Squaring the bovine circle – An Irish perspective

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Summary

The concept of circular breeding goals necessitates looking at the bovine industry in its entirety and becomes broader than the agri-industry circle when issues such as climate, environment, animal welfare and consumer preferences are being considered. Many of the potential solutions discussed have impact across the bovine sectors or have downstream impacts on the other sectors. Economically balanced breeding goals delivering genetic gain across a wide range of measurable traits are a core building block on the journey to breed more sustainable cattle.

Background

The bovine sector comprised of dairy and beef cattle is worth up to 6.5 bn in yearly export revenue to the Irish economy. For the context of this paper the sector can be broadly divided into four distinct but intrinsically linked sub-sectors namely the dairy sector, the commercial suckler sector, the bull breeder sector, and the dairy beef sector. Currently the national bovine herd stands at circa 1.5 million dairy cows, 950,000 suckler beef cows and their progeny giving a total inventory of circa 6 million animals. In recent years since the abolition of milk quotas in 2015 the dairy herd has expanded by 400,000 additional cows with suckler cow numbers declining in the same period by circa 85,000 cows. Recent national farm survey results (Donnellan *et al*, 2020) indicate dairy herd income averaged €1,118 per ha compared to €285 and €381 per ha for suckler cowherds and other cattle rearing herds respectively. From the perspective of circular breeding goals this paper will outline a number of initiatives aimed to increase productivity, profitability and reduce the carbon footprint across all the sectors simultaneously. ICBF have responsibility to harness genetic gain to increase profitability in a sustainable way for all Irish cattle farmers and the wider agri-industry. This is achieved through an integrated database which continues to evolve to meet the demands of the industry. Figure 1 shows the current level of integration or the within agri-sector circle which currently allows genetic evaluations, profit index and genetic gain generation to occur across the dairy and beef sectors. In addition to genetic gain the database is also accessible to farm advisors to access phenotypic data to help improve profitability at the individual herd level but also at discussion group and milk co-operative level. Figure 1 also envisages the potential future circle as the challenges facing the sector such as the environment and greenhouse gas emissions are tackled and new opportunities are identified such as consumer experiences and perceptions and potential animal product related human health benefits.

Climate and the environment

In 2020 the Irish Government launched a national "Climate and Air Roadmap" for the agriculture sector which aims to reduce the current agriculture carbon footprint from biogenic methane by 10% by 2030 and to become carbon neutral by 2050.Many of the assumptions in that report were based on the Teagasc Marginal Abatement Cost Curve (MACC) regarding greenhouse gas (GHG) and ammonia emissions (Lanigan *et al* 2018). Figure 2 outlines some the actions presented in the MACC report ranging from adopting new management practises to the improved efficiency from increased genetic merit.

Role of current Dairy Breeding in Greenhouse gas mitigation

Improving carbon efficiency through adoption of the EBI for dairy cattle breeding was identified as high value in the MACC report from both a low cost and a high impact viewpoint in terms of emissions abatement. Work by Ramsbottom *et al.* (2012) using individual cow-based and herd-based data reported an increase in net margin per cow of €1.94 per one euro improvement in EBI (expectation of €2). Figure 3 is a diagrammatic representation of the current emphasis within the dairy EBI. More recent work by Shalloo *et al.*, (2021) has elucidated 6 primary traits included in the EBI which have contributed significantly to trends in dairy GHG; calving interval, cow survival, liveweight, milk, fat and protein. Cumulatively, genetic progress (€12.6 EBI/yr) for these key traits is improving gross GHG mitigation by 24.9 kg CO2e/lactation (or /cow/year). Table 1 shows the genetic trend of these 6 traits and the impact on GHG emissions. Results indicate increased genetic merit for milk production traits and liveweight and the associated response in phenotypic performance actually resulting an increase in GHG emissions per unit change in those traits while a reduction in calving interval (related to earlier turnout to avail of less costly feed) and better cow survival (due to less replacements needed as cows live longer)both contribute to a reduction in GHG.

