Genetic trends in gestation length

K. Stachowicz[1], E. Ooi[1], P.R. Amer[1],
[1] *AbacusBio Limited, 442 Moray Place, PO Box 5585, Dunedin 9058, New Zealand*

Abstract

Gestation length has become increasingly important in dairy genetic evaluations worldwide. This has occurred for several reasons. The initial focus was on improving calving ease, as calves which are born earlier are typically smaller. This was generally thought to reduce the incidence of dystocia (although this has been disputed in some countries). However, the effects of gestation length on reproductive performance have since become of greater interest. Reducing gestation length has positive effects on calving interval, as cows which have greater intervals between calving and mating are more likely to be cycling and have demonstrably higher conception rates than their late-calving counterparts. However, this benefit is not without its drawbacks. Reducing gestation length does not directly improve a cow's ability to resume estrus cyclicity after calving, or to achieve fertilization after insemination. Gestation length is, rather, a trait that improves reproductive performance indirectly. Moreover, gestation length, if it is reduced too significantly, may have adverse effects on the health and survival of dairy calves, whose welfare is an increasing target of scrutiny from consumers and society in general. Genetic evaluations for gestation length are now being performed in many countries, including the United States and Australia since 2017 and 2020, respectively. This paper examines genetic trends for gestation length in these countries, with a specific focus on: 1) potential reasons for these genetic trends – for example trying to answer the question of whether selection for fertility traits could be placing indirect selection pressure on gestation length; 2) if there are differences between the countries that can be explained by seasonal or year round calving patterns; 3) how gestation length is being used as a tool to manage calving patterns, including the breeding and marketing of sires with extremely short gestation length breeding values; 4) evidence in the literature on genetic and phenotypic associations with other traits; 5) potential long term consequences of selecting for gestation length; and 6) the economic value of gestation length and its inclusion in (economic) selection indexes.

Key words: dairy, gestation length, genetic trends, genetic evaluation

Introduction

The New Zealand dairy industry is dominated by seasonal calving, where peak herd lactations (and hence, nutritional requirements) are aligned with periods of maximum pasture availability (Bowley *et al.*, 2015). While this system maximizes feed utilization and reduces production costs, it also exerts significant pressure on dairy cow fertility. Cows are expected to maintain a 365-day calving interval, which, when considered in the context of a 281-day gestation period, leaves only 84 days post-calving for uterine recovery, the resumption of ovarian cyclicity and successful fertilization. This is a highly constrained window to achieve conception – one which is only exacerbated for cows calving late in the season.

For these reasons, many farmers in New Zealand and Australia routinely used calving induction to manage their calving patterns – a practice which became increasingly important as genetic merit for fertility declined. However, while well-managed calving induction did not negatively affect cows, it resulted in adverse outcomes for calf health and survival (Mansell *et al.*, 2006). In response to increasing societal concerns around animal welfare and ethics, calving induction as a tool for manipulating calving patterns was phased out in 2015 and

2022 for New Zealand and Australia, respectively. However, this only intensified the pressure on cow reproductive performance.

A key strategy to addressing the dairy fertility decline has been the development of genetic evaluation for fertility traits, with the resulting EBVs incorporated into selection indices worldwide (Miglior *et al.,* 2005). In New Zealand, the current genetic evaluation for fertility relies on the Calving Season Day (CSD) phenotype, which describes the interval between planned start of calving and cow calving date. This is in line with many of the fertility traits developed worldwide which focus on continuous traits such as calving interval, days open, and calving to first service.

However, interval metrics inherently combine gestation length (GL) and conception date. GL is also considerably more heritable than most fertility traits; for example, in New Zealand estimate of heritability for GL was 0.67, which is significantly higher than the 0.02 reported for CSD (Amer *et al*., 2016). This can make it easier to influence through selective breeding. In New Zealand, there has been a consistent decline in GL over the past few decades – a pattern which seems to be gaining momentum. This not only raises animal health concerns, but also echoes the ethical issues that prompted the ban on calving induction in the first place.

