologies. As extreme weather events and shifting precipitation patterns threaten pasture availability, real-time data becomes even more critical (IPCC, 2019). Genetic lines that tolerate heat or disease pressures associated with a changing climate will become more valuable. CRISPR and sensor technologies thus serve not just as efficiency tools but also as vital resilience strategies.

10. Call to Action – Dream, Build, Lead

10.1 Farmers: Embrace Innovation and Collaboration

Farmers are central to driving change. Small-scale pilots with new ear-tag sensors or CRISPR-based breeding can offer insights and refine best practices. Collaboration with researchers is essential to customise these technologies, ensuring that solutions address real-world challenges while remaining practical and cost-effective (Lyons et al., 2020). As technology prices decrease, barriers to entry will lessen, making widespread adoption more feasible.

10.2 Researchers: Prioritise Scalability and Affordability

Academics and industry scientists must focus on developing scalable, affordable solutions (Sharma et al., 2018). This involves refining genetic tools to reduce off-target effects, optimising microbial interventions, and making sensors more robust in challenging environments. By keeping smallholders in mind, researchers can help avoid a digital divide that leaves behind critical segments of the agricultural community.

10.3 Industry Leaders: Fund Innovation and Ensure Inclusion

Industry stakeholders – such as large processors, retailers, and feed companies – hold considerable influence by funding development projects and setting industry-wide standards. Offering incentives for data-sharing, building robust networks for digital innovation, and supporting training programmes can accelerate adoption across the supply chain. Ensuring that small and medium-scale producers are included in this transformation helps the entire sector remain resilient and competitive (Goldsmith et al., 2021).

10.4 Policymakers: Align Regulations with Technological Potential

A supportive regulatory environment is crucial. Clear guidelines on gene

editing, data protection, and sustainability metrics can foster responsible innovation without stifling progress (Carlson et al., 2012). Policymakers must engage with scientists and industry representatives, balancing ethical concerns with the need for more productive and sustainable agriculture.

11. Conclusion

By 2035, the landscape of pasture-based beef production will be markedly altered by data-driven feed efficiency strategies. Sensors such as the CERES Tag will provide unprecedented insights into individual animal behaviour and grazing intake, while CRISPR gene editing and microbiome manipulations will enable precise genetic and microbial optimisations. These advancements will not occur in isolation; rather, they will feed into each other, forming a continuous cycle of improvement. On-farm data guides genetic selection, which in turn leads to healthier, more efficient animals, generating more robust data for future refinement.

This integrated approach has profound implications for farmers' profitability, environmental impact, and competitiveness in a market increasingly occupied by alternative proteins. The ability to document and disclose sustainable practices will be a critical differentiator, meeting rising consumer expectations for transparency and ecological responsibility.

Achieving this future requires concerted efforts from farmers, researchers, industry leaders, and policymakers. By embracing innovation in data analytics and biotechnology, the global beef industry can navigate evolving challenges – climate change, consumer scrutiny, and economic volatility – ultimately securing a resilient food system for generations to come.

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Thank you for your attention to this paper on feed efficiency in pasture-based beef production. The integration of real-time data, innovative sensor technology, and breakthrough biotechnologies like CRISPR stands to redefine how producers optimise feed utilisation, enhance profitability, and bolster sustainability in an evolving global marketplace.



The **BRITISH CATTLE CONFERENCE**

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Sustainable breeding for beef sexed semen supports net zero progress

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Veterinary School, Wm Morrisons Ltd

T Phipps

Map of Agriculture, UK

This paper includes two key themes:

- I. Success factors for advanced breeding in beef herds
- II. Modelling the benefits for sustainable beef production of female and male sexed semen

Livestock farming is under intense scrutiny regarding the environment, including Net Zero commitments and must deliver these, as well as wider environmental objectives, all whilst balancing energy and cost efficiency to maintain a resilient food supply. The NFU has set industry goals of achieving Net Zero greenhouse gas (GHG) emissions by 2040; however, Morrisons beef supply chain aims to deliver this by 2030. The study modelled how to move the ratio of calves from 50:50 male:female calves to 80:20 male:female calves using male sexed semen for a consequent increase in beef yield and the benefits of using female sexed semen to deliver maternal traits for breeding replacement dams. Understanding how the health, fertility and welfare of beef cattle can be improved encourages optimal efficiency on a sustainable holistic system on the journey to net zero beef.

I. Success factors for advanced breeding in beef herds

Good fertility is at the forefront of a profitable and sustainable livestock

enterprise; the optimum fertility performance in cattle farming is achieved by maintaining a calving interval of 365 days. Artificial insemination (AI) is still not commonly used in beef cattle reproduction, with less than 10% of UK beef herds adopting the practice. This is mainly due to inadequate/inappropriate handling facilities, lack of confidence in semen quality and implementation, lack of understanding of the precision management required to achieve optimum results or a combination of these factors. However, AI can have many benefits, including allowing farmers to select sires suited to their herd's breeding programme (e.g. maternal vs. terminal traits), without the expense of buying and keeping multiple bulls, improving genetic potential and efficiency, all while decreasing GHG emissions. Using bulls in the top 1% of breeding values becomes possible with AI, in contrast to most natural service by stock bulls.

This project used an innovative AI breeding programme in a small cohort of cattle from a progressive, family-run 850-acre farm, running around 160 breeding Stabiliser beef cows and farming 450 acres of arable crops (including wheat and barley). Practical opportunities to adopt precision breeding for transformative genetic progress in

beef suckler herds were assessed by enhancing sustainable reproductive success in the first phase of the breeding season.

The health and vaccination status of animals in the cohort were assessed to manage infectious disease. Vaccinations were carried out pre-service to reduce stress during pregnancy and provide cover for the foetus, against challenges such as bovine viral diarrhoea virus (BVD), in the critical first 3 months of gestation. Fluke and parasite control were also taken into consideration. Precision management included nutrition assessment and blood sampling to identify trace element deficiencies that might impede AI success (particularly selenium, cobalt, iodine and copper); the use of precision-release fertility boluses ('Fertil' Kersia, UK) provided a controlled dosage for these elements and additional beta-carotene in all study cows. Consistent management with minimal change – including group social factors and grazing/housing – is critical to success.

Before AI, the sourced female-sexed semen was independently assessed by multimodal objective analysis combining CASA (computer assisted semen assessment) with Flow cytometry, delivered by experienced technicians through SemenRate® (RAFT Solutions Ltd, UK).

II. Modelling the benefits for sustainable beef production of female and male sexed semen

The potential benefit of changes with an increased proportion of male calves was modelled by Map of Agriculture (MoA). Productivity cost benefit, reduction in GHG and other key performance indicators were measured. Assessment of bulls versus heifers showed that there was a 60kg difference in carcass weight at slaughter with heifers taking an additional 10 months to reach the reduced slaughter weight. This resulted in an increase of 7.31kg CO₂e/kg beef in emissions intensity for heifers. When the impacts for every 100 calves born in the 80:20 male calf system were compared to the traditional 50:50 system it was shown there was an increase in beef production of 3000kg with a reduction in total emissions of 14256kg CO₂e and ultimately a reduction in emissions intensity of 3.23kg CO₂e/kg beef in the 80:20 system.

Maternal trait benefits from female sexed semen for replacements were also modelled, with increased cow longevity, a reduction in age at weaning and increased fertility rates. Combined, these benefits represent a long-term and permanent enhancement to the herd breeding base.

In conclusion, the sustainable breeding programme could produce additional bull calves by using male sexed semen; this was modelled to produce an additional 3 tonnes of beef per 100 calves per year. As well as clear economic advantages, this precision breeding approach offers significant reductions in GHG emissions intensity – which can be amplified if sexed semen with enhanced maternal traits is additionally used for breeding replacements. Sustainable breeding improvements lead to decreased days to slaughter, reduced waste and increased resource efficiency. Sexed semen also offers a key tool to target maternal genetics in the animals bred as replacements and terminal beef

traits in animals less suitable for breeding replacements, producing more efficient and lower emissions beef.

Further work is required to disseminate the findings of this project to the wider beef industry. The outputs from the project will help provide the industry with evidence alongside complementary skills-based training to break down the barriers for uptake of AI and use of sexed semen on beef farms. With an increased uptake in AI, farms will have the opportunity to advance the genetic potential of their herd, increasing productivity and sustainability through increasing yield of beef per year. Rearing the optimal number of replacement animals required for their farm each season will reduce GHG emissions intensity alongside better longevity, weaning performance and beef yield.

Selecting for the suckler cow of the future

Neil McGowan NSch
Farmer and Nuffield Scholar, Incheoch Farms, Perthshire

Where the River Isla tumbles over the Highland Faultline, as it leaves the bonniest of the Angus Glens, there's a wee place called Incheoch. This is where we, the McGowan family, farm 200 suckler cows and 1,100 ewes. We have been in the bull and ram business for generations and we're proud of the thrifty, robust Lleyne ewes and Luing cows which suit our environment. We complement them to fit our market with Texel and Simmentals. The heart of what we do is to breed *Functional, Efficient and Robust* breeding stock.