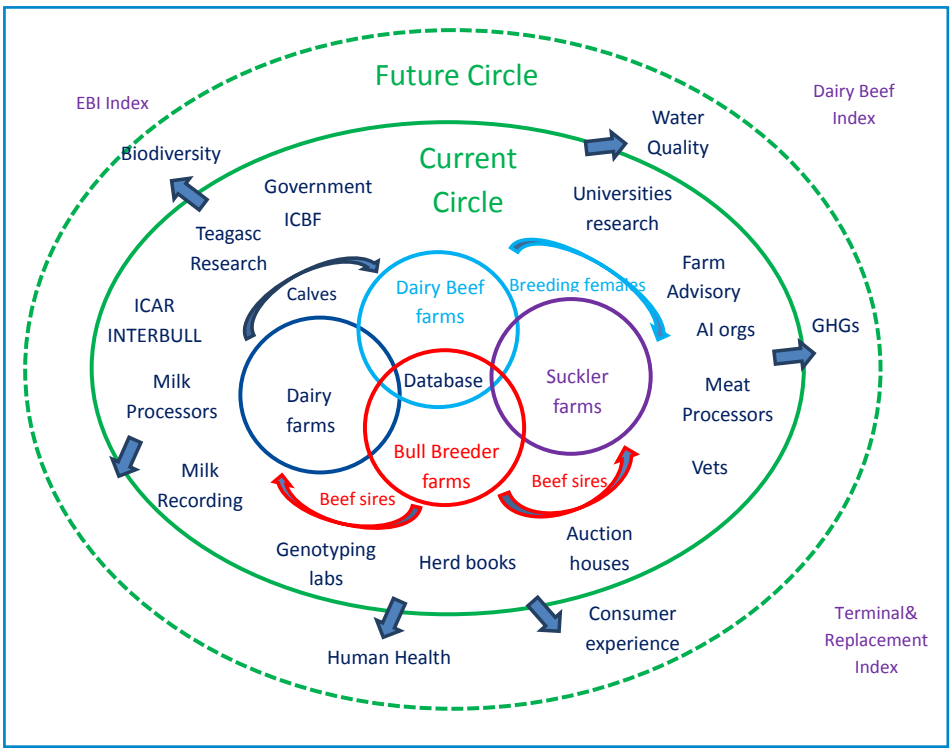

Figure 1. Current and future level of industry integration or circle of engagement for bovine genetic improvement in Ireland

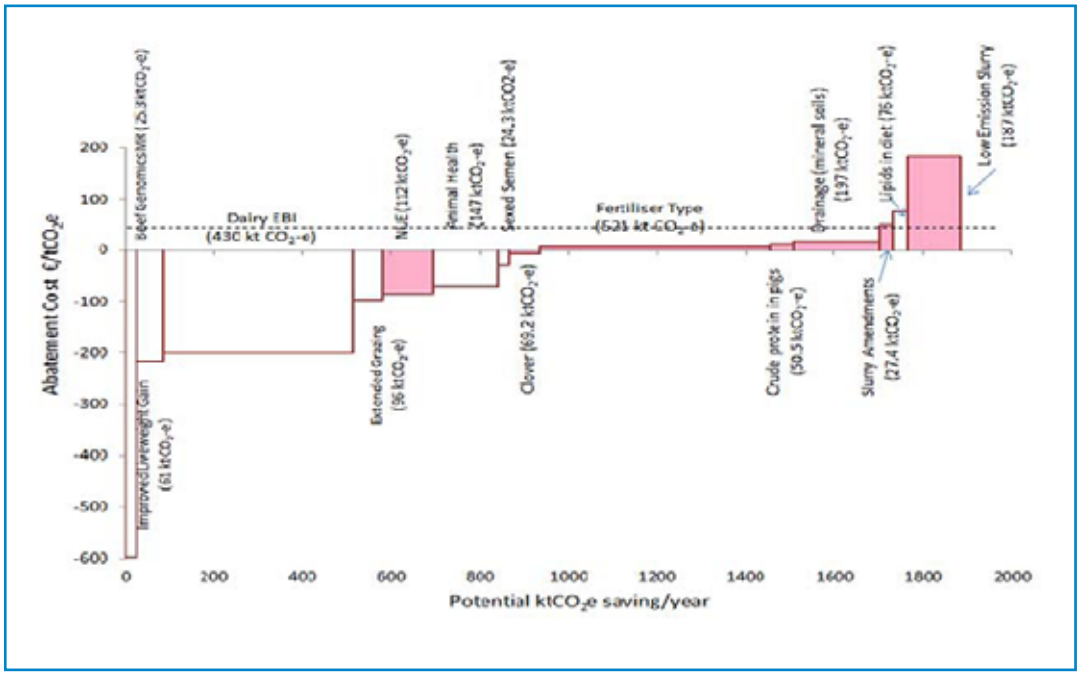

Figure 2. The Teagasc Marginal Abatement Cost Curve for GHG and ammonia (Lanigan et al *2018).*

