Sustainable breeding — what are the options?

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Summary

- The Irish national dairy cow breeding index, the EBI, has delivered a more profitable cow for Irish production systems; the EBI will continue to deliver monetary gains long into the future.
- Selection on EBI is also reducing the environmental hoofprint of Irish dairy cows through a combination of improvements in milk solids output and reproductive performance/survival.
- An economic benefit from crossbreeding with Jersey is still likely via higher production efficiency.
- Sexed semen can be utilised to generate high value female replacements, enabling greater usage of beef semen to reduce the number of low value male dairy calves.
- The recently launched dairy-beef index is a tool to help identify beef bulls for use on dairy females.

Introduction

The Irish Economic Breeding Index (EBI) is a tool to help identify profitable animals. It has been in existence for almost 20 years, and has been widely adopted by Irish farmers. The current makeup of the EBI is illustrated in Figure 1. Milk solids production and fertility/survival constitute two-thirds of the emphasis within the EBI with the remaining one-third made up by calving performance (calving difficulty, gestation length and calf mortality), cow maintenance requirements (i.e., cow live-weight), beef performance (carcass weight, conformation and fat score), health (somatic cell count, mastitis and lameness) and management traits (temperament and milking duration).

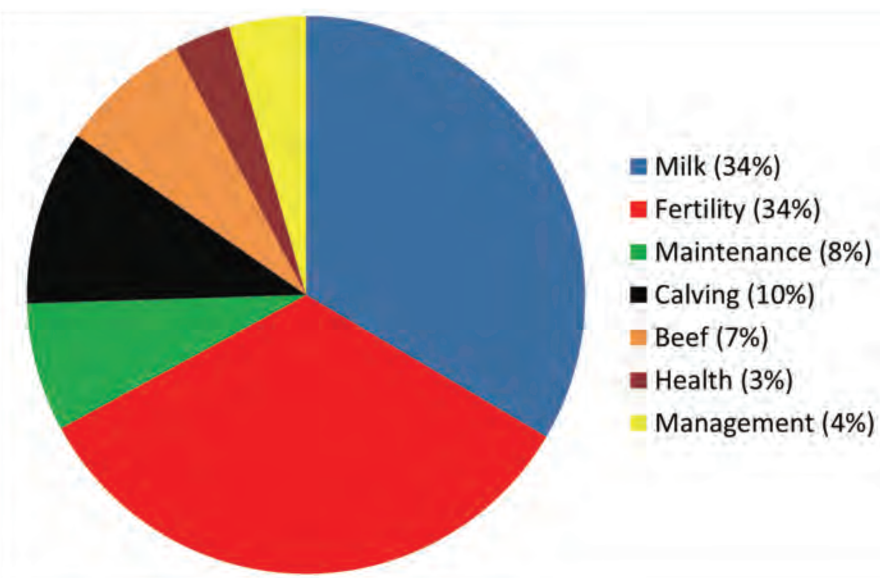

Figure 1. *Relative emphasis on different sub-indexes within the EBI*

The strong emphasis on milk solids, fertility and survival is to boost milk solids yield per cow, but in an economically and socially responsible and sustainable manner. While direct genetic selection for increased milk solids yield will increase 305-day standardised milk yield, concurrent selection for longer lactations via an early calving date from better fertility cows will further increase lactation yield; this is the justification for the large emphasis on fertility within the EBI. Yield per cow is a function not only of yield per lactation, but also the number of lactations achieved. High replacement rate contributes to a younger herd, which will not therefore achieve its mature potential; a mature cow yields 22% more than a first lactation cow. Hence, improved cow longevity through selection for greater survival helps achieve higher milk solids yield per cow, as well as contributing to a socially responsible and economically sustainable system of milk production.