Going back 10 years ago, we had marketed grass-fed, performance recorded dams, rams developed steadily for fertility and longevity for our on farm 'Working Genes' sale and to bulls sold through the Stirling bull sales. They were fed to the nines, pampered to have their hair looking right and calved out of season to be in the right spot in the sale. This didn't sit well, so I set out on a Nuffield Scholarship to try and figure out how to develop an on-farm bull sale.

I dressed it up as a project looking at 'Selection for Feed Efficiency'. I thought a bunch of herds could bring bulls together, measure feed intake and sell them coming off test, all reared the same. A lot of the discussions I had then became about cow efficiency and I am going to share some of these stories and how we have put them to use at home.

The first time I attended a BCBC Conference was to hear Dr John Basarab, the feed intake guru, speak. I caught up with him in Alberta during my Nuffield tour. 'What happened to

the dairy industry when all they selected for was output, without looking at input?' There has got to be some 'limiter' to production, we can't keep selecting for output with an open cheque-book on inputs. Dave Nichols called milk and growth 'Goldilocks' traits, as the saying goes this porridge is too hot, this one too cold and THIS one is 'just right'. If you are going to put some selection pressure on one trait and it's correlated to another one you need to be at the very least keeping an eye on it! That was the kick up the backside to start measuring to get a reliable mature weight EBV.

In Kansas, I visited the Leachman co-operator breeders. Gary Rolland showed me the Stabiliser cattle and over lunch I wanted to get down to the bottom of what he was doing with feed efficiency. He was sitting over the table from me holding a burger

in one hand and I asked him again about feed efficiency. He bangs on the table with his other fist and says "Well it all comes down to this. A cow is only good for two things. One she eats a lot of stuff nothing else will eat and two she tastes damn good. Lose either of these things and all you got is an inefficient hogg". He took another bite of his burger, while I watched the first bit of my project crumble to the floor.

Why cows?

The Working Genes sale is a big day at Incheoch. We run an online silent auction where bidding is done quietly on devices and the bulls are out in paddocks. We aim to make the sale a fun, family event, with the sale concluding in an old stable, with a display of ribbons, rosettes and pictures of bulls from the past. We also display a board (Figure 1).

Figure 1

Calving Year:	2017 ... 2021	2022	2023	2024	2025	2026
Females to Bull	224	221	210	212	217	
Scanned +	205	198	199	199	197	
Scan Percentage	91%	90%	95%	94%	91%	
Scanned Twins	10	10	6	11	10	
- Percentage	5%	5%	3%	6%	5%	
Extra Twins Reared	2	1	1	1		
Calves Weaned	201	185	190	195		
Wean Percentage	90%	84%	90%	92%		
Calf Wean Wt	275 kg	292 kg	285 kg	289 kg		
Age at Weaning	189	202	193	201		
Ax calf birth date	12 th April	3 rd April	11 th April	15 th Apr		
Last Calf Born	6 th Sept	24 th May	31 st May	9 th June		

This keeps me grounded as to why we have cows on our farm. For us it means more calves weaned. If we can keep a dozen more cows and they all wean a calf then we can sell another pen of steers in the spring, bringing in cashflow that mostly goes in the bank. So, more calves weaned come from more cows fitted in for winter, more pregnancies and less losses.

This gives us a breeding goal:

- Moderate cow size
- High Fertility
- Calving ease

I've always wanted to travel to America to see the speed of progress made in the herds of thousands of cows and try to work out how we could replicate that scale at home. One of the most impressive programs I saw was with Greg Golden at Cole Creek, on the banks of the mighty Yellowstone River. With 4,000 acres and 170 cows and just ONE focus over the last 50 years – MATERNAL. He spoke about fertility, longevity, foot and udder structure and early puberty and his advice to me was "Just remember – this job is ALL about the cow! She is in charge of your cost per unit of production and the bull is just a bi-product, he is only there to pass on the cow's genetics."

A Nuffield Scholarship takes about 2 years of study and 8 weeks travel, I spent a lot of those 2 years lost, intellectually, emotionally but mostly just physically! For anyone thinking of going travelling like that, my advice is that it doesn't really matter how fast your car goes, just buy a really good map. The same for breeding programs – direction trumps speed of gain, think back to Greg Golden with 170 cows, 1 direction, 50 years!

1,200 miles down the road amongst the corn and hogs in Iowa is Steve Radakovich with his Angus based composites. His breeding goal was not to make mistakes, he was on the same wavelength as Greg, speaking about adaptability, fertility in a short breeding season, not too much milk, moderate size, low maintenance and

longevity – My story was coming together... Then as I was leaving Steve said "You know Neil, this job is all about the bull!" He went on to explain that:

- You can cull the cows you've got but that's expensive
- Pick heifers but once you've culled the outliers (big and small), sorted on temperament and structure you haven't got a lot left to play with
- Bulls – bulls are where you make progress but on the cow's terms because there's not a lot you can see in the bull that makes any difference!

So, it is the bull but the bull is about the cow, or about the program. At home we need to stop comparing our bulls on terminal traits and feeding regime, we need to sell them out of the paddock at home, and to date have had 7 home bull sales. Some of our Simmental cows were not a good fit for their environment and we found it difficult to calve them at 2 years old and rebreed at 3 years old. We sold a lot of them and culled hard. We have used homebred bulls and sourced bulls from 2 year old calving systems. We have put a LOT of heifers into the program, pregnant within 6 weeks as a yearling and rebreed in 9 weeks while nursing as a 2 year old. By doing this I think we have changed the maturity pattern of our cattle, they are smaller framed and easier fleshing. Our fat EBV's have risen. We've also started to talk about frame Score to help us, and our clients, identify the cattle that fit our farms. There are no fixed targets but if we have got FS 6 cows and are happy with them, we are looking for a bull between 5 and 7 to go with them and not a FS 9. It helps us to pick the right one for our cattle.

A ballerina called Anna Pavlova was once asked after a performance 'What were you trying to say in that dance?' she replied, 'If I could have said it, I shouldn't have to dance it' and I suppose that's what 'art' is. On my travels I met Kit Pharo, a cowboy from Colorado and he introduced me to the phrase – SEXUAL DIMORPHISM. Kit has

made a name for himself breeding very low input cattle which were bigger bodied than I expected. I was struck by a certain cow, my grandfather would say she had 'maternal character', and dad would call it 'balance'. Neither of them could really say what it was but they could breed for it in an *Anna Pavlova* sort of a way, this cow had it – she was sweet-headed, slender-shouldered, wide-hipped and moved gracefully. I asked Kit what the bull looked like that bred a cow like her, he showed me a bull, a son of her's, which he was using widely. He was exactly the opposite – heavy fronted with a big crest. Kit said, "Of course he is, that's Sexual Dimorphism." He explained it like this as 3 ladies or 3 men sitting on a bench, they are tight at different ends, they are opposites. It is the same with the bull. Fertility is all about Reproduction, which is all about Hormones, and that's all about the difference between a bull and a steer, and that is why a cow has to look like a cow and a bull has to look like a bull – Sweet cows and Rugged bulls.

I travelled to New Zealand and was really taken with the Hill Country Angus cows. I was still thinking about Feed Efficiency but people kept asking me the same question, what's the knock-on effect for the cow? I met with a guy from AbacusBio in Dunedin, who had torn the remaining tatters of my project to shreds. He wanted me to meet a beekeeper in Christchurch, I had no idea why. I had been travelling nonstop for 3 weeks, it was approaching Christmas, and I was ready to go home to see my family. On the drive to Christchurch, which takes longer than you think, I needed to stop and clear my head, and as I was driving through Timaru, a kind of industrial town, a lot like Arbroath, I see this statue of a horse and decided to pull over right at the side of State Highway one and I read this story:

About a century ago, Alexander Roberts was a farmer who retired near to town and dabbled in breeding racehorses. He bred a 50 Guinea mare with a one-race, unplaced racing record to a nondescript stallion of 'Sound English Breeding'. Not

much of a start to any story, save for a little ounce of breeding, the mare's great grandmother was a touch of class. The resulting gangly colt foal born in 1926 seemed to disappoint enough to be sold as a yearling, at a sale where the top price was 2300gns, he made 160gns, unseen to Australia on the back of that little ounce of breeding. Rejected by his new owner on arrival to Sydney, he was kept at the insistence of trainer Harry Telford. Eventually making it to the practice track he gained his name from a play on a Chinese dialect word for 'Lightning Strike' – ironically because he was so slow! BUT as a 3 year old this horse, Phar Lap started to race and started to win and kept winning. With 35 wins in 25 months, including 4 in 8 days at the Melbourne Cup Festival in 1930, including the cup itself under a record handicap weight, the best was yet to come. They sailed him to Mexico, where only 10 days off the boat he ran in the richest race in the world, against some of the biggest winners in the US, he won, hands down, in record track time. Phar Lap died just 16 days later in 1932. Years later the clerk of the course in Mexico was asked "which was the greatest horse in America of the 20th Century – was it Man O'War or was it Secretariat?" He replied, "Neither, I saw Phar Lap."

