Evaluation of Conception Rate in Nordic Dairy Cattle

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Abstract

Nordic Cattle Genetic Evaluation (NAV) has recently updated the joint Nordic fertility evaluation launched in 2005. Countries belonging to EuroGenomics Cooperative are harmonizing fertility evaluations to increase the benefit of using the common reference population for genomic evaluation. As a part of this project, NAV included also conception rate (CR) in the group of traits under evaluation. Three breeds that are included (Holstein, Nordic Red Dairy Cattle, Jersey) are evaluated separately. Data include all cows with insemination information. Each service of a cow is defined as an observation and at maximum 10 services per parity are included. Approximately 5% of the CR observations were obtained after third (heifers) or fourth service (cows). According to other biological traits in the Nordic fertility evaluation model, heifers and cows with up to three parities are treated as separate, but genetically correlated traits. For each breed, a multi-lactation repeatability animal model is fitted. Besides conventional fixed effects such as a herd × year, an insemination year × month, and an age of heifer at first service, a service number was included to account for the change in expectation if a cow failed to conceive. Additional fixed effects included are a semen type (sexed/conventional) and a heterosis. Permanent environment and additive animal effects are modeled as random. Means of CR ranged from 0.40 (Holstein third parity cows) to 0.59 (Holstein heifers). Means of Jersey cows, 0.47 on average, were clearly higher than those of Holstein cows that had the lowest means. Countries differed in the phenotypic level of CR and in frequency distribution of services. Use of sexed semen caused approximately 11% reduction in CR for all breeds and parities and inclusion of semen type into the model improved the breeding values of younger bulls having a lot of daughters inseminated with sexed semen. This was observed in genetic trends of heifers in all breeds, and in Jersey cows.

Key words: conception rate, evaluation model, fertility, genetic trend, sexed semen

Introduction

Nordic Cattle Genetic Evaluation (NAV) has recently updated the joint Nordic fertility evaluation launched in 2005 (Fogh *et al.*, 2003). At first, the evaluation was changed from the multi-trait repeatability sire model into the multi-trait multi-lactation animal model with the new estimated genetic parameters (Muuttoranta *et al.*, 2015). For each biological trait, observations from heifers and cows up to first three parities are treated as four separate, but genetically correlated traits in the model. In total, six different biological traits (interval from calving to first service (ICF), interval from first to last service (IFL), 56-d non-return rate (NRR), number of inseminations (AIS), heat strength (HST, Sweden only), and conception rate (CR)), and three breeds (Holstein, Nordic Red Dairy Cattle, Jersey) are evaluated.

Countries of the EuroGenomics Cooperative are harmonizing fertility evaluations to increase the benefit of using the common reference population for genomic evaluation. Therefore, NAV included also CR in the group of traits under evaluation in order to replace NRR with CR and to be sent for international bull evaluation.

Materials and Methods

CR data include all cows with insemination information. Each service of a cow is defined as an observation; at maximum 10 services per parity are included. Records for CR (0, 1, p) are defined by a complex decision process based on several information sources: inseminations, pregnancy check information, calvings, information on selling alive, and cullings. All available data is used to define phenotypes of the records. However, 150 days of the most recent data is cut from the final data set to diminish the effect of right-hand censoring. For open cases without information on, e.g., next calving or pregnancy check, probability p of 0.7 is used to take the uncertainty of the pregnancy status into account.

The use of sexed semen is becoming more and more popular in Nordic countries, especially in Jersey for which fattening of bull calves is not economical. For instance, almost 8% of the services in Danish Jersey heifers are done with sexed semen, cows somewhat less. Its use is the least common in RDC and also countries differ in prevalence. Use of sexed semen is most common at first service (6.2% in Danish Jersey) and decreases with increasing number of services. For some bulls, predominantly sexed semen is marketed and used. Conception rate is somewhat lower with sexed than with conventional semen. In the Nordic data set, the diminishing effect was around 11% units for all breeds and parities. It is therefore expected that the bulls having a lot of daughters inseminated with sexed semen have biased breeding values for fertility. Therefore, it was decided to account for the use of sexed semen in the fertility evaluation in Nordic countries. This was done for CR, but also for NRR, IFL, and AIS. For the latter two, pre-corrected phenotypes are used.

Statistical model for CR

For each breed the following multi-lactation repeatability animal model is fitted:

$$y_{ijklmnopq} = hy_i + iym_j + iage_k + service_l + stype_m + tothet_n + pe_o + animal_p + e_{ijklmnopq},$$

where $y_{ijklmnopq}$ is a repeated observation within parities.