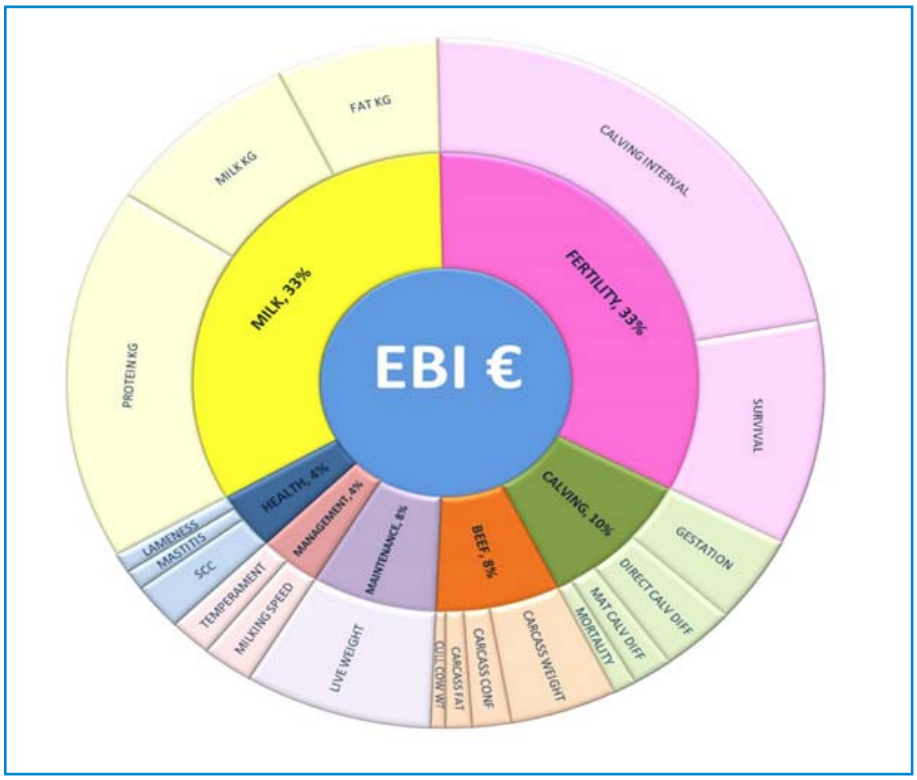

Figure 3. Current trait emphasis in the Economic Breeding Index for Irish dairy cattle

Role of current Beef Breeding in Greenhouse gas mitigation

Genetic progress in the Suckler herd is driven by the Terminal and Replacement economic indexes. The indexes were launched in 2011 but in 2016 the Replacement index was revamped to place more emphasis on maternal traits within the index. Using measures of genetic merit and economic based profit indexes is a more recent concept for suckler beef farmers compared to their dairy comrades. While many dairy herds have been engaging with the ICBF database since 2001 the majority of beef farmers commenced engagement in 2008 with the launch of the Suckler Cow Welfare Scheme (SCWS) where farmers received a monetary payment for recording ancestry, calving, weanling and docility measures. This data provided a significant boost to genetic evaluations and as can be seen in Figure 4 the genetic trend of the suckler herd for Terminal traits increased noticeably from 2010 to 2014 even though there was no stipulation for genetic improvement in that scheme. In 2016 the Beef Data and Genomics Programme was launched which in addition to many of the measures in the SCWS also contained a genotyping requirement along with a genetic improvement stipulation based on the Replacement index. The scheme has resulted in the generation of circa 2 million genotypes from 25,000 herds where the focus was on the breeding males and females in those herds. Those genotypes combined with the phenotypes from these herds have become the corner stone for the ICBF beef genetic evaluations.