There I was sitting at the side of the road in Timaru, trying to read the end of the story and I canna see for tears. I had just realised who I am. I am not a farmer, or a Scotsman or a Nuffield Scholar, I am a Breeder and it's what I want to do. And it's not about the \$15 Million equivalent winnings; it's about the Roberts and Telfords – the men who saw the potential in the little ounce of breeding and had the faith to follow it through and bred a legend.

Then it hit me, we are not breeding racehorses! Phar Lap was a legend because whenever he finished a race

he finished it first. He pulled up a couple of times. BUT in our business first finished isn't everything, it's certainly better than last but somewhere in the middle is just fine. What is REALLY important is getting across the finishing line EVERYTIME. Consistent, mid field finishers. If we can get every pregnancy, born alive, sucked and healthy, weaned, grown out and sold AND the cow can do this Time and Time again, then we are on to a winner. Consistent mid-field finishers – It's not as exciting as racehorses but it's a different job.

In the beef sector we are stuck with the Phar Lap model of breeding. He had this classy mare; we market sons of Show Champions and Grandsons of Record Prices but what we need to do is fill that pedigree full to the brim of consistent mid-field finishers. There is a yearling Luing Bull running around at home just now, 11 out of 15 cows in his pedigree are Incheoch cows and have 115 calvings between them. They are all Consistent Mid-field Finishers. The late Larry Leonhardt of Shoshone Angus said: "When you are looking at that bull you need to imagine the cows in his pedigree as a group standing in a pen because that is what he is going to breed you."

In the far south of New Zealand, Peter Black at the age of 80, running 1200 stud ewes along with his wife Marion, including a flock of 600 pedigree Texels. He told me about a Gene Marker for Footrot Resistance, he says the science isn't perfect, but it's OK and if we don't do something about a trait we're just saying it's alright to live with it, and that is unacceptable to Peter. Nuffield introduced me to a Baroness, policy makers, geneticists, breed association CEO's and breeders. The only people that can actually do something about a trait are the Peter Blacks of this world who are the ones opening the gate to put the

bulls in. If something needs changing, don't wait for a policy change, or blame the market system, or the breed society, if you are the breeder you are the one in charge. At home I wasn't happy with our calf wean weight / cow bulling weight ratio, so, we did what Willie Falloon at Pinebank Angus told me, "Punch in the data, sort it on a spreadsheet and work up from the bottom until you get to a cow that you can't live without. Draw a line and cull below it. Do that for 10 years and things will change."

Luing cattle weren't performance recorded when I started my Nuffield, we were the first herd and now the breed has 70,000 cumulative calving records.

Progress is slow – but we've started.

Conclusion

The cow of the future looks a bit like this:

- *Eats lots of stuff nothing else will eat, and she tastes damn good.*
- *She has some sort of 'limiter to production' – in a Goldilocks kind of a way.*
- *It's all about the bull – on the cow's terms*
- *She's a sweet cow, and her father is a rugged bull*
- *Her pedigree is full of consistent mid-field finishers*
- *We're in charge – just get on and do the right thing and breed her!*

Acknowledgements

Thank you to Nuffield Farming Scholarship Trust for having the vision to send a shepherd with a poor sense of direction into the wide world and thank you to my sponsor, the Royal Highland and Agricultural Society of Scotland for picking up the bill for getting me home again.

Developing AI to monitor changes in social behaviour for the early detection of disease in dairy cattle

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The University of Bristol Veterinary School has received a £1 million award from John Oldacre Foundation dedicated to creating an intensively monitored dairy farm at the school's commercial housed facility, as a result, the John Oldacre Centre for Dairy Welfare & Sustainability Research was established. There have been many improvements implemented so far such as calf behaviour research areas, climate monitoring over a wireless network and over 60 cameras have been fitted for AI development. Further research infrastructure will include a flexible research pen for behavioural studies, and GreenFeed enteric methane emission monitoring equipment. The data collected at the farm from new equipment and sensors will be combined with data longitudinally collected at commercial farms such as individual production and reproductive data, genetics and veterinary records to answer fundamental challenges in livestock production related to health, welfare and sustainability. The farm manages an all-year-round calving herd made up of 200 milking cows split into two smaller groups (≤ 2 lactation and ≥ 3 lactation). The newly fitted video monitoring system covers all cattle housing areas (excluding the dry cow and heifer barns currently) including the current herringbone milking

parlour as well as the entrance and exit to the parlour. The AI development for automated behaviour tracking of each individual is based on deep learning using what we refer to as open-set identification (Andrew et al., 2021). The AI system takes advantage of the unique coat patterns of Holstein-Friesian cows (black and white markings) for the identification of each individual. Through this novel approach the AI will not only detect, identify and track already known individuals but be able to recognise cattle it has not seen previously, removing the need to train the system for each new individual.

The specific management of the herd provides opportunities to continuously monitor cattle at different stages of the production cycle and at different parities. For example, monitoring changes in behaviour during the transition period, which is one of the most critical stages of production (Wankhade et al., 2017). The transition cow pen is monitored using six wideangle cameras, enabling tracking of individuals across different views and monitoring behaviour such as social interactions, feeding, lying and drinking. The additional benefits of the transition pen are the smaller number of individuals present in camera view at one time as well as

regular group composition changes that make this the optimal area for piloting work. Moreover, the exit from the milking parlour is of particular interest for the research surrounding body condition scoring (BCS) and mobility assessment of the herd. Automated AI-based BCS and mobility assessment methods will be trained using expert annotations of the side-view and back-view cameras. There is also a further camera pointed at the ear tag reader, as the cows exit the race, which uses optical character recognition to link the AI data with farm veterinary and production records based on the ear tag number.

Continuous monitoring of cattle using machine vision has the potential to characterise behaviour more accurately than current technologies used on farm (e.g sensors/wearables), through off-cow sensing which avoids welfare concerns around wearable technologies (Tangorra et al., 2024). As such, it can be used to monitor more subtle changes in cattle behaviour for the detection of sub-clinical and clinical conditions in real-time. Behaviours such as feeding, lying and rumination have been reviewed previously and are known to change with incidence of disease (Dittrich, Gertz and Krieter, 2019). These behaviours can be referred to

as “core behaviours” (Caplen and Held, 2021) which are critical to the immediate survival of the animal. Similarly, previous research has demonstrated changes in social behaviour such as displacements at the feed face (e.g Sepulveda-Varas et al., 2016) and social reactivity (Caplen and Held, 2021), which can be referred to as “luxury behaviours” that have long-term, rather than immediate, health and welfare benefits (Caplen and Held, 2021). Behaviours such as social interactions are believed to change prior to changes in maintenance behaviours based on sickness behaviour (Dittrich, Gertz and Krieter, 2019), and therefore present as an ideal candidate for early disease detection. Behaviour monitoring using visual recognition has been successfully applied previously by as such as in wild Great Apes (Sakib and Burghardt 2020, Brookes et al., 2024) and is showing promise when applied to cattle social and individual behaviour. This research at University of Bristol will utilise our AI-infused annotation tool for behaviour scoring. This tool has a user-friendly interface to label BCS, mobility scores, as well as social interactions and individual behaviours to create a library of labelled data to be exploited for the development of automatic detection algorithms.

There are several challenges associated with the use of cameras to ensure the reliable detection of each individual cow which includes differentiating individuals in crowded areas (e.g milking parlour entrance), re-identifying individuals between different camera views, and in diverse lighting. Additional work is

being conducted to apply recognition algorithms across farms with various breeds that may not have distinctive coat patterns. This work focuses on depth images as a biometric measure for individual recognition (Sharma et al., 2025). The depth camera can also be used to optimize the BCS of cattle on farms, with the overall aim of improving the accuracy of the autonomous monitoring system.

Future work in this area of research at the John Oldacre Centre for Dairy Welfare & Sustainability Research will focus on collecting large datasets to optimize locations for capturing all behaviours of interest for automatic and disease detection. Further work will collect data at a number of representative farms across the UK and close collaboration with farmers and other stakeholders to translate the work for commercial use. This will include multiple workshops with the stakeholders to optimize the system and provide services to benefit farmers, such as, notifications of behavioural changes (otherwise called health alerts) as soon as they are detected. There are several advantages of an autonomous tracking system for veterinarians such as remote access to farm data and health metrics of individual animals and the herd as a whole. Despite these advantages it is key to keep the stakeholders at the heart of this development as these systems are aids to farm management not complete replacements of experienced staff. Therefore, the work being conducted at the John Oldacre Centre for Dairy Welfare & Sustainability Research in close collaboration with key stakeholders

aims to deliver direction and an autonomous detection system for a more sustainable future in livestock production encompassing all aspects of sustainability.