New Zealand is not the only country that uses interval metrics for fertility genetic evaluations or has pursued genetic improvement in this trait. Therefore, with the cooperation of other Interbull countries, this paper aims to provide an initial exploration of global genetic trends in GL, within the context of each country’s dominant breeds and systems. It also touches upon some of the genetic and phenotypic correlations that have been identified with other traits.

Materials and Methods

A request for data was sent to all member countries of Interbull who are currently evaluating GL, with responses received from the countries listed in Table 1. For those countries who supplied scaled data (for example, the Netherlands publish GL EBVs with a mean of 100 and a standard deviation of 5), additional data was obtained to convert these results to the phenotypic scale (units of days).

It is important to note that the genetic trends between countries can be difficult to directly compare due to differences in how GL EBVs are predicted. For example, some countries use pedigree-based conventional BLUP to predict EBVs, while others use two-step or single-step genomic evaluation. The publication criteria for GL evaluations can also differ from country to country, in terms of the acceptable thresholds for reliability. Other key differences, such as production system, are outlined in Table 1. It is important to note that these differences are those most relevant to the cattle populations contributing to the genetic trend data provided by each country, rather than a comprehensive description of an entire country’s breed composition or calving systems.

Table 1. Interbull countries (N = 10) who contributed GL data, along with the system(s) associated with the population from which the data were derived.

Code	Country	System
NZL	New Zealand	Seasonal
IRL	Ireland	Mixed
POL	Poland	Year round
NLD	The Netherlands	Year round
USA	United States	Year round
CZE	Czech Republic	Year round
ITA	Italy	Year round
NOR	Norway	Year round
CHE	Switzerland	Year round
AUS	Australia	Mixed

Results

Genetic trends

Figure 1 shows overall genetic trends by country and breed, with some countries contributing multiple breed-specific trends (e.g., New Zealand, Ireland, Australia, Switzerland, and the United States). Trends from the United States were provided separately for males and females.

Apart from Jerseys in Australia and the United States and Brown Swiss in the United States, the overall trend for GL is decreasing.

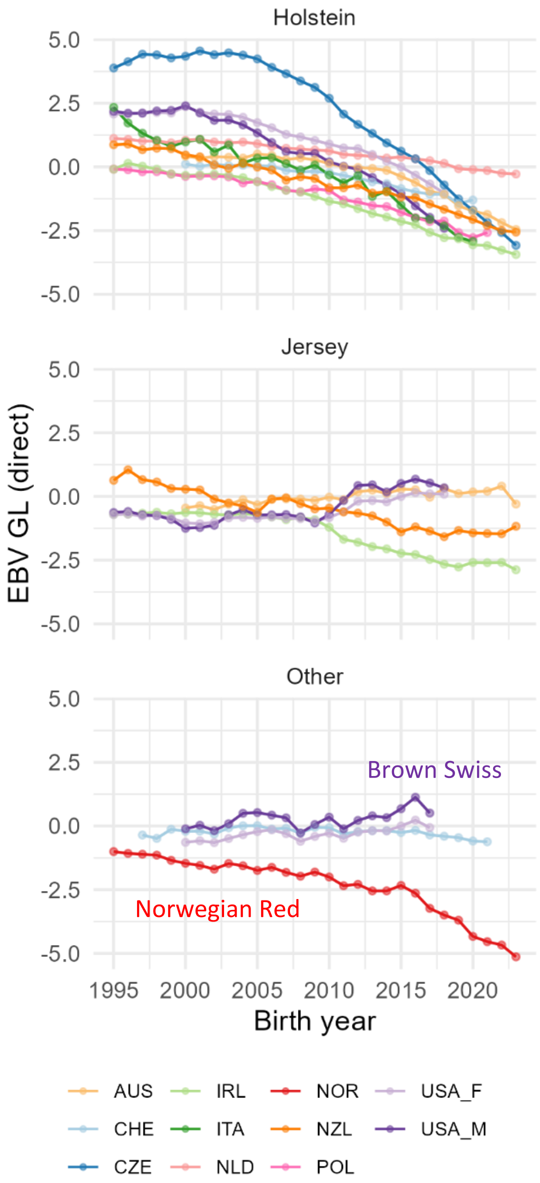

Figure 1. Genetic trends for gestation length as reported by participating countries, separated by breed.