The fixed effects of the model are:

hy_i = herd × birth year for heifers, and herd × first calving year for cows,

iym_j = insemination year × month × country,

$iage_k$ = age of heifer at first service × country,

$service_l$ = service number × country,

$stype_m$ = year class × semen type × country,

$tothet_n$ = total heterosis modeled as a fixed regression effect across countries.

The random effects are:

pe_o = permanent environment,

$animal_p$ = additive animal, and

$e_{ijklmnopq}$ = residual.

All traits are pre-corrected for heterogeneous variance according to country, year of first calving and parity. The applied genetic parameters are collected in Tables 1 and 2.

Besides to the analyses performed under the full model presented above, analyses were also done by excluding the semen type effect ($stype_m$) from the model to demonstrate the importance of fitting this effect. In addition, EBV correlations between CR, NRR, and IFL from the full model were studied from AI bulls born in 2007-2011 and having in minimum 50 daughters and reliability of 0.50. All analyses were carried out with MiX99 (MiX99 Development Team, 2016).

Table 1. Applied heritabilities by breed for conception rate (CR). Numbers after CR refer to parities, zero to heifers.

Trait	Holstein	RDC/Jersey
CR0	0.010	0.010
CR1	0.025	0.020
CR2	0.030	0.023
CR3	0.030	0.025

Table 2. Applied genetic correlations by breed for conception rate (CR). Holstein above diagonal, RDC/Jersey below diagonal. Numbers after CR refer to parities, zero to heifers.

Trait	CR0	CR1	CR2	CR3
CR0		0.72	0.55	0.53
CR1	0.65		0.93	0.92
CR2	0.57	0.93		0.96
CR3	0.47	0.84	0.95	

Modeling herd × year effects

The choice of the year of calving in the herd × year effect for cows was found to be crucial to minimize a bias caused by right-hand censoring of the data, even if the most recent CR data was excluded (and penalized phenotypes were used for traits other than CR). The actual calving year would be the best choice to model the herd × year effect for cows, because it is the closest year for observations. However, by fitting herd × actual calving year the genetic trend in the youngest birth year classes notably improved compared to the herd × first calving year in the model, indicating non-random distribution of daughters in the actual calving year × season classes The most fertile daughters calve first, belonging to the first classes and the poorest daughters calve last, belonging to the last classes. This bias was most pronounced for interval traits and therefore the genetic trend of ICF is shown as an example illustrating the importance of the choice of the year of first calving for the herd × year effect (Figure 1).

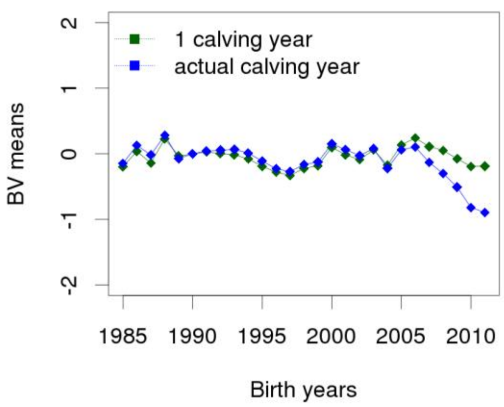

Figure 1. Genetic trends of bulls for interval from calving to first service on an original scale.

The lower the value the better the trend. The only difference between the models used was the choice of the year in the herd × year effect, either the actual calving year or the year of first calving.

Modeling service number

Another crucial effect in the model fitted for CR was the service number to account for the change in expectation if a cow failed to conceive. Muuttoranta *et al.* (2016) showed in the simulation study that by ignoring the service number effect, the environmental trend was severely over-estimated (Figure 2), and genetic trends and estimates of heritability were inflated (Figure 3).

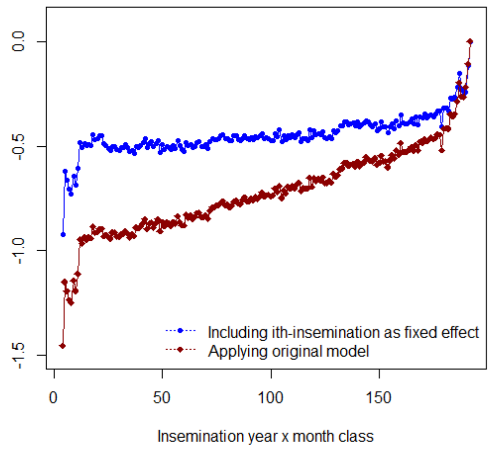

Figure 2. Fixed effect solutions of the insemination year × month effect from the simulation study of Muuttoranta *et al.* (2016).