Two notable examples of the benefits of increasing herd EBI are available: 1) analysis of eProfit Monitor data; and 2) the current *Next Generation Herd*. Analysis of the eProfit Monitor data revealed that a one unit difference in EBI was associated with a €1.94 difference in profit per lactation, which is very close to the expectation of €2 difference in profit per lactation. The *Next Generation Herd* compares Elite EBI Holstein-Friesian cows (top 1%) with cows representing the national average, all managed side-by-side. The elite EBI cows produced more milk solids, commanding both a higher milk price and total milk solids sales; this was complemented by significantly better fertility in the elite EBI cows (92% in calf after 12 weeks of breeding), a trend consistently observed every year since its initiation in 2013.

Genetic trends by year of first calving

The average EBI of heifers entering the Irish dairy herd by year of first calving since 2001 is illustrated in Figure 2; this trend is a good reflection of the rate of genetic gain in Irish herds. The EBI of heifers entering the herd is increasing, on average, by €11 per annum over the past 10 years. The rate of gain in profit for the milk sub-index and fertility sub-index over that 10-year period was very similar (€4.43 and €4.29, respectively), implying balanced genetic gain, and indicating that the improvement in profitability was not from one single factor. Cumulatively, since its introduction in 2001, the EBI of the first calving heifers has increased by €143 implying an extra profit of €286 per lactation in the modern heifer relative to the heifer of 2001.

All sub-indexes, with the exception of the beef and maintenance sub-index, have been improving year-on-year during the past 10 years. The maintenance sub-index has not changed over this time period, while the reduction in beef merit equates to a loss in profit of only €5 over the entire 10-year period. While the EBI, as the name suggests, is economic-based, comparison of the carbon footprint per kg fat and protein corrected milk yield produced by the modern high EBI cow is 14% less than the cow that existed at the introduction of the EBI. This has been achieved through a combination of improved milk solids yield, better reproductive performance and greater longevity. Hence, genetic gain through improving EBI is a major contributor to the abatement of carbon on Irish dairy herds, while also being economically advantageous to Irish farmers.

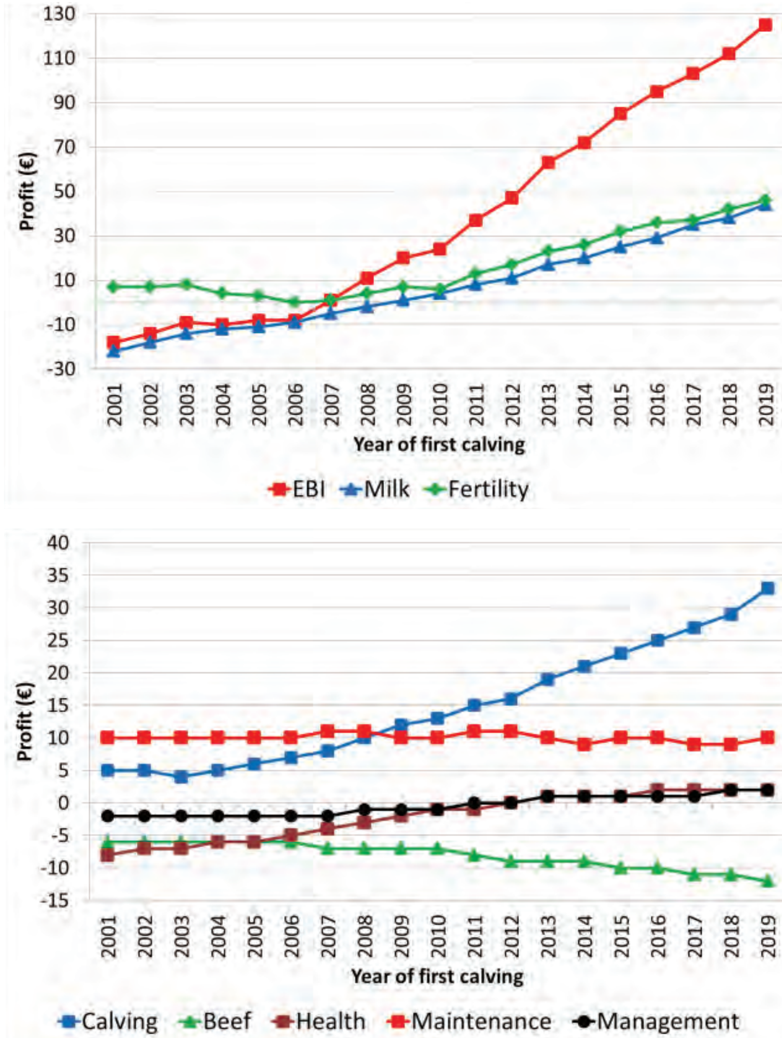

Figure 2. *Average EBI and its component index for Irish heifers by year of first calving*