Holsteins were the dominant breed in the provided data, with all nine contributing countries demonstrating declining genetic trends over time. Some of these countries exhibited weaker trends – such as the Netherlands, which experienced a slight decline of 0.05 days p.a. over 43 years from +1.86 in 1980 to -0.28 in 2023, while others displayed much more dramatic trends such as the Czech Republic, which peaked at +4.6 days in 2001 before dropping to -3.1 days in 2023 – a decline of 0.35 days p.a. over 22 years.

The Jersey breed had diverging trends, depending on the country of origin. Data from New Zealand and Ireland show declining GL EBVs overall, much like the Holstein and Norwegian Red populations. However, a marked split occurred in 2010, where populations from the United States (and to an earlier extent, Australia) began to experience an upward trend in GL EBVs, which occurs contrary to overall trends.

Much like the Holsteins, the Norwegian Red genetic trend shows a significant decrease over time. Data for Brown Swiss were available for two countries. In Switzerland, the trend was relatively stable over time, with a slight decrease beginning to become apparent since 2015. However, the United States Brown Swiss population exhibits a similar trend to Jerseys from the same country, with an increase in recent years.

Relationships with other traits

Selected genetic correlations between GL and other traits are shown in Table 2. These were obtained from a brief search of the scientific literature, as well as calculations on New Zealand data (data not published).

Genetic correlations between GL and fertility traits such as CSD and age at first calving (AFC) were high, as anticipated. The correlations between GL and protein yield were also high, ranging from -0.22 to -0.5, which is somewhat unexpected. However, correlations between other traits varied significantly depending on the source, with genetic correlations for longevity ranging from -0.25 to 0.09, for example, or -0.49 to 0.17 for calving ease. Whether this is due to genuine genetic differences in the populations (country, breed), or due to differences in statistical methods is difficult to say.

Table 2. Genetic correlations reported between GL and other traits.

Trait	R_g	Code	Source
CSDh[1]	0.57	NZL	Amer *et al.* (2016)
CSD[1]	0.45		
PM21[2]	-0.20		
BCS	0.02		
PR42[3]	-0.05	NZL	Unpublished data
AFC[4]	-0.42	ITA	Galluzzo *et al.* (2023)
Calving ease	-0.49	ITA	Galluzzo *et al.* (2023)
	0.17	CAN	Jamrozik *et al.* (2005)
	0.38	DNK	Hansen *et al.* (2004)
Dystocia	0.34	GBR	McGuirk *et al.* (1999)
	0.38	USA	Johanson *et al.* (2011)
Stillbirth	-0.39	ITA	Galluzzo *et al.* (2023)
	-0.11	CAN	Jamrozik *et al.* (2005)
	0.18	DNK	Hansen *et al.* (2004)
Longevity	-0.25	ITA	Galluzzo *et al.* (2023)
	0.09	GBR	Eaglen *et al.* (2013)
	-0.23	NZL	Unpublished data
Milk yield	-0.39	ITA	Galluzzo *et al.* (2023)
	-0.19	GBR	Eaglen *et al.* (2013)
	-0.25	NZL	Unpublished data
Protein yield	-0.50	ITA	Galluzzo *et al.* (2023)
	-0.22	GBR	Eaglen *et al.* (2013)
	-0.43	NZL	Unpublished data
Protein %	-0.23	NZL	Unpublished data
Overall type	-0.31	NZL	Unpublished data
Udder overall	-0.21	NZL	Unpublished data

[1]CSD: calving season day for heifers and cows; [2]PM21: 3-week submission rate; [3]PR42: 6-week in calf rate; [4]AFC: age at first calving

Discussion

Genetic trends

Differences in genetic trends by country could not be attributed to any specific factor such as dominant production system, type of genetic evaluation (i.e., genomic or conventional BLUP), or the traits used to drive genetic improvement in fertility.

