# Potential Consequences Of Selection On Gestation Length On Holstein Performance

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## Introduction

Numerous studies (e.g. Andersen and Plum (1965); Hansen *et al.* (2004); Jamrozik *et al.* (2005); Norman *et al.* (2009)) have found that genetic variation in gestation length (**GL**), the interval from conception to subsequent parturition, is large enough to change GL through selection. Heritability estimates for GL based on service sire have been higher than those based on cow sire (around 0.40 and 0.10, respectively) (Hansen *et al.* (2004); Jamrozik *et al.* (2005); Norman *et al.* (2009)). Thus, GL is largely a characteristic of the fetus rather than the dam (Meyer *et al.* (2000)) as was confirmed in embryo transfer studies (King *et al.* (1985)).

Norman *et al.* (2009) investigated genetic and environmental factors that affect GL and developed service-sire and cow-sire genetic evaluations for GL based on heifer and cow gestations separately. They reported predicted transmitting abilities (**PTA**) for GL of Holstein bulls that ranged from −5.4 to 5.3 days for service-sire GL and −2.8 to 3.1 days for cow-sire GL. Their correlations between Holstein cow- and heifer-based PTA for GL were high for both service-sire PTA (0.96 to 0.98) and cow-sire PTA (0.75 to 0.91). They also found that Holstein service-sire and cow-sire PTA for GL were moderately correlated (0.73 for heifer-based PTA and 0.79 for cow-based PTA).

Although GL can be changed genetically, the desirability or direction of such change is not clear. Selecting shorter or longer GL without considering dependent traits could lead to adverse consequences. Several studies have found low to moderate correlations between GL and stillbirth (**SB**) (e.g. Chassagne *et al.* (1999); Hansen *et al.* (2004); Jamrozik *et al.* (2005); Manatrinon *et al.* (2009)) and small correlations between GL and dystocia (e.g. Philipsson (1976); Niskanen and Juga (1997); McGuirk *et al.* (1999); Meyer *et al.* (2001); Johanson and Berger (2003); Hansen *et al.* (2004); Jamrozik *et al.* (2005)). Decreases in GL also result in reduced calving intervals, but Hansen *et al.* (2004) concluded that calving interval was best reduced by selecting for fewer days open (**DO**). Hageman *et al.* (1991) found that GL for cows selected for high milk yield were 1.1 days longer than for cows selected for mean milk yield. Norman *et al.* (2009) reported that GL was 0.6 days shorter for cows with standardized yield of ≤8,000 kg compared with ≥14,001 kg. Although GL has little direct economic significance, it does have indirect effects through correlations with SB, dystocia and calf size (Hansen *et al*. (2004)). Selection for shorter or longer GL would contribute to coincidental selection for correlated traits without the knowledge of dairy producers.

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No single optimum for GL is evident. Lopéz de Maturana *et al.* (2009) proposed that a GL of 274 days (3 days shorter than mean) would be best for Holsteins as related to dystocia and SB. Because of nonlinear relationships of GL with dystocia and SB, an intermediate GL may be optimal (e.g. Niskanen and Juga (1997); McGuirk *et al.* (1999); Meyer et al., (2000, 2001); Johanson and Berger (2003); Steinbock *et al.* (2003); Jamrozik *et al.* (2005)). If mid-range GL are desired, identifying bulls that transmit extreme GL could be useful.

The objective of this paper was to determine if genetic evaluations of Holstein GL were reliable and repeatable and to assess potential consequences of selection for either shorter or longer GL by examining impact on performance in the subsequent lactation.

# Material and methods

**Data.** Holstein bulls used to develop PTA for GL (Norman *et al.* (2009)) were stratified into 7 groups by PTA for service-sire GL based on calvings from 1998 through 2005: ≤−3.00, −3.00 to −2.01, −2.00 to −1.01, … 1.00 to 1.99 and ≥2.00 days. An independent set of 261,598 first-parity cows mated to the same bulls and calving from 2006 through November 2009 were grouped by the service-sire PTA GL groups (group size of 8,317 to 73,324 gestations). Cow GL were examined to determine predictive effectiveness of previous service-sire PTA GL as well as the impact that differing GL had on phenotypic performance in the subsequent lactation. Responses in those traits were assumed to have occurred as if intentional selection had been directed toward either shortening or lengthening GL even though PTA for GL are not available to the dairy industry.

Phenotypic relationship between GL and subsequent performance also was examined using 9 cow GL groups: ≤275, 276, 277, … 282 and ≥283 d. Group size ranged from 17,493 to 64,876 gestations.

**Statistical analyses.** The model to analyze effectiveness of service-sire PTA GL included fixed effects for herd-year (HY) and service-sire PTA GL group (SS) as well as covariates for conception date (CD) and $CD^2$ to eliminate differences in time opportunity among mates:

$$y_{ijk\ell} = HY_i + SS_j + b_1(CD_k) + b_2(CD_k^{\ 2}) + e_{ijk\ell},$$

where $y_{ijk\ell}$ is the phenotypic trait in the subsequent lactation of cow ℓ that resulted from a conception on day k in herd-year i from a mating to a sire with a PTA GL in group j, b is a regression coefficient and e is residual. The model for analysis of cow GL groups was the same except that SS was replaced with a fixed effect for cow group. Analyzed traits included GL (service-sire analysis only); standardized milk, fat and protein yields; somatic cell score (**SCS**); productive life (**PL**); DO; calving ease (**CE**) score (1 to 5, where 1 is no difficulty and 5 is extreme difficulty); SB incidence (yes or no) and culling incidence (yes or no).

