

Improving dairy herd fertility through genetic selection

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In a continuation of our series looking at fertility in the dairy herd, ICBF geneticist Dr Francis Kearney looks at the role of breeding programmes and genetic selection.



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Introduction

The purpose of any breeding program is to produce a cow that, through her genes, will maximise profitability for a farmer. It has been consistently shown that improving the cow's genetic merit, in addition to nutrition, health and proper management, can play a vital role in improving productivity. A cow with the correct combination of genes for production, reproduction, and health will be a lot easier to manage than a cow without the correct genes. At a time when the price of milk is generally on the decline, increases in profitability need to be generated through a reduction in the costs of production.

On Irish dairy farms, costs due to infertility rank amongst the highest. The dairy cow of tomorrow will have to produce high value milk, conceive easily, be long-lived and as free from calving, mastitis, lameness, and metabolic disorders as possible. The job of geneticists is to produce a breeding objective consistent with the wants of farmers, and to put in place an effective progeny testing scheme that will identify bulls that will breed the cow of tomorrow as

quickly as possible. The aim of this article is to highlight, from a genetics perspective, some of the reasons why fertility has become such a problem, and how it might be addressed as we try to breed tomorrow's more profitable cow.

Genetic trends for milk and fertility

The improvement in economically important traits in many livestock species (e.g., milk yield, growth rate and feed conversion efficiency) through genetic selection has been widely documented (Rauw, 1998). Dairy breeding programmes (especially for the Holstein breed), have seen huge benefits in identifying and selecting the best animals to breed from for increased milk production. **Figure 1** shows that the average genetic merit for milk production of daughters of AI bulls in Ireland has increased by almost 600kg over a 35-year period. This equates to an annual increase of approximately 1% of mean production (Dillon *et al.*, 2006). This is consistent with the intense selection for milk production in countries like the US, Canada and the Netherlands and the subsequent use of high milk Holstein sires from these countries in Ireland.

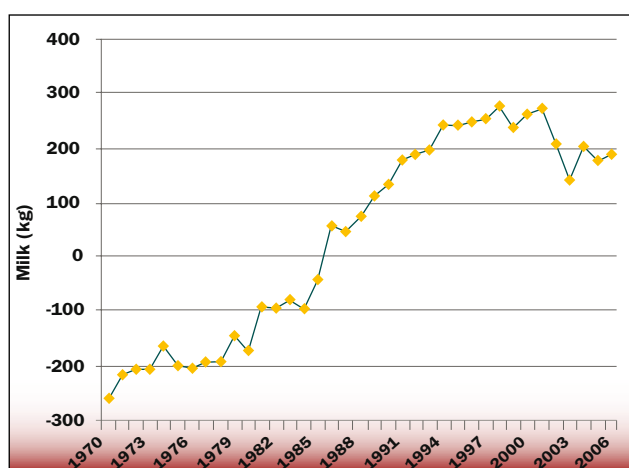


Figure 1: Genetic trend for milk (kg) for AI bulls born since 1970.

While intense selection for production has increased yield of milk, fat and protein, it has also had unfavourable correlated responses for traits such as fertility and longevity. An antagonistic relationship exists between yield and fertility traits such that higher producing cows, in general, have poorer fertility and subsequently less chance of survival (Rauw, 1998; Evans *et al.*, 2006; McCarthy *et al.*, 2007). **Figure 2** clearly shows the effect of selecting for production on calving interval and survival. As we have increased the genetic merit for production, genetic merit for calving interval has also lengthened (by approx. six days) and genetic merit for survival has decreased.

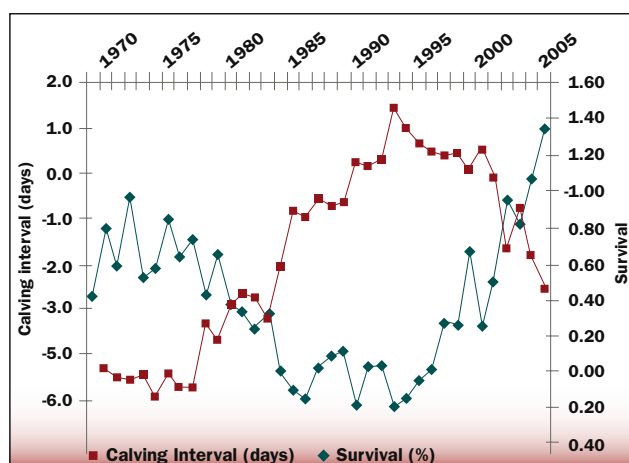


Figure 2: Genetic trend for calving interval (days) and survival (%) for AI bulls born since 1970.

This trend is evident in all dairy producing countries where intense selection has been placed on milk production. The fertility problems in Holsteins have been widely acknowledged and many countries are now changing their breeding objective to reflect this. At the moment the relative emphasis on production in most major dairy producing countries is at or less than 55%, with an ever increasing emphasis being placed on non-production traits aimed at reducing costs (Faust, 2007).

