Refinement of U.S. Reproductive Performance Evaluations for the Modern Dairy Herd

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Abstract

United States (U.S.) national genetic evaluations for reproductive performance include Daughter Pregnancy Rate (DPR), Cow Conception Rate (CCR), Heifer Conception Rate (HCR), and Early First Calving (EFC). Since their introduction, 2003, 2009, 2009, and 2019, respectively, changes in reproductive management (e.g., variable voluntary waiting periods, sexed semen, synchronization protocols, and beef-on-dairy usage) have altered the biological and data structure underlying these traits. In addition, undesirable run-to-run behavior was observed in recent years, including seasonal fluctuations and directional shifts in young bull predicted transmitting ability (PTA). A comprehensive review of the phenotype pipeline and evaluation model was conducted. Key updates implemented for the April 2026 evaluation include: (1) herd-year and lactation-specific voluntary waiting period adjustment in DPR; (2) introduction of a new trait, First Service to Conception (FSC), defined as days from first insemination to confirmed pregnancy (capped at 200 d with penalty for non-conception); (3) revised CCR and HCR pre-adjustments accounting for service sire breed, mating type, and short-cycle inseminations; (4) stricter daughter age-related inclusion rules to reduce outcome-dependent bias in young bulls; (5) updated contemporary group edits; (6) new variance component estimation; and (7) stricter convergence criteria. DPR, CCR, HCR, and FSC are evaluated in a multi-trait model, while EFC is analyzed separately. Genetic correlations among DPR, CCR, and FSC exceed 0.94, with moderate correlation to HCR. Across seven consecutive triannual runs from December 2023 to December 2025, the revised system demonstrated improved genetic trend behavior, elimination of systematic downward drift in young bull PTA, and more symmetric run-to-run changes. Traditional PTA distributions by birth cohort better reflect expected selection response. Reranking is trait-dependent and most pronounced for CCR and DPR in low-reliability animals, whereas rankings among young high-reliability bulls (REL ≥95) remain highly consistent (>0.94 Spearman). Interbull validation requirements were met. The revised evaluation provides improved biological alignment with modern reproductive management while maintaining appropriate stability and interpretability for international comparison.

Key words: estimated breeding values, female fertility, management changes, reproduction, trait stability, voluntary waiting period

Introduction

Reproductive performance is an important component of dairy cattle profitability and herd sustainability. In the United States (U.S.), genetic selection for female fertility is supported by national evaluations for Daughter Pregnancy Rate (DPR), Cow Conception Rate (CCR), Heifer Conception Rate (HCR), and Early First Calving (EFC). These evaluations are provided by the Council on Dairy Cattle Breeding (CDCB; Bowie, MD, USA) and

describe related but distinct aspects of reproductive performance. DPR reflects the rate at which nonpregnant lactating cows become pregnant and was introduced as a national genetic evaluation in 2003 (VanRaden et al., 2004). CCR and HCR measure conception success following insemination in cows and heifers, respectively; development of heifer fertility evaluations was described by Kuhn et al. (2006). The reproductive performance traits have subsequently been incorporated into multi-trait national evaluations to utilize information among correlated traits (VanRaden et al., 2014). Most recently, EFC was implemented in 2019 (Hutchison et al., 2017) and measures genetic differences in age at first calving.

Management practices affecting reproduction have continued to change since these traits were implemented. Greater use of sexed semen, synchronization programs, beef semen in dairy herds, and herd-specific reproductive strategies has altered both insemination patterns and the structure of the data used in national evaluations. Changes in reproductive technologies, including the rapid increase in embryo transfer, have previously required modifications to U.S. fertility evaluations (Miles et al., 2023). Voluntary waiting periods also vary among herds and across lactations, which is particularly relevant for DPR because its phenotype is derived from days open, the interval between calving and conception. These changes raised questions about whether existing phenotype definitions, adjustments, and data edits continued to represent reproductive performance appropriately in modern dairy herds.

At the same time, routine evaluation monitoring identified unexpected behavior in some reproductive performance traits. Genetic trends showed seasonal fluctuations and predicted transmitting abilities for some groups of young bulls exhibited directional changes between consecutive evaluations. These patterns and the initial investigation of the U.S. female fertility evaluations were described by McWhorter et al. (2025). Although PTA changes are expected as additional daughter information becomes available, changes should generally occur in both directions rather than display a persistent systematic shift. These observations motivated a broader review of the reproductive performance evaluation system.