Acknowledgements

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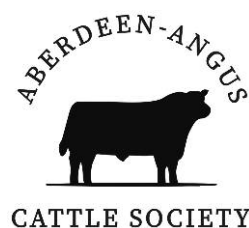
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'The Herd of the Future'

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Genetic gain – are we squandering a great opportunity?

Ben Williams
Sustainability Manager UK and EU, Leprino Foods

Dairy production is a manufacturing industry. This is a statement that can spark all sorts of interesting discussions and debate. However, at its heart inputs enter the system, they are processed, and outputs leave. They are at least akin to a manufacturing system, if not a direct parallel.

In Manufacturing, the machinery of production is sought to be optimized through aligning with the pull of demand. Inputs and resources flow through the system and, upgraded machinery can increase throughput, boosting the productivity of the manufacturing system. If newer, faster machines are deployed, there is always a risk of underutilization of their true potential, if the surrounding production environment limits their capacity or creates 'bottlenecks'.

The same challenge can be observed in dairy production, newer, potentially higher yielding animals are brought into the herd under the promise of genetic gain. This is measured by an increase in the Productive Lifetime Index (PLI) with lifetime being a key word we'll discuss later. Bringing a high yielding cow into a system that has bottlenecks, means that the potential gain is often lost in the system. The dairy production system at its very core doesn't really seem to recognise that risk, even the way farmers may introduce themselves, suggests that there is a lack of understanding value creation in the dairy system,

'Hi, I'm Ben and I have 300 cows.'

In manufacturing that is weird, it's not normal. *'Hi, I'm Ben and I have 3 metal presses.'*

Who cares? *'I'm Ben and I generate £500,000 of revenue'*, that's an interesting discussion.

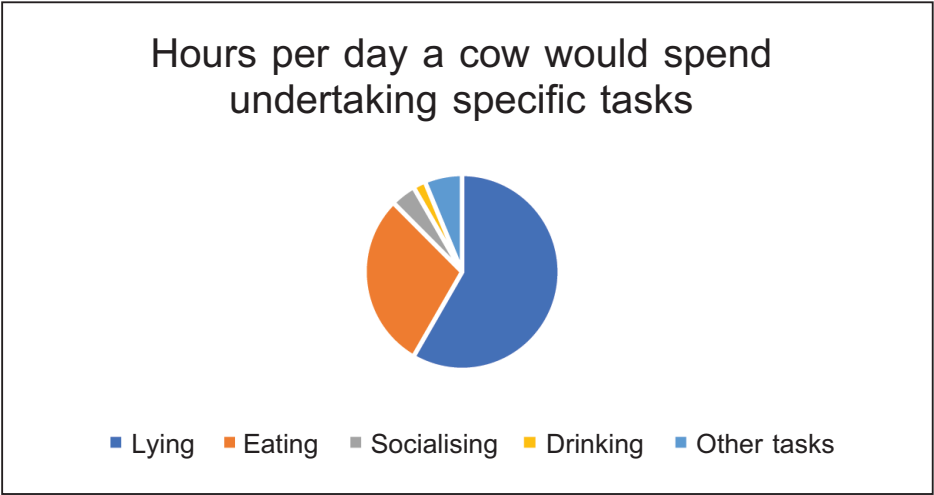
Starting to focus on yield or return, the value in production, is key to a 'sustainable' dairy system – Both profit and planet.

So, what constrains yield in dairy? Let's look at the cow day (see Figure 1) a cow likes to lie down for 14 hours a day, feed for at least 6 (in lots of short breaks not one long feast), drink, socialise and display normal behaviour for another 2–3, leaving at best 1–2 hrs for everything else 'we' want to do to the cow including milk her. Any limitation on these values and the optimal environment in which to express behaviour is constrained. Losing one hour of lying time, loses a litre of milk, a mile spent walking to the parlour, loses a litre of milk, lack of optimized day night cycles to encourage lying, loses litres of milk.

We often measure the optimization of a cow's environment by access to grass or suitable housing. In both scenarios we may well limit the cow. In grazing scenarios, grass is a long way from the parlour, limiting intake, water can be at the far end of fields, limiting intake. In the housed system we use measures such as 'stocking density', the cubicles per cow to assess suitability however, having the right number, doesn't mean they are suitable for the cow. We often see bed lengths too short, head rails too low and limited lunge space that leaves cows perched on beds rather than fully engaged. In manufacturing, if your workers were 140% more productive sat on comfy chairs you'd buy them the comfiest chairs. A dairy cow produces 140% more milk lying down than stood (McWilliams et al, 2022).

Let's imagine the cubicles are plentiful, comfortable and at least close to feed (less than 10m), can

Figure 1: Value add tasks in a cow day that impact yield.



the cow still get there or is access limited by one way in or out and a great big bully cow blocking? Is there enough feed face? Legal provision does not necessarily meet genetic provision. What about water? Again, legal does not mean palatable, at a high enough flow rate or accessible. A cow should not derive dry matter from the drinking trough. Limiting any one of these, creates a bottleneck and biological pressure on the cows. In a pressured system, we see distribution from the norm, some cows do well, often confirming our bias that we have succeeded in producing great cows, some won't. These are our unproductive animals and 'voluntary culls', I suspect if you asked her, she wouldn't class herself as a volunteer. Those are the cows 'we broke'.

Surely this isn't commonplace though. We all know 'good farms' with high yielding cows, those impressive operators we aspire to see more of. We have worked with some of our best operators to embed lean thinking into their management processes, centering the cow as the sole value creator on the farm. The result was a reduction in the cost of production (3–6ppl YOY), often due to increased literacy or fewer losses for the same inputs. In essence optimizing the cow flow and environment to ensure they can realise their full potential.

So what? That's easy to do, just takes experience/good advice/good collaboration with your advisors. Yet we still see the same rubbed necks, lame cows and poor retention rates across the sector. The advice for whatever reason is not being delivered, used or acted on. What's more interesting is that the poor flow through the day-to-day environment is amplified by poor flow through the production cycle. Let's be frank, in a production system the machinery of production has a finite lifespan, the same being brutally honest is true of a cow, they like us, will not live forever. Data provided for average UK lactation has moved between 2.8 (NMR) and 3.6 (BCBC) depending on your source and time of assessment (affected by milk price and cull

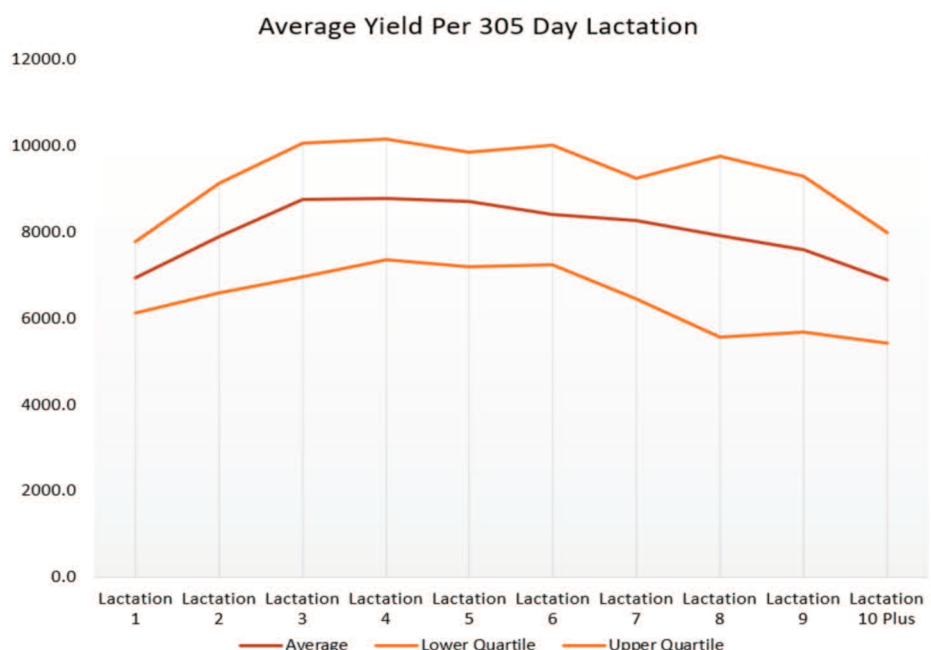
value). Looking at when a cow reaches peak varies hugely by breed and system, but a 1st lactation cow is biologically limited to around 85% of an adult's yield, in Leprino herds, peak lactation is seen around 3rd lactation with a stable curve to 6th and even 7th lactation before dropping back beyond 8th (see Figure 2). This tracks similarly to research by the likes of De Vries (2021) and Dallago et al. (2021) which suggests 3rd–5th lactation animals are the most productive and profitable of cows, before a loss of genetic gain (from lower replacement rates) and old cow costs start to affect the value of the cow. This would suggest that a replacement rate (allowing for TB losses, mortality and expansion plans) of 20% would be the most 'sustainable rate of replacement (factoring in business performance and carbon footprint).