This last point is of particular interest, as it could be hypothesized that the decline in GL has been due to strong selection for fertility improvement in Holsteins, which experienced the greatest historic decline (Heins *et al*., 2006). The Scandinavian dairy populations famously avoided this decline due to the early incorporation of genetic evaluations for fertility – but despite this, we still see a strong downward genetic trend for GL in the Norwegian Red breed.

The absolute difference between countries in genetic trends for GL cannot be determined from the results presented as each country's values are on different genetic scale/base. Haile-Mariam and Pryce (2019) examined differences between GL EBVs for bulls from different countries that were used in Australia, and observed that, on average, bulls that had their first proofs in Denmark, the Netherlands and New Zealand had shorter GL than bulls first tested in Australia or North America. Such results are only possible to be obtained for bulls that have already been used in each country. For importing foreign bulls with desired GL genetics, access to international genetic evaluation of GL would be of considerable value.

Relationships with other traits

Genetic associations between GL and fertility traits are high for traits that have GL embedded in, or closely related to, them (Amer *et al.*, 2016; Galluzzo *et al*., 2023). This is undesirable, as the general aim of selecting for fertility traits is to address inherent infertility issues – i.e., physiological failures of reproduction in dairy cows. Arguably, achieving indirect gains in reproductive performance by decreasing GL is not true fertility improvement.

In New Zealand and Italy in particular, the relationship between GL and milk production traits is surprisingly strong. We could not find any reported studies that would explain the source of this relationship. It is possible that admixtures of breeds or the combination of subpopulations with high milk yield and short gestation length, as well as lower milk yield and longer gestation length could cause this association. However, if there is a direct causal relationship between these two traits, the physiological mechanisms have yet to be found.

The genetic correlation between GL and calving traits varied depending on the population (see Table 2). This is especially important to monitor as shortening GL below a certain (yet unknown) threshold could have a negative impact on calf size and survival, with Norman *et al.* (2009) concluding that direct selection pressure should not be placed on GL without further research becoming available. In New Zealand, Jenkins *et al*., (2016) concluded that slightly increased perinatal mortality rates in calves with very short GL (mean of 273 days) were likely to be offset by a reduction in calves with very long GL (mean of 291 days), which were 3 times more likely to die than calves in the short GL category. However, an appropriate lower threshold has yet to be defined.

Our findings indicate that indirect selection pressure on GL is likely to be a widespread phenomenon across various countries and dairy breeds, even though the underlying mechanisms are not yet fully understood or anticipated. Furthermore, as restrictions on calving induction and the general use of hormonal interventions increase in response to consumer concerns (Pieper *et al.*, 2016), farmers are more likely to opt for short GL sires as a tool to manage calving patterns. Although farmers are cautioned against retaining the daughters of such sires as replacement cows, these animals are still sometimes finding their way into milking herds, potentially exacerbating the decline in GL. Given this trend, the ongoing monitoring of GL is increasingly important.

GL in selection index

The economic value of GL can be substantial, especially when farmers respond to a shorter herd mean GL by delaying planned start of mating to achieve their preferred timing for seasonal calving (Ooi *et al.*, 2023). Despite not being a true fertility trait, high economic values can be derived through GL's indirect effects on fertility, with an associated improvement in milk profit, a reduction in empty rate, and a higher proportion of artificially bred calves.

This finding prompted a revision of how fertility traits are included in the national selection index for seasonal dairy cows in New Zealand. The main fertility phenotype, which previously included GL, is slated for replacement by a conception-based fertility trait that is phenotypically independent of GL (Stachowicz *et al.*, 2023). Both this new conception-based fertility trait and GL will be incorporated into New Zealand's economic selection index. This change allows the development of non-linear index functions that avoid favoring selection for excessively short GL, which could compromise the welfare, viability, and productive performance of the resulting calves (Norman *et al.*, 2009).

Conclusion

It is evident that there is a consistent downward trend in GL for almost all countries, production systems, and dairy breeds. The reasons for these trends as well as the long-term implications of them are not fully understood yet. For this reason, the authors believe that close monitoring of genetic (and phenotypic) trends of GL is important. An international genetic evaluation of GL is strongly recommended; it is needed especially for countries heavily dependent on imported semen for their genetic improvement programs.

