Is genetics the key to dairy herd fertility?

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Summary

- Excellent fertility performance is key to profitable farming, irrespective of the production system.
- Unnecessary hormonal intervention reduces profit. The continuous requirement to undertake heat detection because of poor pregnancy rates reduces profit. Extra services per cow reduce profit. Embryo mortality reduces profit.
- The evidence is conclusive that fertility can be improved through breeding. Anyone that says the contrary is simply lying or misinformed.
- High genetic merit for milk production does not mean poor fertility. Evidence is presented in this paper on animals that have high genetic merit for milk yield yet have good fertility.
- Genomic selection is a tool that uses the DNA signature of an animal to calculate a more accurate estimate of the genetic merit of an animal for all traits including fertility.

Introduction

Irrespective of production system, fertility plays a key role in the overall profitability of the system. The relative importance of fertility, however, may differ across production systems. For example, fertility is arguably more important in strict 100% spring-calving or 100% autumn-calving production systems compared to year-round calving systems. Also, the definition of the pertinent fertility trait may vary by production system. Nonetheless, irrespective of the production system, farmers want cows that return to cycling early post-calving with no intervention, show obvious signs of heat, and hold to first service. Hormonal intervention reduces profit. The continuous requirement to undertake heat detection because of poor pregnancy rates reduces profit. Extra services per cow reduce profit. Embryo mortality reduces profit. Therefore, fertility is key to sustained profitability.

Although genetics contributes significantly to differences in fertility performance among animals, it is how the genes interact with the environment that give rise to eventual differences in fertility. In other words good genetics will not compensate for bad management; the opposite if also clearly true. For example, the most genetically fertile cow will not go back in-calf unless she is in appropriate body condition score and routine heat detection is practiced. However, improved genetic merit for traits like fertility will ensure that cows maintain body condition more easily and also express longer and more obvious signs of heat. This paper will deal solely with the genetics of the animal and will not discuss other management factors that are vital to a successful pregnancy.

Dispelling myths about selection for fertility

Some people say that fertility cannot be improved by genetics. This is rubbish! Firstly, the existence of significant differences in fertility among breeds, shown in almost all experiments across the world, conclusively demonstrates that genetic variation exists. Some critics say that this is "*only due to differences in breed*". However, significant differences in fertility within selected lines of Holstein-Friesians have also been clearly documented in controlled experiments in countries like Ireland (Table 1 and 2), the UK (Table 3), and New Zealand.

Table 1. *Fertility performance of three genotypes of Holstein-Friesian animals*[†] *at Curtins Research Farm, Moorepark from 2003 to 2008 (Coleman et al., 2009)*

Fertility Trait	Low EBI-NA	High EBI-NA	High EBI-NZ
24 day submission rate (%)	72.7	93.0	90.3
Pregnancy rate to first service (%)	36.4	46.1	56.7
6 week in-calf rate (%)	50.8	61.7	67.9

[†] *Low EBI-NA = Low EBI animals of North American ancestry; High EBI-NA = high EBI animals of North American ancestry; High EBI-NZ = high EBI animals of New Zealand ancestry.*

Table 2. *Fertility performance of two groups of Holstein-Friesian first lactation animals of equal genetic merit for milk yield but differing in genetic merit for calving interval (Cummins and Butler, unpublished).*

Trait	High Fertility	Low Fertility
Pregnancy rate to 1st/2nd service (%)	83	50
6 week in-calf rate (%)	72	41
Calving to conception. interval (days)	86	114
No. of services (per cow)	1.8	2.9

Table 3. *Fertility performance of two lines of Holstein-Friesian dairy cattle at the Langhill research herd in the UK, selected for either high milk fat plus protein yield or the national average (Pryce et al., 2004).*

	Selection line	Control line
Days to first heat (days)	52.9	42.0
Days to first service (days)	77.2	71.9
Calving to conception interval (days)	124.0	106.6
Conception to first service (%)	39	45
Calving interval (days)	395.3	383.5

Another justification offered by some to explain why genetics doesn't have a role in improving fertility is that "*the heritability of fertility is too low".* Unfortunately, people who use such arguments have absolutely no knowledge of the basics of genetics. Heritability is a number that indicates how much of the difference among animals is due to genetics. It varies from zero to one. The heritability of milk yield is 0.35; this means that 35% of the variation in milk yield among a group of similarly managed cows is due to differences in their genetic makeup. The heritability for calving interval in Ireland is 0.03. This means that 3% of the variation in calving interval among a group of similarly managed cows is due to differences in their genetic makeup. However, heritability is only one piece of the jigsaw of genetic gain. The amount of genetic variation also influences the genetic gain achievable. For example, 3% of large variation may be considerably larger than 35% of small variation. The genetic variation in calving interval in Ireland is as large as the genetic variation in other performance traits such as milk yield. Therefore, genetic gain for fertility is definitely possible as evidenced by Tables 1, 2, and 3.