Leprino herds tend to operate a 32–38% replacement rate (the rate varies across the year depending on exits from block systems and all year round). This is a long way from the sustainable 20% figure and aligns with the 2.8–3.6 lactations we see of longevity. Again, so what? If we replace them, thanks to sexed semen, genomics and the ability to select bulls on a number of 'proven

traits', what we lose in 3rd lactation plus cows, we gain in genetic potential. Each generation comes in better than the last! Or does it? And if so, at what cost?

Here is the first misconception, when we look at the impact of environment on potential, this is often set or limited by the calf facilities, the push for larger numbers of heifers, stretches the capacity of the calf rearing environment. What we find in Leprino herds is that the average 1st lactation animal yields around 75% of a peak 3rd lactation yield, not the realistically achievable 85%. As I shift ever more animals away from my peak yielding lactations (3rd–5th) and into my lower yielding 1st lactation animals (at best 85% of adult yield and more often than not, worse than that) I lower my total herd average. Not necessarily drastic but enough to lose litres in my tank equivalent to any potential genetic gain I would have seen. The cost of lost litres of milk, due to overproduction of heifers to Leprino farmers in Wales alone is circa £8.1 million per year (valuing milk at the long run average price of 30ppl). This is a lost opportunity cost, a value not seen on the books but there for claiming if we make the movement of animals in the system more efficient.

Figure 2: Milk yield by lactation for Leprino herds.



But genetic gain is permanent! Even if I lose in my 1st lactation, my entire system will catch up and see a step change in yield. The only permanence in any system is death! Death actively removes genetics from the system and of the heifers born into the system around 15% never make it to calve in, furthermore, a large number never make it to their second lactation. Going back to the measure of genetic gain – PLI, the key word is lifetime. We gain little to nothing if its dead. Even a heifer that has provided 1–2 calves before passing has likely passed you a compromised cow, into a compromised system. We know that genetic markers, epigenetics, are inherited and set not by genetic potential but by environmental pressure. Plus, a hope of reaching a newer, higher peak of milk from older cows is never achieved if you don't keep them to beyond 3rd lactation (ideally an average of 5th). Replacing 32–36% of the herd means that 'on average' this is mathematically impossible.

So, we see a system in which innovation, of huge value – genetic gain, is squandered.

- Should we lambast the farmer for ineptitude?
- The genetics companies for a failure to support the farmer in using their product effectively, whilst pushing semen sales through advising unsustainably high replacement rates?
- The milk recording organisations that fail to provide data that gives any meaningful insight?
- The levy bodies with their KE events that teach the same tired tropes of sticky plaster solutions?
- The feed advisor, building designer that can't make a bed the right length, or suggest the feed face is compromised?
- The dairy processor that pushes an assurance scheme that looks at paperwork and less at actual cow welfare?

The honest answer is all of the above. For whatever reason we have all lost sight of what drives value in our system – The cow. If we want to see true progress for better bank balances and a better planet, we need to improve how we manage

our farming systems from the day to day to the strategic guidance and support. If we don't, despite all the amazing technology at our disposal, there will be no change. In fact, we may as well pee into the wind.

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Adapting to the changing world of genetics in dairy farming: the search for the 'Invisible Cow'

Andrew Thompson, Consultant, Preston

Introduction

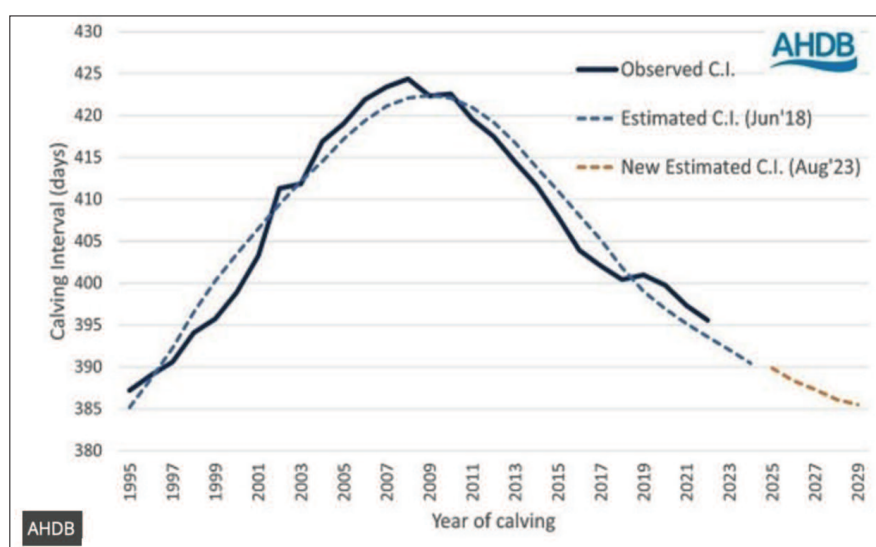
The dairy farming industry is undergoing a significant transformation, largely driven by advances in genetic research and breeding technologies. As farmers seek to optimise production, improve herd health, and increase sustainability, they are confronted with a new challenge: navigating the evolving genetics landscape.

The search for the 'invisible cow' – a term that represents the ideal dairy cow of the future – has intensified as industry stakeholders recognise the crucial role genetics plays in shaping the future of dairy production. This paper explores the changing genetics industry, the impact of these changes on dairy farmers, and how they will need to adapt to remain competitive and sustainable.

The Genetics Revolution in Dairy Farming

Over the last few decades, the genetics industry has revolutionised dairy farming practices, offering farmers unprecedented opportunities to improve herd performance. Conception rates, for instance, have improved significantly, with an average conception rate now standing at 39% (Hanks et al. 2024, University of Reading), a remarkable 7-point increase over the past 14 years. This surge in fertility is attributed to a combination of factors: more intense breeding strategies, healthier herds, better farm environments, and advances in semen technology. These developments have led to faster genetic progress, higher yields, and a more efficient farming process.

Figure 1: Ref, AHDB, demonstrating the significant improvement in dairy cow fertility over the last 14 years.



However, while these advancements have brought about a more productive industry, they have also created new challenges, particularly for genetics businesses. The more efficient breeding process has reduced the overall number of straws of semen needed to be sold to maintain herd size, thus diminishing the revenue for genetics companies.

This 22% reduction in semen sales, through fertility alone, has resulted in a significant income loss for the genetics industry, with estimates showing that the reduction in income from genetics businesses could be in the tens of millions of pounds globally, for each of those who market on a global basis.

While farmers benefit from improved dairy cow performance, greater income from beef calves, and improved animal well-being, genetics

businesses are seeing shrinking margins and a shrinking market. This economic discrepancy signals a major shift in the market, with genetics businesses facing increased consolidation as they strive to remain profitable.

The Role of Genetics Businesses in the Changing Landscape

The changing dynamics of the dairy industry have prompted genetics businesses to rethink their strategies. As the demand for more efficient dairy herds continues to grow, genetic companies are faced with the difficult task of staying relevant in an increasingly competitive marketplace. To achieve this, they are focusing on cost savings, particularly in field operations, as well as pushing for greater investment in research and development (R&D) to continue advancing genetic progress. However,

Figure 2: Ref, Toghiani and Van Raden, 2021, USDA, to demonstrate the correlation between different global dairy cow genetic indexes.