While fertility of the national herd is improving, it is still far from industry targets on the average Irish dairy farm. Based on the *Next Generation Herd*, under good management, a fertility sub-index of approximately €100 is required to achieve reproductive targets. The average fertility sub-index of heifers calving for the first time in 2019 was just €46. Hence, considerable emphasis still needs to be placed on fertility within the EBI for the foreseeable future. As reproductive performance improves, however, cows will, on average, live for longer. Hence, the health status of the national herd will become ever-more important. Animal health is under partial genetic control, and thus breeding programs focusing more on animal health are warranted to ensure the sustainability of the breeding program.

Crossbreeding with Jersey — does it still have a role?

Crossbreeding exploits favourable characteristics among contrasting breeds, removes inbreeding depression, and capitalises on heterosis or hybrid vigour. Heterosis occurs in crossbred animals resulting in synergies that mean crossbred animals perform better for certain traits than expected based on the average of their parents. It results in 'non-additive' genetic improvement, the magnitude of which depends on the genetic distance between the parents. The heterosis effect also varies depending on the trait of interest;

for example, the heterosis effect is greater for fertility than milk yield, and is greater for milk yield than milk composition. Heterosis is not directly passed from generation to generation, and reflects the contribution of genetics from different breeds within an individual animal (degree to which the animal is crossbred). For this reason, heterosis is not (and cannot be) included directly in the EBI, but it is included in the COW index.

The Jersey breed has many favourable characteristics for crossbreeding in Ireland: small size, moderate yield coupled with high milk fat and protein content, high intake capacity, superior feed efficiency and compatibility with a pasture based system. These characteristics complement the higher yielding Holstein-Friesian. Research has been conducted at Teagasc Moorepark to evaluate the merits of crossbreeding with Jersey since 2006. Five independent studies have been completed, ranging from controlled systems studies in research herds to analyses of commercial farm data. The findings from each study have been entirely consistent with each other and with international research findings. Each has demonstrated that Jersey×Holstein-Friesian cows outperform Holstein-Friesian cows due to a combination of improved fertility and herd productivity. The economic advantage estimated varied between studies, but generally approximated €150 per cow per lactation. The availability of high EBI genomically selected Holstein-Friesian sires has lead people to question if the advantage identified in previous Jersey crossbred research studies still holds true.

The significant and rapid expansion of the dairy industry since 2015 has led to increased supply of very low value dairy bred male calves. This presents a potential image/welfare challenge to the industry. This issue is directly linked to the characteristically compact and seasonal nature of our dairy system. As a result, use of Jersey semen has been targeted for particular criticism due to the poor beef merit associated with the breed.