Ireland's answer to declining herd fertility

Key to breeding for any trait, including fertility, is a) acceptance by the industry that the trait is vital for its sustainability and that breeding will yield benefit, b) a clear and accurate measure of the trait, c) an estimate of the relative importance of the trait, d) the continuous availability of genetics which excel in all traits, and e) a mechanism to deliver accurate and pertinent information to the end user in a format that is easily interpretable.

Acceptance. There is now a general consensus internationally, including among Irish dairy farmers, that fertility within the Holstein-Friesian breed has deteriorated and is now at a critically low level. Low fertility impacts all production systems including year-round calving systems. Pregnancy rate calculated across 74 Irish spring-calving Holstein-Friesian dairy herds in 1999 and 2000 was 48% which is considerably less than the recommended target of 60%. Conception rate to first service in US lactating Holstein-Friesians from 1996 to 2006 averaged 31% with an average interval to first breeding of 90 days (Norman *et al.,* 2009). Such poor fertility coupled with high cow mortality, means that US farmers are finding it difficult to generate sufficient replacements within their own herd to maintain herd size

Accurate measure. A clear and accurate definition of the trait under selection is key to ensuring genetic gain in the pertinent trait. Possibly the single most important reason that a trait is not included in a breeding program, is that routine data is unavailable. The availability of routine data therefore limits the definition of traits that can be included in breeding goals. Up until recently the only routine data available on fertility performance in Ireland which could be used to estimate genetic merit of animals, was calving dates. Availability of calving dates facilitated the calculation of calving interval and survival. Early prediction of genetic merit for calving interval and survival was undertaken using information on milk yield and linear type traits. However, in recent years the use of electronic handhelds by AI technicians facilitated the collection of insemination data for the calculation of more pertinent fertility traits and these will soon be included in the Irish genetic evaluation system to better predict genetic merit for calving interval and survival. Detailed recordings of all artificial and natural matings as well as pregnancy diagnosis data is key to accurate estimates of animal genetic merit for fertility. The traits proposed to be included in the Irish national genetic evaluation for fertility is consistent with most other countries, thereby facilitating more accurate conversions of genetic merit for bulls originating from other countries

Importance. Selection indexes were first proposed in the 1940's as a means of facilitating simultaneous selection on a number of traits that may or may not be genetically related to each other. However, they are also useful in summarising a plethora of figures into a single index to rank animals. In Ireland the breeding goal is called the Economic Breeding Index. One of the main shortcomings of breeding goals is that they require accurate estimates of the relative weightings that should be placed on each trait. The weightings on each trait within the EBI, like in most other countries, is based on expected economic benefit per unit change in the given traits derived from predicted future costs and prices, in the average herd. Future prices (e.g., milk price) in the EBI are based on FAPRI projections.

Economic weights for all traits in the EBI were derived across a range of production systems including high yield per cow, winter milk production systems, and liquid milk production systems. With the exception of liquid milk production systems, the relative economic weights between systems changed only slightly, and selection on the EBI in these production systems was still expected to increase profitability. The exception was for farmers on a 100% liquid milk contract, where milk receipts are based solely on milk volume with no cognisance of milk composition. With such a milk-pricing system there is a negative weight on milk fat and milk protein, because they require energy to generate, and with liquid milk contracts the farmer is not paid on constituents. Therefore, with this index, farmers would be breeding for watery milk. However, few farmers sell all their milk under such a pricing system with most supplying milk also for manufacturing; these farmers would need to select on two different indexes, making decisions complicated and diminishing the benefit of using indexes. This was, however, the rational behind the introduction of the five sub-indexes: milk production, fertility & survival, calving performance, beef performance and health. Farmers wanting to select more aggressively on milk production could put more emphasis on the milk production subindex within the EBI. However, one must be cautious when selecting aggressively on milk production that it is not to the detriment of fertility and other traits. Bulls are available that are favourable for all traits.