	AUS	CAN	CHE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	JPN	NLD	NZL	USA
AUS	1.00	0.74	0.72	0.74	0.74	0.74	0.84	0.71	0.82	0.76	0.69	0.79	0.69	0.86	0.71
CAN	0.74	1.00	0.92	0.94	0.96	0.96	0.85	0.94	0.92	0.93	0.93	0.80	0.92	0.80	0.97
CHE	0.72	0.92	1.00	0.95	0.94	0.94	0.88	0.94	0.91	0.91	0.94	0.81	0.95	0.83	0.91
DEU	0.74	0.94	0.95	1.00	0.94	0.95	0.90	0.91	0.89	0.92	0.92	0.85	0.92	0.79	0.93
DFS	0.74	0.96	0.94	0.94	1.00	0.96	0.87	0.95	0.92	0.93	0.94	0.83	0.95	0.83	0.94
ESP	0.74	0.96	0.94	0.95	0.96	1.00	0.87	0.95	0.91	0.94	0.97	0.82	0.94	0.81	0.96
FRA	0.84	0.85	0.88	0.90	0.87	0.87	1.00	0.81	0.86	0.88	0.85	0.92	0.85	0.80	0.84
GBR	0.71	0.94	0.94	0.91	0.95	0.95	0.81	1.00	0.92	0.91	0.92	0.76	0.94	0.84	0.93
IRL	0.82	0.92	0.91	0.89	0.92	0.91	0.86	0.92	1.00	0.89	0.88	0.77	0.90	0.93	0.89
ISR	0.76	0.93	0.91	0.92	0.93	0.94	0.88	0.91	0.89	1.00	0.93	0.80	0.94	0.83	0.94
ITA	0.69	0.93	0.94	0.92	0.94	0.97	0.85	0.92	0.88	0.93	1.00	0.79	0.94	0.79	0.93
JPN	0.79	0.80	0.81	0.85	0.83	0.82	0.92	0.76	0.77	0.80	0.79	1.00	0.79	0.73	0.78
NLD	0.69	0.92	0.95	0.92	0.95	0.94	0.85	0.94	0.90	0.94	0.94	0.79	1.00	0.81	0.92
NZL	0.86	0.80	0.83	0.79	0.83	0.81	0.80	0.84	0.93	0.83	0.79	0.73	0.81	1.00	0.78
USA	0.71	0.97	0.91	0.93	0.94	0.96	0.84	0.93	0.89	0.94	0.93	0.78	0.92	0.78	1.00

¹ AUS: Australia (BPI index), CAN: Canada (LPI index), CHE: Switzerland (ISEL index), DEU: Germany (RZG), DFS: Denmark, Finland, and Sweden (NTM index), ESP: Spain (ICO index), FRA: France (GDM index), GBR: Great Britain (PLI index), IRL: Ireland (EBI index), ISR: Israel (PD11 index), ITA: Italy (PFT index), JPN: Japan (NTP index), NLD: Netherlands (NVI index), NZL: New Zealand (BW index), USA: United States (NMS index)

² Sires born between 2005-2010 with at least 200 USA yield daughters

these innovations come at a steep cost.

For global genetics companies, market penetration and strategic alignment with international breeding standards are critical for survival. Companies must decide which ‘race’ they want to run – whether to prioritise genetic progress in high-volume markets like the US or to target the rapidly evolving genetic needs of diverse markets across the world.

Given the global scale of the market, estimated at 200–250 million doses annually, genetics companies are under immense pressure to develop products that are not only efficient but also adaptable to various farming systems and markets.

Furthermore, genetics companies are increasingly engaging in partnerships with farmers through contractual agreements. These partnerships, often focused on creating ‘nucleus herds,’ involve strict terms to safeguard the value of genetic material. These arrangements help to mitigate the risk of ‘genetic leakage,’ which can result in significant financial

losses for genetics companies. With sires like ‘Shottle’ in the past and ‘Captain’ more recently, subsequently influencing at least 4–5 generations of animals and beyond, it’s conceivable that easily tens and perhaps even hundreds of millions of pounds of the value of any of these genetic businesses, could be wiped out with such leakage.

As a result, it is critical for farmers to understand the nuances of these contracts and their implications for herd management, as failure to comply with contractual terms could result in legal action and financial penalties.

Adapting to a New Era of Genetic Breeding

For dairy farmers, adapting to the changing genetics landscape involves embracing a combination of traditional breeding methods and new technologies. The integration of genomic testing, the use of sexed semen, and the development of specialised beef genetics are becoming increasingly essential for maintaining profitability and meeting consumer demands. Indeed, more

beef today in the UK is now supplied from the dairy herd as crossbred animals, rather than traditional suckler style, pure bred animals.

Genomic testing has become a crucial tool for selecting the right cows to breed, helping farmers make more informed decisions about which animals to include in their breeding programs. Ultimately selection accuracy has been revolutionised through this process, all helping to contribute to the rapid genetic progress being made in the UK dairy herd. With genomic testing allowing for the identification of desirable traits early in an animal’s life, farmers are able to make better breeding choices that align with both economic and sustainability goals. Farmers who embrace genomic testing will be better positioned to improve herd health, reduce disease susceptibility, and increase overall milk production efficiency.

PLI ultimately embraces many of these traits and helps to shape why the UK dairy herd has remained relatively stable in population. Although profitability is never enough, when compared to other areas of

the world, UK dairy farms perform competitively on a pence per litre cost of production.

Sexed semen has also played a transformative role in dairy breeding. By ensuring a higher proportion of female calves, farmers can increase their milk production potential while simultaneously reducing the number of male dairy calves, which we know had become a low value by-product of the breeding process. Similarly, the integration of beef genetics into dairy herds is helping farmers tap into new revenue streams. Beef calves, produced from dairy cows, offer a valuable market opportunity that helps to offset the costs of dairy farming and improve overall farm profitability.

As genetic advancements continue, it is likely that we will see even more specialised breeding programs designed to meet specific production targets. This includes the development of cows with optimised health profiles, higher feed efficiency, and reduced environmental footprints. These cows, often referred to as 'invisible cows' in the industry, are those that exhibit superior traits without necessarily being visible to the naked eye. These advancements hold the promise of creating more resilient, efficient, and sustainable dairy systems.

The Economic and Environmental Impact

One of the most significant challenges for the genetics industry is the cost-effectiveness of breeding programs. Ultimately many genetics businesses all around the world can find themselves investing close to £100,000 per bull in their own program before production costs, before considering spending a million pounds for a free agent top 10 bull in the world. Contrast this against the average farmer spending 1–2% (0.4–0.8ppl) of the cost of production on their genetics.

On the environmental front, genetic improvements hold great promise for reducing the carbon footprint of dairy farming. More efficient cows that require less feed to produce the same amount of milk can help reduce methane emissions and lower the overall environmental impact of dairy operations. As sustainability becomes a key focus for the agricultural sector, dairy farmers will need to prioritise genetic programs that align with both environmental goals and economic viability.

Conclusion

The dairy industry is entering a new era, one that demands increased attention to genetic strategies. The advancements in genetic testing,

breeding technologies, and the integration of sexed and beef genetics have transformed how dairy farms operate. To remain competitive, farmers must adapt by staying informed about the latest scientific developments, understanding the financial implications of their breeding decisions, and forge strategic partnerships with genetics companies.

As the agricultural supply industry continues to consolidate, dairy producers need to pick their partners of choice, in the same way they pick their customers of choice of whom they sell their milk and livestock to. This isn't just about purchase price but about delivering consistent value for money and the correct genetics for the long term vision of their dairy farm, with clarity around the terms of how they can market future genetics.

As genetic technologies continue to evolve, dairy farmers will need to embrace new tools and practices to optimise their herds and ensure long-term sustainability. While the search for the 'invisible cow' may seem abstract, the reality is that the cows of the future will be shaped by science, technology, and careful decision-making. Those who can successfully navigate this rapidly changing genetics landscape will be best positioned to thrive in the years to come.

Developing future dairy genetics at farm level

Andrew Rutter

Herd Manager, Clayhanger Hall Farm

In the late eighties, genetic selection was based on a few production traits and type linears. Today we have a plethora of traits and composites designed specifically and evaluated for the UK farmer through AHDB. We can aggressively select for improved profitability, whilst reducing our impact on the environment and make our cows less susceptible to diseases and reasons for involuntary culling, whilst ultimately improving the efficiency for turning forages and bi products into healthy, nutritional, delicious food for a growing and ever more demanding population.

And generally, select for these traits we have as an industry. We have embraced the new traits and indices which is borne out by the improvement in genetic levels we see for production, improved health traits and now reduced carbon footprints.

Genetics and breeding equates to about 1–2% of outgoings on a dairy farm in the UK, yet its return on investment is second to none. Do we as an industry spend enough time selecting? Are we selecting for too many traits which will blunt genetic progress in more key traits or even selecting for antagonistic traits by following aesthetics rather than out and out performance.

Looking at correlations on traits and composites for the available bull list today, high TMerit composites counterintuitively slows down progress in improving longevity compared to selecting for PLI/ EnviroCow/healthy cow indices. Type Merit is actually negatively correlated with Feed advantage. Feed is one of our largest costs on farm so surely breeding our cows to be more feed

efficient should be a key goal for both our profitability and sustainability.

Shouldn't form follow function? Type used to be one of the main reasons for culling in the national herd decades ago, these days it wouldn't trouble the top five reasons as studies by AHDB, CAFRE and Esselmont et al have shown.

We have significantly skewed the population for udders, legs and feet and frame and we should also consider the continuing troubling correlations with "higher" type merit and size. We have slowed the rate of progress of size increases in the national herd, but we still increase, which is troubling.

The national herd could progress genetically more rapidly with targeted selection. At Clayhanger we started with aggressive sire selection. After a few years we started genomic testing females to make much more progressive matings for goal traits.

I use AHDBs HGR at home religiously. All our youngstock are now genotyped, and the eldest ones tested are now in the milking string (genetic audits are showing that genetics pays us back on its promise). Each proof run is like GCSE day for our girls so I can grade our females well in advance of reaching the breeding pens. I use a combination of a cutoff for certain traits below which they will be bred to beef, and a ranking that will sort my top 2/3–3/4 which are bred to sexed dairy.