Figure 5 is a graphical representation of the traits in the Replacement and Terminal indexes. All Terminal index traits are also included in the Replacement index. The Replacement index places heavy emphasis on Milkability, carcass weight, fertility, longevity and the maintenance cost of the suckler cow as measured through the cow liveweight trait. Work by Quinton *et al.* (2018) estimated that a €1 increase in Replacement index for beef suckler cows reduced enteric methane emissions intensity

Table 1. Key traits in the Dairy EBI which are influencing Enteric methane emissions intensity.

Trait	PTA Trend (units/year)	Change in kg CO2e/trait unit
Calving interval (days)	-0.21	59.8
Survival (% per lactation)	0.12	-34.4
Milk fat (kg)	0.60	5.41
Milk protein (kg)	0.55	5.65
Milk kg	3.12	0.22
Liveweight (kg)	0.22	2.05

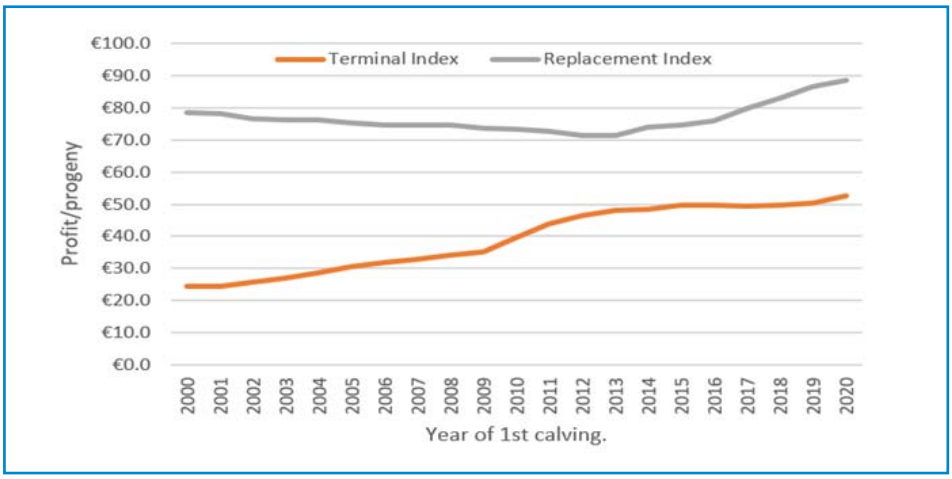

Figure 4. Trend in Terminal and Replacement Index for Suckler herd females.

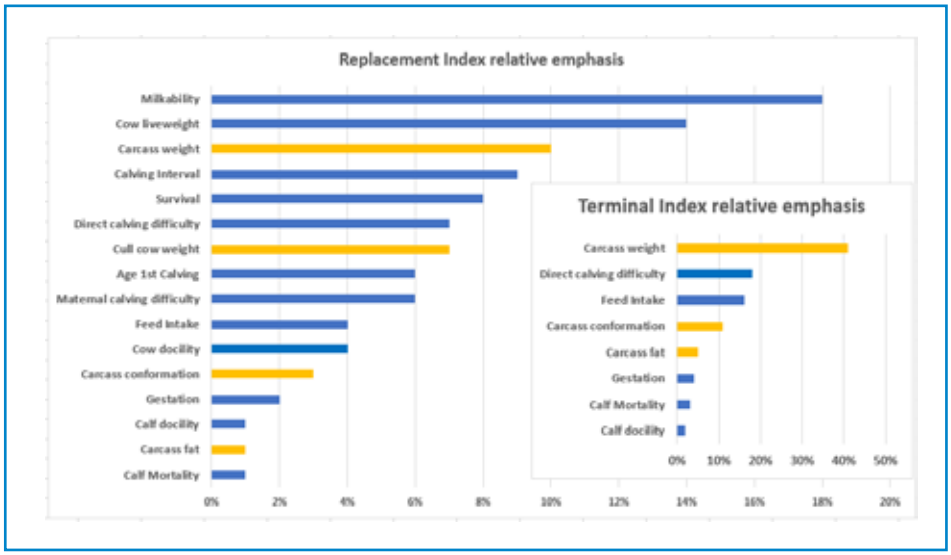

Figure 5. Relative emphasis in the current Replacement and Terminal indexes. Revenue traits are in orange with costs of production traits in blue.

by 0.009 kg CO2e/kg meat/cow/year, and that a €1 increase in Terminal index reduced emissions intensity by 0.021 kg CO2e/kg meat/cow/year.