The role of breeding programmes

Through intense selection and proliferation of high producing Holstein sires, Irish dairy farmers have seen the benefit in terms of increased milk production, but also an undesirable increase in fertility problems in these cows. Associated with higher milk yield, a taller, more angular dairy-type cow was bred. These cows tend to mobilise body reserves shortly after lactation resulting in negative energy balance and subsequent body condition loss. Animals that lose a lot of body condition shortly after calving and before breeding have greater infertility problems (Roche *et al.*, 2007). As a consequence, it is necessary to put in place a breeding program to address the problems of the modern dairy cow.

In Ireland, the economic breeding index (EBI) based on a national farm economic model was developed, and has been in place since 2001. The aim of the index is to provide farmers with a tool to help them maximise their profit from breeding. It aims to identify what the key drivers are in terms of profitability and weight them accordingly. The main traits in the current index are milk, fat, and protein yield and calving interval and survival. **Table 1** shows the full breakdown of the traits, economic values (the value of a one unit increase in genetic merit for that trait) and weightings in the EBI. The EBI of a bull (or cow) is the sum of each of the individual sub-indices and indicates the profit per lactation his or her daughters are expected to leave.

Table 1: Traits, economic values and emphasis that make up the EBI

Sub-index	Trait	Economic value	Emphasis
Milk	Protein kg	€5.36	24%
	Fat kg	€0.96	5%
	Milk kg	-€0.08	13%
Fertility	Survival (%)	€10.51	13%
	Calving interval days	-€10.87	24%
Calving	Maternal calving difficulty	-€1.28	1%
	Direct calving ease difficulty	-€3.26	3%
	Direct gestation	-€6.86	3%
	Calf mortality	-€2.85	1%
Beef	Cow carcass weight	€0.04	0.2%
	Carcass weight	€1.40	4%
	Carcass conformation	€10.3	2%
	Carcass fat score	-€11.7	2%
Health	Locomotion	€1.13	0.4%
	Somatic cell count	-€55.4	5%

Note: EBI information for all AI bulls is available at www.icbf.com.

High value milk (more fat and protein and less water), good fertility and the ability to survive several lactations are essential to profitability in a seasonal calving herd where the aim is to maximise production from grass, our cheapest and most plentiful food supply. Over the last number of years, the weighting on fertility/fitness relative to production has increased to approx 50/50 to reflect the growing importance of these traits on reducing the costs of production. For example, McCarthy *et al.*

(2007) recently reported on a trial at Moorepark, which looked an economic comparison of divergent strains of Holstein-Friesian cows in various production systems. Cows that were selected for higher milk yield (€46 milk; €2 fertility) were much less profitable (approx. €14,000 on 100,000 gallon farm) than cows that were selected for more moderate milk potential but significantly better fertility (€41 milk; €38 fertility). While the high milk yield group produced more milk during lactation (6,748kg vs 6,335kg), they had significantly poorer fertility. As a consequence, they did not have the opportunity to express their full milk yield potential (milk per cow per day of herd life), they milked for less lactations and, therefore, had a high replacement rate. In addition, they produced fewer replacement heifers, had increased semen usage and added costs due to vet intervention for fertility related problems. Interestingly, increasing concentrate supplementation to as much as 1,500kg/cow had no significant impact on the reproductive performance of any of the strains involved in the trial, as the cows nutritional requirement were met from grass.

Can fertility be improved through genetic selection?

The phenotype of a cow (e.g., actual milk produced in 305 days or her calving interval) is a combination of her genes and her environment. The heritability of a trait gives us an indication of the influence of an animal's genes on that trait, the remainder being due to the management and the environment. Heritabilities can range from 0% to 100%, with most in the 1-50% region. The higher the heritability, the more effective genetic selection is at changing a trait where adequate genetic variation exists.

For example, the heritability of production traits is about 35%. Therefore, the milk yield of a cow would be made up of approximately 35% genetics with the remaining 65% due to management and the environment. The heritability for fertility and fitness traits are much lower than production, with calving interval having a heritability of approximately 3-4%. This would suggest that little progress can be achieved in fertility through breeding and the most gains can be made through improvements in management, nutrition etc.

A question often asked is: "why select for fertility if the heritability is so low?" While it is true that selection for lower heritability traits is less effective than higher heritability traits, there is a lot of variation for fertility among bulls that are available throughout the world. This is not surprising - most farmers can tell you about bulls whose daughters went in-calf easily and bulls whose daughters did not. There is significant variation both within breeds and across breeds for fertility. **Table 2** shows some statistics for EBI, milk and fertility sub indices for AI bulls of various breeds in Ireland.