High EBI purebred Jersey cows were introduced into Teagasc's *Next Generation Herd* in 2018 to provide a direct comparison with both high EBI (ELITE) and National Average (NA) Holstein-Friesian cows. A simulation to determine the economic and environmental consequence at farm level between the three 'pure' breed groups and two crossbred groups was conducted based on biological data (Table 1). The relative breed differences are consistent with previous research that reported higher milk solids production per ha with Jersey. Improvements in milk constituent values reflect recent favourable genetic progress for milk fat and protein content in both breeds. There are no Jersey×Holstein-Friesian cows in the *Next Generation Herd* currently. Crossbred performance has been estimated using the breed performance data obtained in the Next Generation study [2018 performance] and heterosis levels determined from previous research at Ballydague. Replacement rate was assumed to be 17% for the ELITE and both crossbred genotypes, 27% for NA and intermediate for the pure Jersey. The performance presented is based on F1 performance, i.e., cows resulting from the mating of Jersey to Holstein-Friesian. These animals would express 100% heterosis. In the longer term, where the breeds are rotationally crossed, expressed heterosis would be reduced to 66%. As indicated in Table 1, it is expected that the performance benefits from crossbreeding with Jersey would be greater where the EBI of the Holstein-Friesian herd is lower (i.e., NA×JE). This is because of the substantial reduction in replacement costs arising from improved fertility and longevity in crossbred cows in addition to the improvements in productivity highlighted. Nevertheless, crossbreeding with Jersey is still expected to result in improved productivity where the EBI of the Holstein-Friesian herd is high (i.e., ELITE×JE). In this case, it is not expected that crossbreeding would markedly improve fertility and longevity (already good in ELITE cows), and is instead driven by expected productivity gains alone (increased value of milk and greater milk solids output per ha). It is important to note that the performance of the crossbred animals in Table 1 are simulated, and not based on recorded biological data. Further investigation is warranted to determine whether the heterosis estimates and extrapolated results for Jersey crossbreds with NA and ELITE Holstein-Friesian genetics would be substantiated in reality.

Table 1. Simulated farm level (40 ha) performance of the National Average (NA), ELITE and Jersey (JE) genotypes within Next Generation Herd and anticipated impact of crossbreeding

	NA	ELITE	NZ JE	NA×JE*	ELITE×JE*
EBI	110	214	185	~150	~200
Stocking rate (cow/ha)	2.63	2.68	3.18	2.73	2.76
Herd size	108	110	133	114	114
Milk yield (kg)	5,649	5,675	4,100	5,325	5,221
Fat (%)	4.17	4.51	5.86	5.03	5.19
Protein (%)	3.52	3.73	4.24	3.90	3.99
Milk solids (kg)	434	468	414	475	479
Body weight (kg)	515	517	390	470	467
Milk solids/kg of body weight	0.84	0.90	1.06	1.01	1.03
Milk solids (kg/ha)	1,141	1,254	1,317	1,297	1,322
Milk price (c/l)	33.9	36.6	44.8	39.6	40.1
Net profit/cow (€)	622	844	564	829	873
Net profit/ha (€)	1,709	2,322	1,868	2,365	2,479

**Extrapolation based on Next Generation Herd data 2018 & Prendiville et al. 2011*

Research to objectively quantify the influence of dairy cow genetics on the beef merit of their progeny at slaughter was conducted using data extracted from the national dataset from 2008 to 2018 (Table 2). Progeny sired by Holstein-Friesian sires and Angus sires were evaluated across five different dam genotypes: 100% Holstein-Friesian, 33% Jersey, 50% Jersey, 66% Jersey and 100% Jersey.

The first observation is that the progeny sired by either Holstein-Friesian or Angus out of cows ranging from 33% to 100% Jersey genetics were close in value to the same crosses out of Holstein-Friesian cows. The mean differences ranged from €30 less for progeny from cows with 33% Jersey genetics to €100 less for progeny from cows with 100% Jersey genetics when compared to progeny from cows with 100% Holstein-Friesian genetics. Carcass value was €53 less for both Holstein-Friesian sired and Angus sired progeny out of first-cross dams (50% Jersey) compared to the equivalent progeny from 100% Holstein-Friesian cows. This analysis has quantified the impact of dam Jersey genetics on offspring beef merit and indicates that the deterioration is less of an issue than generally perceived. Importantly, the research also highlights the gain in beef merit and carcass value achieved by crossing beef sires on the Jersey crossbred cow.