Can we accelerate genetic progress?

There are a range of avenues available to improve the genetic progress currently occurring but for the purposes of this paper they have been classified into two broad categories namely a) increasing the gain in the current traits and b) incorporating new traits which have either an economic or environmental benefit not captured in the existing trait suite.

Increasing genetic gain in the current traits

Below are 6 areas which can be improved to facilitate increased genetic gain.

Increased AI sire usage and sire recording

Currently the level of AI usage in the dairy herd to generate replacements is high with 73% of dairy sired calves in 2020 sired by an AI sire with the remainder either sired by a natural service sire (10%) or no recorded sire (17%). For those 2020 dairy sired calves the average superiority of AI sires versus natural service sires in EBI was €73. In those same dairy herds the level of AI usage of beef sires on dairy cows is low at 26% with the remainder either sired by natural service sires (34%) or no sire recorded (40%). The average superiority of AI sires versus natural service sires in Dairy Beef Index (DBI) was €22. Similarly in the 2020 suckler herd calves only 19% were sired by AI with 57% sired by natural service sires and 24% with no sire recorded. The average superiority of AI sires versus natural service sires was €7 for Terminal and €36 for Replacement index.

Increased engagement in milk recording

Milk recording drives the Milk sub-index of the dairy EBI but also has a large effect on the Health sub-index which includes the somatic cell count trait. Currently circa 55% of cows are milk recorded. Various initiatives are underway such as engagement with milk recording organisations to provide more value added at the individual cow level (detailed SCC reports, harnessing of spectral for new traits like energy balance and potential GHG emissions) but also with milk co-operatives to build on the existing within co-op benchmarking reports currently available.

Increased cow liveweight recording

Cow live weight is a key component of both the dairy and beef profit indexes where there is a penalty on increased liveweight due to the increased maintenance feed costs associated with larger cows. To date most of the cow liveweight prediction has come from cows which are weighed in auction houses before slaughter or from a numerically smaller dataset from Teagasc research herds which provide comprehensive data throughout lactation. Genetic correlations are also utilised in the genetic evaluation with traits with larger volumes of data such as weaning weight, carcass weight and cull cow weight. The launch of the Beef Environmental Efficiency Pilot scheme in Suckler herds (2019 and 2020) has resulted in over 700,000 new cow and calf liveweight records potentially available for inclusion in genetic evaluations. A nationwide weighing service infrastructure has been put in place to facilitate the low- cost rental of scales by farmer which will be available to both beef and dairy farmers to avail of.

Genotyping all animals through DNA based calf registration

Three pilot projects have been initiated since 2018 to assess the feasibility of DNA based calf registration. The most recent in Spring 2021 included 400 dairy herds. Participating herds must have their full list of breeding females and males genotyped which then allows the ICBF database to parentage verify the calf based on the returned genotype and this information is then relayed to the Department of Agriculture (DAFM) for calf registration. The vision is to migrate the full national herd to DNA based registration by 2030 which will have many benefits in terms of removing parentage errors from evaluations and enhancing genomic training populations.

Harmonisation of bio-economic models

Currently the economic values used in the dairy and beef indexes are derived from the Teagasc Moorepark Dairy Systems Bioeconomic model (Shalloo *et al.*, 2004) and the Teagasc Grange Beef Systems Model Bioeconomic model (Crossan *et al.*, 2006). The two models are independent of each other and designed to accurately assess the economic impact of the traits within that particular sector. However, with issues such as environment and Greenhouse gases and the obvious links between the sectors described in Figure 1, initial discussions have commenced on the potential to combine both models into a single entity to allow synergies such as the ability to model national inventory for aspects such as beef production and GHG emissions.

In 2020 ICBF launched a new profit index called the Dairy-Beef index (Berry *et al* 2019). This index is for dairy farmers who want to use beef sires on their dairy cows. In 2020 690,000 calves were born to a dairy dam and a beef sire which represented 46% of the total 2020 dairy calves. In recent years with dairy expansion, herd size has increased from an average of 44 cows calving in 2010 to 77 cows in 2020. Farmers have placed more priority on calving ease and short gestation for both the dairy and beef sires used on their cows. As a result the carcass merit of the dairy x beef male

calf available to the dairy-beef rearing herds has been declining. The Dairy-Beef index aims to maintain calving traits for the dairy farmer while improving feed efficiency and carcass traits for the beef rearer and finisher.