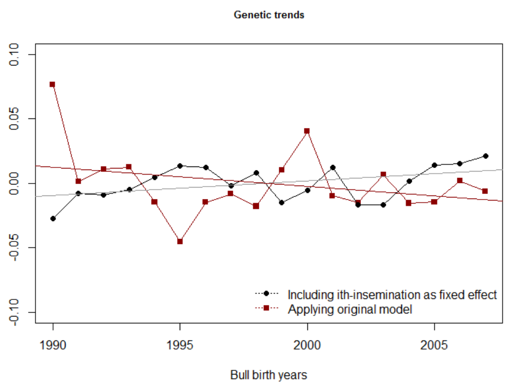

Figure 3. Genetic trends from the model with service number excluded (red line) or included (black line). Results are from the simulation study of Muuttoranta *et al.* (2016).

The solutions of the service number clearly increased with the increasing number of services, capturing the change in expectation, if a cow failed to conceive at the first service (Figure 4).

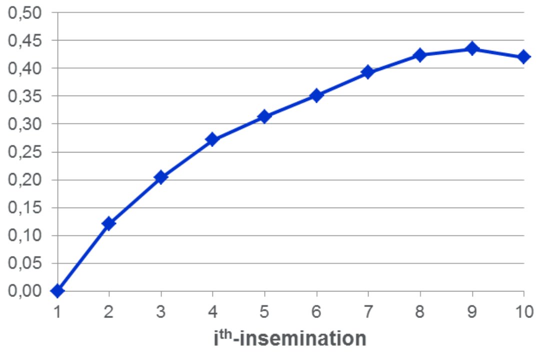

Figure 4. Fixed effect solutions of the service number from the simulation study of Muuttoranta *et al.* (2016).

Results & Discussion

Phenotypic mean of CR was highest for the Holstein heifers (0.59). The difference was, however, minor compared to the RDC and Jersey heifers (Table 3). The phenotypic mean of CR for the Jersey cows (0.47) was clearly higher than the means for the RDC and Holstein cows with Holstein having the lowest mean (0.42). Around 95% of the CR observations were recorded within the first 3 services for heifers and within the first 4 services for cows. Phenotypic means and distribution of CR observations clearly differed among countries. The lowest CR means were observed in Finland.

Table 3. Phenotypic means of conception rate by breed. Zero refers to heifers.

Parity	Holstein	RDC	Jersey
0	0.59	0.58	0.57
1	0.44	0.45	0.47
2	0.41	0.43	0.47
3	0.40	0.42	0.46
Cows	0.42	0.44	0.47

Genetic trends for conception rate in bulls are increasing for all Nordic breeds and parities (Figures 5-10). The figures also illustrate how genetic trends of Jersey cows (Figure 10) and heifers especially in Holstein (Figures 5, 7, 9) differed between the models with semen type effect included/excluded. Inclusion of semen type into the model improved the EBV of younger bulls having a lot of daughters inseminated with sexed semen. As an example, the EBV of the current best progeny tested Jersey bull improved with three index units for the heifer CR, four index units for the first parity CR, and two index units for the second and third parity CR.

The EBV correlations between CR and NRR in AI bulls born in 2007-2011 were highest for heifers in all breeds, being approximately 0.88. The corresponding EBV correlations were somewhat lower for cows, being 0.80 over parities and breeds (Table 4). The corresponding EBV correlations between CR and IFL were higher for all breeds and parities. Thus, the results show that the above traits are similar, but not identical, in accordance with the estimated genetic parameters between the traits (unpublished data).

Table 4. EBV correlations for AI bulls born in 2007-2011 between conception rate (CR), 56-d non-return rate (NRR), and interval from first to last service (IFL). Numbers after trait names refer to parities from 1 to 3, zero to heifer traits.

EBV correlation	Holstein	RDC	Jersey
CR0, NRR0	0.89	0.87	0.88
CR1, NRR1	0.84	0.82	0.80
CR2, NRR2	0.80	0.79	0.77
CR3, NRR3	0.78	0.76	0.81
CR0, IFL0	0.88	0.94	0.93
CR1, IFL1	0.90	0.89	0.88
CR2, IFL2	0.91	0.88	0.88
CR3, IFL3	0.88	0.87	0.87

Conclusions

CR has replaced NRR in Nordic genetic evaluation for female fertility and is currently sent for international bull evaluation instead of NRR. Modeling service number and sexed semen effect proved to be necessary. Genetic trends of CR are improving for all breeds and parities in Nordic countries.

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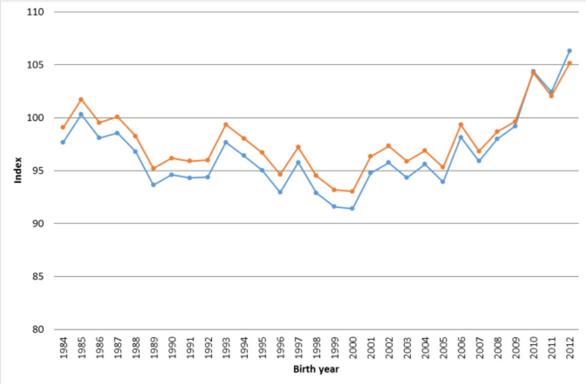

Figure 5. Genetic trends in Holstein bulls for heifer conception rate without (orange) / with (blue) modeling sexed semen effect.