Table 2. Average slaughter performance of male progeny sired by either Holstein-Friesian or Angus breed bulls out of dams with varying proportions of Jersey genetics (national data, 2008–2018)

Breed	Jersey proportion of dam	Carcass weight (kg)	Carcass grade (1–15)	Carcass fat (1–15)	Value (€)	Age at slaughter (days)
Holstein-Friesian sire	0%	323	3.76	6.28	1,101	834
	33%	314	3.95	6.39	1,072	836
	50%	310	3.81	6.45	1,052	838
	66%	305	3.82	6.50	1,036	840
	100%	296	3.86	6.58	1,003	843
Angus sire	0%	327	5.37	7.00	1,179	803
	33%	319	5.24	7.11	1,143	806
	50%	314	5.18	7.16	1,126	808
	66%	310	5.12	7.22	1,108	810
	100%	300	5.00	7.32	1,072	814

[1]*Reference animal is a steer slaughtered at 28 months, except for age at slaughter which is a steer slaughtered at 320 kg of carcass weight and a fat score of 7.*

It is, therefore, advised that Jersey genetics be exploited responsibly with consideration given to the use of sexed semen, greater use of high DBI beef sires, more cognisance of required replacement numbers and acceptance that it may be necessary to retain non-replacement calves longer in order to increase saleability in the market place.

Sexed semen

The use of sex-sorted semen allows predetermination of calf sex with ~90% reliability. Despite this benefit, sex-sorted semen currently represents a small percentage of the artificial insemination (AI) market in Ireland. The main barriers to greater uptake are compromised fertility, the price per straw and the EBI of the bulls that are available. In studies comparing conventional semen and sexed semen, the mean conception rate achieved with sexed semen is often expressed as a percentage of the mean conception rate achieved with conventional semen, and is termed the 'relative conception rate'. For example, if the conception rate with conventional semen was 60%, then sexed semen would need to achieve a conception rate of 54% to result in a relative conception rate of 90% (i.e., 54/60 x 100). When AI is conducted once a day after detected heat (as is normal in Ireland), large field studies in 2013 and 2018 demonstrated that sex-sorted semen had poorer conception rates compared with conventional semen in both virgin heifers and lactating cows (76% to 89% relative conception rate). Importantly, bulls that were resident close to the sexed semen lab (all 10 bulls in 2013 trial, four out of 10 bulls in 2018 trial) had mean relative conception rates ≥84%, but the mean relative conception rate for bulls located in Ireland and that had their ejaculates shipped to the sorting lab was ~70%. For now, sexed semen use should be limited to bulls that are located close to the semen sorting lab.

Any reduction in fertility that causes deterioration in calving pattern will reduce the financial benefits from using sexed semen, and usage of sexed semen is unlikely to be profitable in herds with poor fertility. Nevertheless, targeted use of sexed semen can achieve acceptable fertility. The animals selected to be replacement dams should be high EBI, heifers or young cows (parity 1, 2 or 3), calved ≥ 60 days on the farm mating start date and in good BCS (≥3.00). These are the highest fertility animals on the farm, and are most likely to become pregnant following AI (with conventional or sexed semen). In addition, sexed semen should be used at the start of the breeding period only, and it may be useful to incorporate synchronisation to advance submission as a strategy to mitigate reduced conception rates. In fact, combining synchronisation with sexed semen usage to breed eligible cows on the farm mating start date can increase the proportion of early calving cows and improve the compactness of the calving pattern.

The first decision is to decide how many replacement heifer calves are needed. Next, based on fertility performance in previous years in your herd, calculate the expected conception rate of the dams that will receive dairy semen (mix of cows and heifers). The number of conventional semen straws required for a 100-cow herd that needs 25 replacement heifer calves is summarised in Table 3. The expected conception rate has a big impact on the number of straws required (77 straws at 65% conception rate, increasing to 100 straws at 50% conception rate). For the purposes of evaluating the direct costs and receipts arising from AI usage, it was assumed that conventional semen cost was €18 per straw, dairy heifer calves were worth €250, and dairy bull calves were worth €50.