Table 2: Mean performance of AI bulls of different breeds for EBI, milk sub-index (MSI), fertility (FSI) and calving interval (CI)

Breed	No. of bulls	Mean EBI €	Mean MSI (€)	Mean FSI (€)	Mean CI (days)	Min CI (days)	Max CI (days)
Friesian	277	53	0	50	-3.8	-10.4	6.9
Holstein	1961	20	26	-6	0.6	-8.8	11.9
Jersey	86	42	23	60	-3.8	-9.1	0.0
Montbeliarde	101	76	6	63	-3.2	-8.3	3.3
Normande	35	51	-13	60	-3.2	-7.2	0.0
Norwegian red	27	62	13	36	-2.4	-6.5	0.4
Rotbunt	36	46	-2	50	-3.3	-6.4	0.0
Red Danish	4	36	3	31	-2.2	-4.2	0.0
Swedish red	9	51	7	39	-2.6	-5.8	0.0

The make-up of the EBI for the different breeds is as expected from the recent history of selection in the breed. For example, Holsteins gain more of their EBI from milk as this is what they were selected for, but they suffer on fertility with the calving interval of their daughters been extended by about 0.6 days over the average. Other breeds, such as pure Friesian, Montbeliarde, Jerseys and Norwegian reds, were either bred for improved fertility or were not intensely selected for improved milk production; hence their fertility sub-index contributes more to their overall EBI. On average, bulls of these breeds can reduce calving interval by about 2-4 days. Equally as interesting is the range in bulls for their calving interval. For example, some Holstein bulls can reduce calving interval by up to 8.8 days which is comparable to the best bulls in other breeds. The key message is that while the heritability is low, effective progress can be made by selecting the correct bulls for fertility. The fertility sub-index provides us with the tool by which we can identify these high fertility bulls. The results of McCarthy *et al.* (2007) provide further reinforcement for this argument. They showed that cows with a balanced EBI performed very well reproductively with 74% in calf in the first six weeks and an overall pregnancy rate of 93%. This is in comparison to the high milk group with only a 54% six-week in-calf rate and a 74% overall pregnancy rate.

Further evidence for the effectiveness of improving fertility through breeding can be assessed by looking at the Scandinavian breeding programmes that have been selecting for a balance between production and fertility for over 20 years. These countries have improved, or at least maintained, fertility at little or no loss to production, thus indicating that genetics can play a vital role in improving fertility.

Achieving better fertility on farm

It is possible to improve fertility through breeding by correctly choosing a bull that is proven to improve fertility. Farmers can receive the breakdown of their herd's EBI (through the ICBF HerdPlus service) which can identify strengths and weaknesses in terms of milk output and fertility. Where herd fertility has been identified as a

problem, the use of bulls that have a high EBI coupled with a high fertility sub-index will help improve fertility in the next generation. Where possible, cows that are consistently hard to get in-calf, or calve late, should be culled. In addition, retaining replacement heifers from very problematic cows should be avoided, though this can be difficult where a high replacement rate exists, or if a farmer is expanding. Cross-breeding Holstein to another breed that has been selected for fertility is also another option. This has the advantage of using additional hybrid vigour in the initial crosses to boost production and fertility. However, often farmers prefer the uniformity offered by one breed, and these farmers should concentrate on using good fertility bulls within a breed. It should be advised that breeding to improve fertility will not result in overnight success; in athletic terms it's more like a marathon than a sprint. However, genetic progress is permanent and cumulative. Once you make some improvement it can be built on each year and over time it will provide very meaningful results, just as it has done with production.

Achieving better fertility in the national herd

Effective progeny testing of bulls is required to produce the next generation of top bulls. These bulls will hopefully be successful at breeding tomorrow's more profitable cow. For the last three years, bulls for progeny testing have been sourced primarily on commercial Irish farms, a marked departure from previous programmes. As we can see from **Figure 1**, these bulls have been selected for slightly less milk production, but more importantly for much improved fertility (**Figure 2**). Currently, the trend lines for bulls born from 2003 onwards are based on pedigree predictions rather than actual daughters. However, it is anticipated that when these bulls are fully proven they will have, on average, the figures we see on the graphs. Some bulls will be better, others will be poorer. Only the ones that excel for EBI (and with good milk and fertility) will be selected for widespread use on Irish dairy farms to produce the next generation of cows and young bulls. The changing impetus of world breeding programs towards seeking bulls with a balance between production and fitness will also help. We now have very good fertility and survival information in addition to production information on foreign AI bulls with no daughters in Ireland. This will benefit AI companies looking to source international bulls that will deliver cows suitable to working under Irish conditions.

Conclusion

It is very evident that past selection decisions have contributed greatly to the current fertility problems that are prevalent on many Irish dairy farms. Given the time back, a more sensible multiple trait breeding objective incorporating both production and non-production traits rather than just focusing on production would have been the mantra of breeding programmes worldwide. However, the success of selection for production has proven that selection for other traits such as fertility and longevity is also possible. Significant variation exists both within and

across breeds for these traits to enable effective breeding programmes to exploit this variation and produce bulls that will breed tomorrow's more profitable cow. Farmers and their vets have never had more information, both domestically and internationally, at their disposal to base their bull selection decisions on. They should look closely at the weaknesses in the herd and use bulls to correct those weaknesses. Improving a cow genetically for fertility, along with factors such as nutrition, cow health and welfare and grass management among others, will go along way to improving a dairy farm's profitability.

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