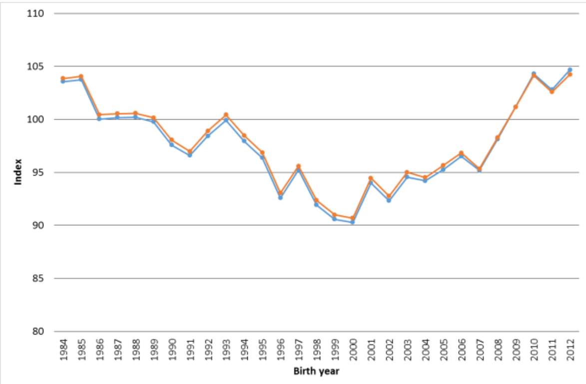

Figure 6. Genetic trends in Holstein bulls for cow conception rate without (orange) / with (blue) modeling sexed semen effect.

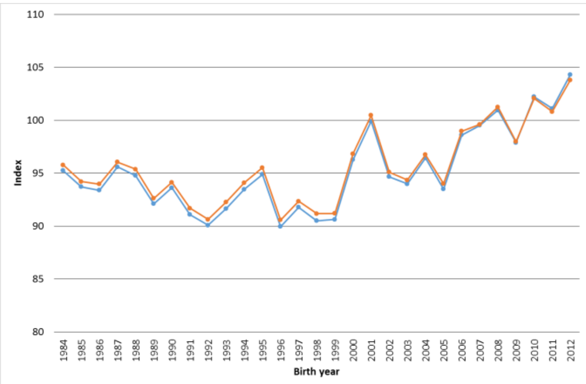

Figure 7. Genetic trends in RDC bulls for heifer conception rate without (orange) / with (blue) modeling sexed semen effect.

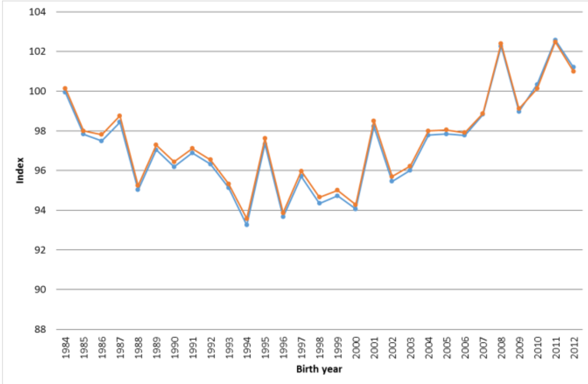

Figure 8. Genetic trends in RDC bulls for cow conception rate without (orange) / with (blue) modeling sexed semen effect.

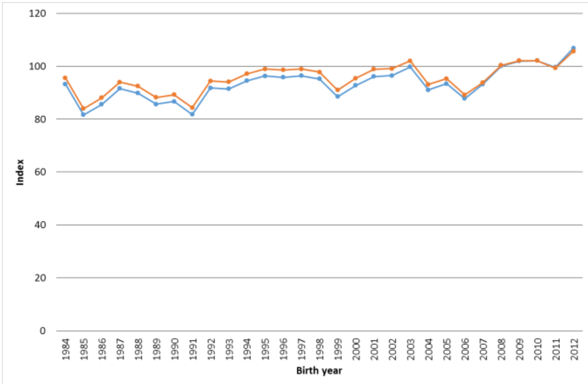

Figure 9. Genetic trends in Jersey bulls for heifer conception rate without (orange) / with (blue) modeling sexed semen effect.

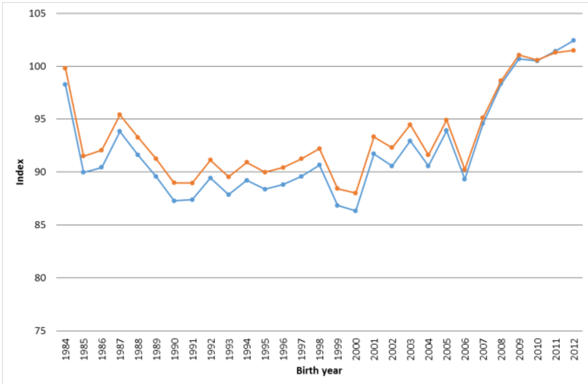

Figure 10. Genetic trends in Jersey bulls for cow conception rate without (orange) / with (blue) modeling sexed semen effect.