Table 3. Number of conventional semen straws required to generate 25 heifer calves at varying herd conception rates

	Conventional semen conception rate			
	65%	60%	55%	50%
Dairy heifers calves (n)	25	25	25	25
Dairy bull calves (n)	25	25	25	25
Beef calves (n)	0	0	0	0
Conv semen straws required (n)	**77**	**83**	**91**	**100**
Semen costs (€)	1,385	1,500	1,636	1,800
Calf value (€)	7,500	7,500	7,500	7,500
Net return (€)	6,115	6,000	5,864	5,700

What would be the implications of deciding to generate the 25 replacement heifer calves using sexed semen? Again, herd fertility has a big effect, but so too does the expected reduction in conception rate due to sex sorting. In Table 4, sexed semen relative conception rate of 85% is examined, which represents the mean relative conception rate achieved by resident bulls in the 2013 and 2018 field trials. In addition to the assumptions used for Table 3, sexed semen was assumed to cost €45 per straw. It was also assumed that the reduction in conventional dairy semen usage would be displaced by beef semen (€12 per straw), and the resulting beef calves were worth €150 (half male, half female). Hence, total straw numbers used for this analysis were the same as each fertility level in Table 3 (77 straws in the best fertility herds, 100 straws in the poorest fertility herds). Using sexed semen caused an increase in expenditure on semen but the value of the subsequent calf crop value was also increased. Reduced conception rates with sexed semen, however, will lead to longer calving intervals. Management options to mitigate this include starting breeding earlier, restricting sexed semen usage to a defined period at the start of the breeding season (first seven to 10 days) and incorporating synchronisation to accelerate the submission of eligible cows.

Table 4. Number of sexed semen straws required to generate 25 heifer calves at varying herd conception rates

	Sexed conception rate (85% of Conv)			
	55	**51**	**47**	**43**
Dairy heifers (n)	25	25	25	25
Dairy bulls (n)	3	3	3	3
Beef calves (n)	17	17	17	17
Sexed semen straws required (n)	50	54	59	65
Beef straws required (n)	27	29	31	35
Semen costs (€)	2,582	2,797	3,052	3,357
Calf value (€)	8,987	8,987	8,987	8,987
Net (€)	6,405	6,190	5,935	5,630

Beef merit of dairy crosses

The expanding dairy herd, coupled with improving reproductive performance, dictates that a greater proportion of slaughtered cattle in Ireland will originate from dairy herds. Hence, a dairy-beef index was required that ranks beef bulls for use on dairy females providing a balance between the desires of the dairy farmer and those of the beef farmer. The dairy-beef index ranks bulls on estimated genetic potential to efficiently produce a high-value carcass, while having minimal repercussions on the milk, health and reproductive performance of the dairy female. Traits included within the dairy-beef index and their relative emphasis are illustrated in Figure 3; two-thirds of the emphasis is on calving performance.

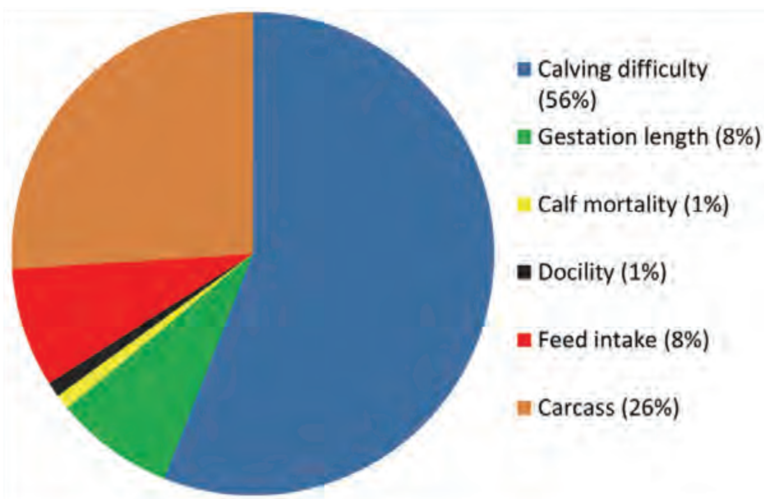

Figure 3. *Relative emphasis on the component traits within the dairy-beef index*

Conclusions

The EBI continues to deliver improved profitability and reduced environmental footprint per unit of milk produced. The benefits can be furthered through crossbreeding with Jersey, even in high EBI herds. This strategy can be complemented by using sexed semen to generate high value female replacements, enabling greater usage of beef semen to reduce the number of low value male dairy calves.