Adoption of the Dairy Beef Index

Incorporating new traits

Resistance to Tuberculosis and Liver Fluke

Tuberculosis (TB) and Liver Fluke infection are two common diseases which afflict Irish dairy and beef cattle. Levels of TB in the population over the last 5 years has averaged 16,800 cases with 4.3% of all herds experiencing a reactor in the annual herd test. This is despite decades attempting to eradicate the disease and annual costs almost reaching €100m in 2020. Liver Fluke is a common parasite in Irish cattle afflicting 7-8% of steers and heifers and up 40% of cows in wet years. Animal Health Ireland have estimated an average cost of €70 per condemned liver in slaughtered steers factoring in condemned livers and lack of thrive due to infection. The launch in 2019 of genetic evaluations for Tuberculosis (Ring *et al.*, 2019) and Liver Fluke resistance (Twomey *et al.*, 2016) were the culmination of 10 years of collaborative work involving Teagasc, ICBF, DAFM and Animal Health Ireland (AHI). Heritability of TB and Fluke is estimated at 9% and 1% respectively. Work is underway to derive economic values for these new traits to facilitate inclusion is the EBI and beef profit indexes.

Meat Eating Quality

Recent UK retailer research has indicated that if a consumer has a negative experience eating beef, it will be six weeks before they purchase beef again. These results are against a backdrop of declining beef consumption within the EU, compared to pork and chicken alternatives. To address these trends, it is necessary to develop systems to help improve the eating quality attributes of beef for the traits that are of value to consumers, most notably tenderness, juiciness, and flavour. Genetic evaluations for meat eating quality were launched in 2020 as part of ICBF's participation in an industry backed programme called the Meat Technology Centre (MTI) which is a consortium involving Teagasc, Irish Universities and the Irish meat processors. The evaluations are based on circa 5,300 trained sensory panel phenotypes for tenderness, juiciness and flavour of prime cattle steaks following a standard operating procedure around rearing, slaughter and sensory assessment. Resulting heritability estimates (Berry *et al.*, 2021) ranged from 13% for flavour to 15% for tenderness. Genetic evaluation results are transformed to an *expected satisfaction rating* of the progeny from a given sire. The average expected rating for each trait is 80% (i.e., 80% of progeny are expected to have satisfactory tender, flavour or juicy score), with sires higher than this expected to produce progeny with superior meat-eating quality for the relevant trait. The range in average satisfaction values across AI sires with published evaluations (September 2020) is 70% to 90%. While clear breed differences exist (Figure 1), of similar relevance is the variability in meat eating quality that exist within breeds.

Age at slaughter

Reducing age at slaughter is viewed as a potential low hanging fruit in terms of reducing GHG emissions. Initial modelling suggests that if the current prime cattle kill (equivalent to 1.32m cattle in 2020) was slaughtered 1 month earlier than the current 802-day average this has the potential to remove 247 Kilotonnes of GHG from the system or the equivalent of not having to cull 97k cows from the National herd. Initial parameter estimation work suggests the trait has a heritability broadly equivalent to the current carcass traits but that the data needs more stringent editing to remove management effects related to the age of the current kill which are driven by penalties once an animal is killed over a certain age.

Methane yield

The collection of direct methane yield in a meaningful volume is now feasible with the availability of the Greenfeed System (C-Lock, Rapid City, South Dakota).The ICBF progeny performance test centre has evaluated 670 animals to date over the last 2 years using the Greenfeed system alongside the Insentec Feed system (Hokofarm, The Netherlands). Evaluation is being carried out on a range of animal's types (steer, heifer, bulls) and diet types (high concentrate and mixed roughage and concentrate). In addition, the Moorepark Research station is actively collecting methane yield on lactating dairy cows at pasture using the Greenfeed systems. It is hoped that data collected at both centres will help to initially inform researchers of the phenotypic relationships between GHG emissions with diet, animal type, feed intake but as volumes grow it will become feasible to estimate genetic parameters and generate genetic evaluations for methane yield or residual methane yield.

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