References

Amer, P.R., K. Stachowicz, G.M. Jenkins, and S. Meier. 2016. Estimates of genetic parameters for dairy fertility in New Zealand. J. Dairy Sci. 99: 8227-8230.

Bowley, F. E., R. E. Green, P. R. Amer, and S. Meier. 2015. Novel approaches to genetic analysis of fertility traits in New Zealand dairy cattle. J. Dairy Sci. 98: 2005-2012.

Eaglen, S. A. E., M. P. Coffey, J. A. Woolliams, and E. Wall. 2013. Direct and maternal genetic relationships between calving ease, gestation length, milk production, fertility, type, and lifespan of Holstein-Friesian primiparous cows. J. Dairy Sci. 96: 4015–4025.

Galluzzo, F., G. Visentin, J.B.C.H.M. van Kaam, R. Finocchiaro, S. Biffani, A. Costa, M. Marusi, and M. Cassandro. 2023. Genetic evaluation of gestation length in Italian Holstein breed. J. Anim Breed. Genet. 00: 1-11.

Hansen, M., M.S. Lund, J. Pedersen, and L.G. Christensen. 2004. Gestation length in Danish Holsteins has weak genetic associations with stillbirth, calving difficulty, and calf size. Liv. Prod. Sci. 91: 23-33.

Haile-Mariam, M., and J.E. Pryce. 2019. Genetic evaluation of gestation length and its use in managing calving patterns. J. Dairy Sci. 102: 476-487.

Heins, B.J., L.B. Hansen, and A.J. Seykora. 2006. Fertility and Survival of Pure Holsteins Versus Crossbreds of Holstein with Normande, Montbeliarde, and Scandinavian Red. J. Dairy Sci 89:4944–4951.

Jamrozik, J., J. Fatehi, G. J. Kistemaker, and L. R. Schaeffer. 2005. Estimates of genetic parameters for Canadian Holstein female reproduction traits. J. Dairy Sci. 88:2199–2208.

Jenkins, G. M., P. Amer, K. Stachowicz, and S. Meier. 2016. Phenotypic associations between gestation length and production, fertility, survival, and calf traits. J. Dairy Sci. 99:418–426.

Johanson, J. M., P. J. Berger, S. Tsuruta, and I. Misztal. 2011. A Bayesian threshold-linear model evaluation of perinatal mortality, dystocia, birth weight, and gestation length in a Holstein herd. J. Dairy Sci. 94:450–460.

Mansell, P.D., A.R. Cameron, D.P. Taylor, and J. Malmo. 2006. Induction of parturition in dairy cattle and its effects on health and subsequent lactation and reproductive performance. Australian Veterinary Journal 84: 312–316.

McGuirk, B.J., I. Going, and A.R. Gilmour. R. 1999. The genetic evaluation of UK Holstein Friesian sires for calving ease and related traits. Anim. Sci. 68: 413–422.

Miglior, F., B.L. Muir, and B.J. Van Doormaal. 2005. Selection Indices in Holstein Cattle of Various Countries. J. Dairy Sci. 88:1255–1263.

Norman, H. D., J. R. Wright, M. T. Kuhn, S. M. Hubbard, J. B. Cole, and P. M. VanRaden. 2009. Genetic and environmental factors that affect gestation length in dairy cattle. J. Dairy Sci. 92: 2259-2269.

Ooi, E., N. Howes, F. Hely, M. Stephen, P. Amer, and C. Quinton. 2023. The economic value of gestation length. Proc. Assoc. Advmt. Anim. Breed. Genet. 25: 99-102.

Pieper, L., M.G. Doherr, and W. Heuwieser. 2016. Consumers attitudes about milk quality and fertilization methods in dairy cows in Germany. J. Dairy Sci. 99:9.

Stachowicz, K., E. Ooi, B. Santos, and P.R. Amer. 2023. Conception-based fertility trait for genetic evaluation of New Zealand dairy cattle. Proc. Assoc. Advmt. Anim. Breed. Genet. 25: 362-366.