Least squares means were calculated by service-sire PTA GL and cow GL groups for the independent dataset using the GLM procedure of SAS.

## Results and discussion

Least squares means by service-sire PTA GL group are shown in table 1. Mean GL for mates increased from 275.3 days for lowest service-sire PTA to 281.7 days for highest PTA. Thus, PTA for GL was effective in identifying bulls that could be expected to modify GL and, as a direct result, calving interval. Service-sire group effect was significant for culling ($P < 0.01$) and all other traits ($P < 0.001$) except SCS (non-significant). Relationship between service-sire PTA GL and performance in subsequent lactation was curvilinear for yield and DO; intermediate service-sire PTA GL was optimal. For PL, CE, SB and culling, performance generally became less favorable as service-sire PTA GL increased.

Cow GL group effect (table 2) was significant ($P < 0.001$) for all traits except SCS. Statistical tests showed that all traits except SCS had linear and quadratic coefficients that

**Table 1: Least squares means in phenotypic performance in the subsequent lactation by service-sire PTA GL group**

| | Service-sire PTA GL group$^{\alpha}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| Trait | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| GL (days) | 275.3 | 276.5 | 277.8 | 278.6 | 280.6 | 280.7 | 281.7 |
| Milk (kg) | 11,611 | 11,616 | 11,681 | 11,710 | 11,724 | 11,745 | 11,695 |
| Fat (kg) | 425.7 | 424.6 | 426.9 | 428.0 | 428.8 | 428.7 | 427.5 |
| Protein (kg) | 350.5 | 350.6 | 352.4 | 353.2 | 353.2 | 353.3 | 352.5 |
| SCS | 2.70 | 2.69 | 2.69 | 2.68 | 2.68 | 2.69 | 2.70 |
| PL (months) | 34.8 | 34.9 | 34.8 | 34.9 | 34.8 | 34.5 | 34.5 |
| DO | 142.8 | 142.2 | 140.4 | 142.5 | 141.2 | 143.5 | 144.7 |
| CE score | 1.30 | 1.32 | 1.34 | 1.36 | 1.36 | 1.38 | 1.42 |
| SB (%) | 3.3 | 4.3 | 4.2 | 4.5 | 4.7 | 4.4 | 5.7 |
| Culled (%) | 19.1 | 19.4 | 19.4 | 19.2 | 19.5 | 20.4 | 20.4 |

$^{\alpha}$Service-sire PTA GL group defined as 1 = ≤−3.00 days, 2 = −3.00 to −2.01 days, 3 = −2.00 to −1.01 days, 4 = −1.00 to −0.01 days, 5 = 0.00 to 0.99 days, 6 = 1.00 to 1.99 days and 7 = ≥2.00 days.

**Table 2: Least squares means in phenotypic performance in the subsequent lactation by cow GL group**

| | Cow GL group (days) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Traits | ≤275 | 276 | 277 | 278 | 279 | 280 | 281 | 282 | ≥283 |
| Milk (kg) | 11,386 | 11,626 | 11,695 | 11,720 | 11,785 | 11,791 | 11,823 | 11,824 | 11,914 |
| Fat (kg) | 416.6 | 425.2 | 427.7 | 428.3 | 430.2 | 431.2 | 431.1 | 432.4 | 435.3 |
| Protein (kg) | 345.7 | 351.2 | 353.0 | 353.5 | 354.8 | 355.0 | 355.5 | 355.3 | 357.0 |
| SCS | 2.69 | 2.69 | 2.69 | 2.68 | 2.67 | 2.69 | 2.70 | 2.68 | 2.68 |
| PL (months) | 34.5 | 34.9 | 35.0 | 35.0 | 35.0 | 34.9 | 35.0 | 35.0 | 34.7 |
| DO | 141.5 | 140.3 | 141.3 | 140.5 | 142.1 | 141.5 | 141.8 | 141.4 | 144.2 |
| CE score | 1.35 | 1.32 | 1.31 | 1.33 | 1.32 | 1.33 | 1.35 | 1.36 | 1.42 |
| SB (%) | 7.5 | 4.0 | 3.6 | 3.8 | 3.0 | 3.2 | 2.9 | 3.1 | 3.8 |
| Culled (%) | 21.1 | 19.5 | 19.1 | 18.7 | 18.8 | 19.0 | 18.8 | 18.5 | 19.2 |

were significant ($P < 0.001$) when regressions on cow GL replaced cow group in the model. Performance generally improved for subsequent lactation yields as GL increased. In contrast, intermediate GL was optimal for PL, CE, SB and culling. Intermediate GL also was optimal for DO, but group fluctuations made this interpretation less obvious.

## Conclusion

Based on independent data sets, Holstein GL can be changed through the choice of service sire. Herd managers could take advantage of this knowledge to aid in controlling calving season or predicting calving date. Relationship between GL and subsequent performance for three yield and six fitness traits were generally small (but real) for most of those traits. Changing Holstein GL by more than a day or two would have limited benefit for overall performance.

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