The consistency in relative economic weights calculated within the EBI across the different production systems in Ireland is not surprising given the similarity in relative economic weights in breeding goals across the world (Figure 1). The relative emphasis on milk production in the Irish EBI is consistent with most other countries and is greater than the emphasis on milk production in some countries like The Netherlands. The emphasis on fertility and survival in the Irish EBI is also similar to the emphasis on these traits in other countries. Therefore, irrespective of the production system a balanced cow is required.

Traits currently missing from the EBI (as with most other indexes around the world) are milk quality measures such as fatty acid content, as well as net feed efficiency, environmental impact and animal welfare. Currently the weighting on animal health in the EBI is less than optimal, primarily due to a lack of data. By accurately recording diseases such as lameness, mastitis, retained afterbirths and others disorders in the ICBF system, more accurate estimates of animal genetic merit for these traits can be calculated and subsequently included in the EBI.

Availability. Without the constant supply of new and better genetics from breed societies and breeding organisations, genetic gain in the elite herds will stall. Bulls of high genetic merit for milk production, fertility and health are certainly available. In 2007, Moorepark purchased from Irish farms, heifers of high genetic merit for milk yield and divergent genetic merit for calving interval. Average genetic merit of the two groups of animals generated were similar for milk yield (~250 kg) but differed in genetic merit for calving interval (-3.3 to 2.9 days). Results to date are summarised in Table 2. Despite no difference in milk yield between the two groups of animals, last year 72% of the high fertility group were in-calf 6 weeks into the breeding season compared to only 41% of the low fertility animals. Therefore, good fertility is achievable in cows that are high genetic merit for milk production. Thus, the onus is on breed societies to help identify the genetically elite bull dams with high milk production and fertility, and the AI organisations to mate these elite dams to high milk and fertility sires to produce the next generation of young test sires suitable for production systems in Ireland. Such a collaboration will ensure the constant supply of superior genetics to the Irish farmer.

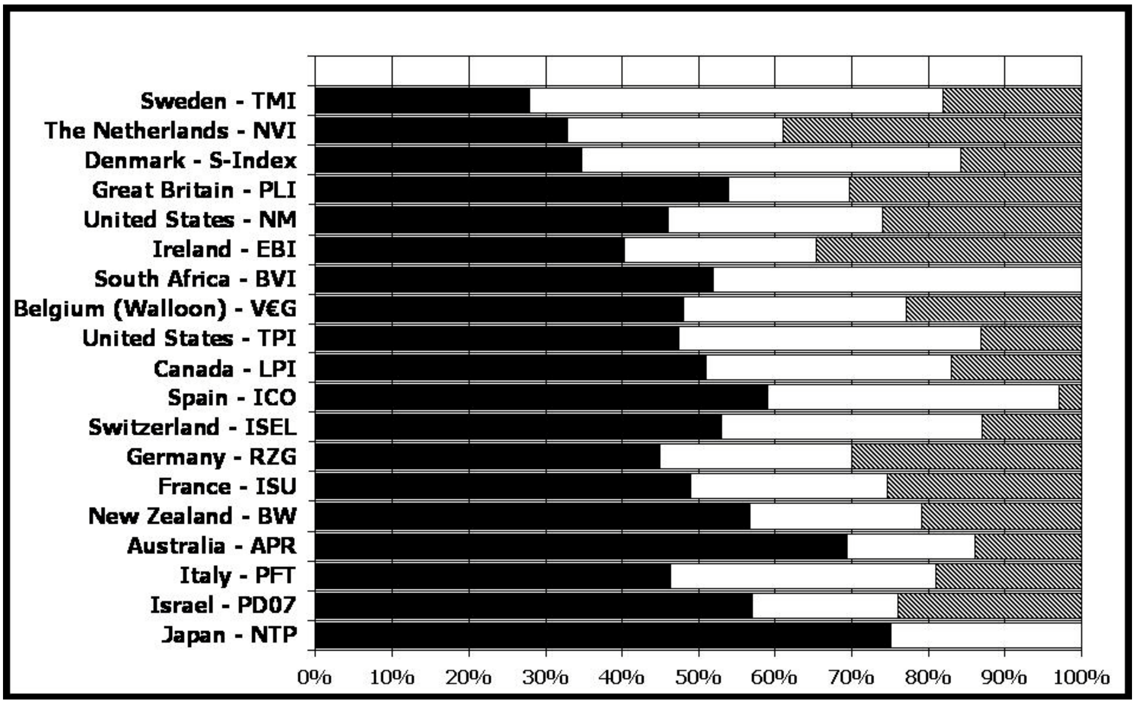

Figure 1. *Relative emphasis, depicted by the relative length of the horizontal bars on milk production (black bars), fertility & survival (diagonal bars), and other traits (hollow bars) for the different indexes across several countries.*