We started with a herd and youngstock both in the 65th percentile, and

within six years have got the herd into the top 5%, without buying in stock or ET, showing what targeted selection can offer for performance, efficiency and future proofing stock.

For a 400-cow milking herd, moving up this much is worth nearly 230k in improved margin over the herds lifespan. And for our youngstock, a further 200k.

We have seen UK females at the top end of the list improve phenomenally in respect to the sires available. The interesting point now is looking at the top list and seeing how they would compete against bull studs. 137 females would each have been high and old enough to take a place in the top 100 PLI sires available today to the UK farmer had they been born male, yet not one of the bulls in the top 100 is born and bred on a UK farm.

UK females have to perform under UK conditions, and we have generations of world class leading information and reliability on them, yet they seem to be overlooked these days as a population for the studs. Should we just depend on overseas sires going forward? These bulls at the top of the list will have initially been made as matings to hit US goals and we are just "lucky" they rank so well on our system.

TPI and NM\$ remain internationally accepted and marketed indices. If they breed for NM\$, then the correlation is high, nearly 0.9 between PLI and NM\$ so we should end up with high UK value bulls.

However, the correlation is not 1 and that correlation whilst high starts to

show noticeable differences when you get to the extremes as when you get to the top 100 NM\$ available list and compare to the top 100 PLI they are very different beasts.

The issue with the main studs breeding for overseas indices first is that we could be missing out on more tailor made solutions to our own problems, which ultimately could affect the speed of progress. PLI is a financial index, and not historic, it's also forecasting and predicting what the market will be like in the future for UK dairy farmers, it's the only index out there doing that.

Then, consider the semen contracts. Many of the top bulls today come with some sort of a contract.

Of the top 100 sires available today, 34 came with some sort of contract you must sign before being able to buy semen to use on your own stock at home. Genus ABS's Geneadvance/Icon sires, Alta Edge, Faststart from Semex, WWS Nxsgen, AI total and STCogent Legend contracts all have some restrictions about what you can do, where and when. Some of them where you can use them, some impact your ability to sell females and/or bulls without permission, if at all, some even impact the next generation, some include a compulsory purchase for stock over a certain value, and anything in between, all as a way for the studs to protect their IP.

You should speak to your genetic company of choice about the full implications to your business before you sign anything.

The studs want to protect their assets, but who is protecting the IP of farmers? We have developed female lines in the country some-times of many generations, and decades of work to get the herds we have today, so the ability to breed a world class female and lose it or force some of your decision making for the next generation or two is alarming. Ultimately this will slow genetic progress for the country. And the reasons are three fold.

As it currently stands, it's not easy finding out which sires currently have contracts, it just becomes a bit of a nightmare. This is another reason for farmers to align themselves to one stud, sign up to them to use their best bulls and save themselves the hassle. Which means you are beholden to that stud for the long term. If you are considering this, work with a stud with a large enough critical mass of sires at the top, and continuing large investment, with goals that seem to fit in general with your business, as they are more likely to deliver high ranking sires that suit you. The downside is you have a much smaller pool of genetics with one stud, missing some extreme bloodlines that other studs develop and you will likely see your inbreeding coefficient rise more aggressively.

You may elect to use just contract free sires, as currently 2/3 of the top 100 are free. Over time, pressure will increase this ratio detrimentally, and the higher that bull is in the charts, and certainly when he is extreme in some combinations of traits, the more likely he carries a contract.

You may decide to sign and follow all the contracts to use the best bulls to make maximum genetic progress. The issue is that all of these contracts are different, and in some cases you just cannot make some matings as the contracts forbid crossing sire A over daughters of sire B which will impact your progress. Some contracts even demand you use 100% of that studs semen to even be able to use their top bulls. And if you do make a worldie, you could see her leaving the farm in some situations for a pre-set fee, which ultimately slows your herds progress as you lose her altogether.

Ultimately genetic progress is also harmed from the studs POV as it means they affected which mating sires they themselves are able to use, impacting their ability to make what could be the best matings, and breeding from within will see inbreeding rise.

As time progresses, we are likely to see more consolidation from the studs, more sires controlled by contracts, and less flexibility of what you, the breeder can do.

We are making serious genetic progress in the UK, thanks to top class indices to select from, genomic sires, g testing females and the huge improvement in sexing technology all which have seen the UK population improve massively.... But we could be breeding even more robust, profitable, efficient cows right now, which in an extremely challenged sector from all sides seems like something we want and need, and what is holding us back is not the cow or the how, but rather us ourselves.

Optimizing heifer rearing: balancing efficiency, profitability, and welfare

Professor Ginny Sherwin

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Synopsis

How can we ensure that our heifer rearing practices are both efficient and profitable while also supporting longevity and welfare? This lecture delves into various methods to assess and improve the efficiency of heifer rearing on individual farms, with a focus on maximizing profitability and sustaining animal welfare.

Impact of Longevity on Herd Performance

Enhancing cow longevity, particularly reaching the third lactation, can reduce the number of heifer replacements needed, increase the number of beef calves available for sale, and lower annual heifer rearing costs. It also reduces overall methane production, as youngstock can contribute 19–33% of total herd methane emissions (Knapp et al., 2014), and optimizes profitability since cows typically reach peak yield by the fifth lactation. Recent studies suggest that the economically optimal longevity is five lactations, based on factors such as genetic opportunity cost, herd replacement cost, and calf value (De Vries and Marcondes, 2020).

The longevity of dairy cows is increasingly recognized as a crucial metric in evaluating herd performance. It influences not only the economic viability of dairy farming but also the environmental footprint and public perception of the industry. Traditionally, longevity refers to the length of time an animal lives. For dairy cows, while their natural

lifespan can extend up to 20 years, the average productive lifespan is much shorter – around 6 years in the UK and 5 years in the USA (Hanks & Kossaibati, 2022; Nowak, 1999). This disparity suggests that management practices significantly influence cows' productive lifespans, often leading to their early exit from the herd. This trend is concerning, as it reflects inefficiencies that have broad implications for herd economics and sustainability.

Understanding Longevity and Herd Dynamics

Longevity in dairy cows is commonly measured in terms of productive life, defined as the duration from a cow's first calving to its removal from the herd, either through culling or death. Other metrics include lifetime milk production and the age at which cows are culled. However, these averages can be misleading as they do not account for the variation within a herd. A more accurate measure might be the percentage of cows that achieve the target lifetime yield, adjusted for farm-specific goals such as fat-protein corrected milk output.

Cows leave the herd for various reasons, typically categorized as either voluntary or involuntary culls. Voluntary culls are economic decisions made by farmers, while involuntary or "forced" culls occur when a cow can no longer contribute productively due to health issues or other factors (Fetrow et al., 2006). Understanding the reasons behind culling is essential for managing herd

longevity effectively. It can reveal whether cows are being replaced efficiently or if underlying management issues are forcing premature culls.

Rather than relying solely on average statistics, it is more useful to monitor the survival rates of cows at key points in their lifecycle. For example, the survival rate of first-lactation heifers to their second lactation is a critical metric, as approximately one in eight heifers in the UK does not make it to their second lactation. This failure represents a significant economic loss, as the cost of rearing these heifers is not recouped through their milk production. Therefore, improving the survival rates of young cows is essential for enhancing overall herd longevity.

Efficiency of Heifer Rearing

Two key performance indicators (KPIs) are used to evaluate heifer rearing efficiency (Bach et al., 2021):

- **Rearing Efficiency:** Percentage of heifers born alive that calve by the target age of ≤670 days (target ≥85%).
- **Heifer Effectiveness:** Percentage of heifers born alive that calve by the target age and complete three lactations (target ≥75%).

Achieving optimal heifer effectiveness depends on survival through calfhoo and reaching first calving by 22 months. The median age at first calving (AFC) in the UK is 28 months, with higher AFC linked to increased rearing costs and potential impacts

on future survival, productivity, health, and fertility (Bach, 2011; Eastham et al., 2018; Sherwin et al., 2016).

Economic Impacts of Longevity

Herd longevity has a direct impact on the profitability of dairy farms. A longer productive life increases the number of days a cow spends in milk production, thereby improving its lifetime yield and overall efficiency. Research from the Scottish Rural College (SRUC) indicates that the British cattle industry loses over £860 million annually due to inefficiencies such as decreased daily live weight gain (DLWG), mortality, and fertility issues. These losses are compounded by high culling rates, which result in a younger herd with more cows in their first and second lactations – periods typically associated with lower milk yields and higher vulnerability to health issues (Geraghty, 2022).

The economic impact of premature culling is significant. For instance, culling during early lactation can cost farmers between £325 and £650 per cow (Vries, 2013). These losses underscore the importance of managing herd longevity to optimize economic returns. By extending the productive life of cows, farms can reduce the need for frequent replacements, lower rearing costs, and improve overall profitability.