Information. The appropriate information as well as the knowledge on how to effectively use it is key to profit. However, information is only as good as the data used to generate it. By accurately recording all observations on Animal Events, in particular animal health, more detailed and accurate information for herd management can be generated. Accurate data recording is also necessary for accurate genetic evaluations. The genetic merit values for individual traits like milk yield and survival are called predicted transmitting ability (PTA). They are the expected difference in performance of the offspring of the animal in an average herd relative to an animal with a value of zero. For example, the daughters of a bull with a PTA for milk yield of +300 kg will yield 300 kgs more milk than daughters of a bull with a PTA of 0 kg, and 100 kg more milk than daughters of a bull with a PTA of +200 kg, when producing in the average herd. As a rule of thumb, in most well run herds, one generally observes a 2 to 3 fold difference greater than expected.

A question often asked is "*how much milk will the daughter of a +200 kg milk yield bull produce*". The answer is dependent on the production system and is affected by management factors such as feeding system, herd health and overall management style. Key to determining the answer for your herd is knowledge of the genetic merit of your herd, via HERDPLUS®. If your herd has an average genetic merit for milk yield of +200 kg then any team of bulls with an average genetic merit of milk yield of +200 will hold yield constant assuming your management does not change. A team of bulls with a PTA for milk yield of greater than +200 will increase herd yield over time. If herd genetic gain is being achieved, then the calves should be the genetically superior animals and this group of animals (or the average of the top 20%) should be used as the benchmark to select genetically superior sires. However, information on other traits should not be ignored. High milk production with poor fertility and survival is not sustainable and the evidence is clear that animals with high genetic merit for milk production, fertility and survival are available. Remember, with greater survival, the average age of the herd is older and yields on a herd basis will be greater.

Improving dairy cow fertility with genetics

There is a lot of talk on the use of crossbreeding to rapidly improve fertility. The evidence from Moorepark, as well as all other experiments internationally, is conclusive that fertility can be rapidly improved by selecting genetically elite sires for fertility of alternative breeds. The heterosis obtained from the crossing of animals of genetically different background tends to be greater in traits associated with fitness such as health and fertility. Heterosis is simply the opposite of inbreeding. Crossbreeding is a fast-track solution to a fertility and health problem but is not for everyone.

As discussed previously, there is considerable genetic variation for fertility (as well as other traits) with the Holstein-Friesian breed itself. Key to breeding for improved fertility is determining the herd average genetic merit for fertility (i.e., calving interval) from HERDPLUS®. If the average genetic merit for calving interval of the team of bulls selected is superior to the average genetic merit of the herd (preferably the top 20% on calving interval) the genetic gain in fertility will be achieved in the long-term.

The role of genomic selection in improving cow fertility

Genomic selection is a new tool to help in identifying genetically elite animals. It is based on comparing an animal's DNA signature to the ideal DNA signature for traits like fertility. DNA is the building blocks of genes and it is genes, in combination with management, that determine the performance of an animal. Using previous methodology of genetic evaluations, one had to wait until several hundred daughters of a sire re-calved before a good indication of the genetic merit of the sire for calving interval could be estimated. High reliability proofs for calving interval in cows that are still alive is rare.

Because DNA is present in all cells and remains the same throughout an animal's life, knowledge of the ideal DNA signature for Ireland will facilitate more accurate genetic evaluations of animals at a younger age. However, genomic selection is still a new technology and research into improving the methodology is underway all over the world. Genomic selection has little or no impact on proven sires with high reliability, but increases the reliability of estimated genetic merit (e.g., EBI) of young bulls from approximately 30% to 50%. Although fluctuations in proofs are still possible with the accumulation of daughter information, the use of genomic selection reduces the interval in which the proofs may fluctuate. Genomic selection has a potentially greater role in genetic evaluations for fertility and survival because the reliability for calving interval and survival traits in young animals tends to be almost always lower than the reliability for production traits. With time, as more accurate information on the best DNA signature for Ireland is generated, as well as breeding programs to fully exploit the technology are implemented, the benefits of genomic selection will become more obvious.

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