Sustainability Considerations

Longevity also plays a critical role in the sustainability of dairy farming. Dairy cows are a significant source of greenhouse gas emissions, particularly methane, which is produced during rumen fermentation and from manure management (Wolf et al., 2017). Increasing milk yield has been proposed as a strategy to reduce methane emissions per unit of milk produced (Knaus, 2009). However, higher milk yields are often associated with shorter productive lifespans, leading to increased culling rates and a higher demand for replacement heifers, which contribute substantially to a farm's overall methane emissions.

By extending the productive life of cows, the number of replacement

heifers needed can be reduced, thereby lowering the overall greenhouse gas emissions of the herd. This strategy not only benefits the environment but also aligns with the growing consumer demand for more sustainable dairy products (Knapp et al., 2014).

Determining Optimal Longevity

The optimal longevity of dairy cows is a complex issue that depends on several factors, including genetic potential, economic considerations, and herd management practices. Research by Professor DeVries suggests that the ideal productive lifespan for a cow is around five lactations, assuming the cow remains healthy. However, this optimal point can vary significantly between farms and requires careful monitoring and management to achieve (De Vries, 2020; De Vries & Marcondes, 2020).

Key drivers in determining optimal longevity include the genetic opportunity cost of keeping older cows versus introducing genetically superior heifers, the lack of maturity costs associated with younger cows, and the aged cow cost, which considers the reduced productivity of older cows. Balancing these factors is crucial for maintaining an efficient and profitable herd.

Conclusion

Longevity is a vital metric for modern dairy herds, influencing both economic performance and sustainability. Extending the productive lifespan of cows can lead to increased profitability by maximizing lifetime yield and reducing the need for costly replacements. Additionally, improving herd longevity can significantly reduce the environmental impact of dairy farming by lowering methane emissions associated with replacement heifers. Determining the optimal longevity of cows requires a nuanced understanding of both economic and environmental factors, tailored to the specific conditions of each farm. By focusing on longevity, dairy farmers can achieve a more sustainable and profitable operation, aligning with industry trends and consumer expectations.

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Micra or Ferrari?

Selecting the right cow for a profitable and sustainable dairy system

Sophie Gregory
Dairy Farmer and Nuffield Scholar

Introduction

It was an honour to be invited to speak at the British Cattle Breeders Conference and to share our experiences in dairy farming and herd development. When first approached about delivering this talk, I questioned whether I had anything significant to contribute to a breeding-focused conference, particularly given that our herd at home is far from a meticulously bred pedigree operation. However, upon reflection, I recognised that our journey in dairy farming – from a share-farming start to full ownership – has been shaped by critical breeding decisions that have directly impacted our farm's profitability, efficiency, and sustainability.

In preparing for this talk, I noted an interesting comment on a flip chart outside the conference room:

“Farmers need inspiration, not education.”

This resonated deeply with me. My goal today is not to provide textbook breeding advice, but rather to share the real-world lessons we have learned in building a herd that is resilient, efficient, and well-suited to our specific farm system.

The title of my presentation, ***“Micra or Ferrari?”***, serves as an analogy for choosing the right cow for a particular farm system. Much like selecting a vehicle, the ideal choice depends on factors such as efficiency, adaptability, cost, and long-term value. A high-input, high-

output dairy cow (the “Ferrari”) may be ideal for intensive systems with full feeding programs, while a low-maintenance, high-fertility cow (the “Micra”) may be more suitable for grass-based, seasonal systems. Understanding what your farm needs – not just what looks best on paper – is critical for long-term success and profitability.

Farm Background and Business Development

My husband Tom and I began dairy farming ten years ago under a share-farming agreement, starting with 280 organic cows on 600 acres. At the time, Tom was working as a full-time foot trimmer, and I was employed as

an accountant with no intention of becoming directly involved in farm operations. However, our passion for dairy grew alongside our business, leading us to purchase full ownership of the business in April 2024.

Today, we manage:

- 400 organic dairy cows, supplying milk to Arla, a European dairy cooperative.
- A total of 1,400 acres, spanning Dorset, Devon, and Somerset, managed across three tenancies and one contract farming agreement.
- 150 head of dairy x beef, a mix of Hereford and Angus crosses, marketed either through direct beef sales or restaurant supply chains.
- 300 acres of arable land, primarily used for additional silage and protein for the farm.

Our calving system follows a structured approach:

- **Spring block** – 300 cows calving within seven weeks (heifers calve within the first ten days).
- **Autumn block** – 100 cows calving to beef sires over seven weeks, providing flexibility in seasonal milk supply and enabling strategic dry periods in response to climatic conditions.

We operate with a small but dedicated team:

- Two full-time employees, both of whom joined as trainees and have been with us for 3–4 years.



- Two part-time staff, including a college student gaining hands-on experience.

One of our most significant investments in farm infrastructure and community engagement is the development of an on-farm education and training facility, set to open in February 2025.

This space will accommodate:

- School visits, which have historically been logistically challenging.
- Apprenticeship and industry training, including sessions for veterinary professionals.
- Local community events, strengthening the connection between consumers and producers.

In addition, we are hosting Open Farm Sunday on June 8, 2025, providing a unique opportunity for the local community to gain insight into modern organic dairy farming.

Breeding for Longevity, Fertility, and Economic Efficiency

A major focus of our herd development strategy has been selecting resilient, efficient cows – those that:

- Require minimal intervention in terms of fertility and health.
- Calve unassisted and transition smoothly post-calving.
- Maintain consistent production levels on predominantly forage-based diets but if the feed milk price ratio is right respond to increased concentrate.
- Exhibit strong feet and legs to cope with a system that involves significant walking distances up hill.

We refer to these high-performing cows as “**ghost cows**” – the ones that require little attention, consistently get in-calf without intervention, and deliver high lifetime production.

A key example on our farm is a family line of cows that originated with a pedigree Shorthorn matriarch.



She produced multiple generations of productive, long-living daughters, including:

- “D**khead” (previously “Friendly Cow,” before her personality dictated a renaming!).
- No. 8, another highly productive daughter.
- Lady Lur (Lurpak), a strong-willed but apart from her attitude you wouldn’t have to do anything to.

These cows embody functional efficiency, demonstrating high fertility, longevity, and adaptability.

Genetic Selection and Breeding Strategy

Our breeding program is based on data-driven decision-making with a strong emphasis on:

- Milk recording and fertility tracking – Continuous monitoring of cell counts, solids, and reproductive performance.
- Johnne’s control program – Early testing and aggressive culling of positive animals have significantly reduced herd prevalence over time. It’s had improved mastitis levels, lameness and improved fertility.
- Tailored AI strategy – We select 6–8 bulls per year, all sexed semen, using a bull-a-day rotation approach.
- Weighing youngstock regularly and getting them to weight something we are still working hard on.

- We are a closed herd but buy in pedigree bulls every couple of years from a high health Johnes free herd.

Our AI approach follows a structured method:

- 42% of inseminations result in a calved heifer (accounting for conception rates, early losses, and stillbirths).
- Selective breeding lists ensure only the highest-performing cows contribute to replacements.
- Beef genetics (Hereford & Angus) are used on low-ranking cows to maximize calf value.

By focusing on fertility, calving ease, milk solids, and structural soundness, we are steadily improving herd efficiency and uniformity.



Lessons from International Dairy Systems

Through my Nuffield Scholarship, I have observed first hand the impact of breeding decisions on global dairy systems:

- In Sri Lanka, farms built for 200 cows house only 30, producing 7 litres per cow per day due to genetic limitations.
- In Indonesia, imported genetics have transformed smallholder dairy farms, increasing average production to 21 litres per day.
- Across Europe and Australia, top-performing dairy businesses have

achieved success by aligning genetics with farm system requirements, ensuring maximum efficiency and profitability.

Conclusion: The Right Cow for the Right System

The key takeaway from our journey in breeding and herd management is not about having the “best” cow but having the “right” cow for the system. Whether your ideal cow resembles a Micra or a Ferrari, the fundamentals remain the same:

- ✓ Focus on resilience, fertility, and efficiency.

- ✓ Breed for profitability, not just aesthetics.
- ✓ Invest in data collection you can't monitor what you don't measure.
- ✓ Make breeding decisions based on system-specific requirements.
- ✓ Get professional help – Tom from dairy services southwest comes once a year to provide advice but also, we buy our semen it doesn't cost us anything extra and he knows our herd.

Dairy farming is a long-term game, and breeding is an investment in the future. The best time to start is always yesterday.



ABERDEEN-ANGUS

The word 'effect' in a bold, lowercase sans-serif font. The letter 'e' is stylized with a white silhouette of a cow inside it. A trail of white dust or particles emanates from the 'e' and curves upwards and to the right, passing behind the text 'effect'.

economic • environmental • efficiency



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