The objective of this work was to refine the U.S. reproductive performance evaluations to better reflect current management practices and improve run-to-run behavior. This paper describes the revisions implemented in the national evaluation and summarizes their effects on genetic trends, PTA stability, and ranking consistency.

Materials and Methods

National reproductive records used for U.S. genetic evaluations were obtained from the National Cooperator Database managed by CDCB. Phenotypes included records for lactating cows and heifers. The evaluation analyzed DPR, CCR, HCR, FSC, and EFC for Ayrshire, Brown Swiss, Guernsey, Holstein, Jersey, and Milking Shorthorn. Tests were performed using the routine U.S. evaluation system over time. National evaluation data was tested across seven consecutive triannual runs from December 2023 through December 2025, including every April, August, and December evaluation in between. The legacy system refers to the evaluations before any updates were applied and the revised system refers to the evaluations after updates and the new trait, FSC, were applied. Record counts for the December 2025 evaluation are shown in Table 1.

Trait Definitions

DPR is a non-linear transformation from days open to pregnancy rate and predicts the proportion of nonpregnant cows expected to conceive during a 21-day estrous cycle (VanRaden et al., 2004). CCR and HCR evaluate conception success following insemination in lactating cows and maiden heifers, respectively. They can be understood as

Table 1: The number of phenotypes and cows/heifers available in the December 2025 evaluation run after all updates have been applied.

Trait*	Records	Cows/Heifers
DPR	93,692,573	37,064,183
CCR	45,286,331	19,071,905
HCR	14,136,039	14,136,039
FSC	45,286,331	19,071,905
EFC	34,634,436	34,634,436

*DPR=daughter pregnancy rate; CCR=cow conception rate; HCR=heifer conception rate; FSC=first service to conception; EFC=early first calving

the sum of adjusted inseminations (0=failed, 1=successful with an adjustment), divided by the total number of attempts, up to seven inseminations. Adjusted inseminations refer to accounting for effects on individual inseminations prior to combining into a single conception rate per lactation. EFC is the number of days between an animal's first calving and her birth. FSC was introduced to evaluate the interval between first insemination and conception and complements the existing fertility traits by characterizing reproductive performance after the first breeding event. In the phenotype calculation for FSC, conception is the date of the successful insemination confirmed through pregnancy diagnosis or subsequent calving.

Evaluation Updates

Several revisions were implemented across the reproductive performance traits evaluation system. DPR was updated to account for herd-year and lactation-specific voluntary waiting periods. Pre-adjustments for CCR and HCR were revised to account for service sire breed, mating type, and short-cycle inseminations. Data edits and inclusion criteria were also updated, including stricter daughter age requirements and contemporary group edits. Additional changes included updated variance components, stricter convergence criteria, and the introduction of FSC.

DPR, CCR, HCR, and FSC were evaluated jointly in a multi-trait animal model. In the legacy system, EFC was included in the multi-trait analysis with DPR, CCR and HCR, it was treated as uncorrelated. Therefore, in the revised system, EFC was evaluated separately using a single-trait animal model for computational efficiency. Updated variance components were estimated before implementation.

Results & Discussion

The revisions described in this study represent a comprehensive update to the U.S. reproductive performance evaluations following the initial review of evaluation behavior described by McWhorter et al. (2025). The revised reproductive performance evaluations produced more consistent behavior across routine national evaluations while maintaining biologically plausible genetic trends.

Genetic trends (mean PTA by birth year) in the legacy system demonstrated patterns more consistent with expectations (Figures 1 and 2). The legacy system showed downward shifts over time for DPR and CCR. In the revised system, the trends slowly started increasing from the onset of implementation of their genetic evaluations. Therefore, the revised system genetic trends more closely reflected the expected response to ongoing selection.

Run-to-run genetic trends were also more consistent under the revised evaluation system (Figure 3). Whereas the legacy evaluation occasionally produced shifts in average PTA for younger bulls between consecutive evaluations, the revised system resulted in a more consistent trend from one run to the next.

Implementation of the revised evaluation resulted in reranking of animals, with the greatest changes occurring among animals with lower reliability. However, rankings among young bulls with high reliability remained highly consistent across evaluation systems. Interbull validation requirements were satisfied for the revised evaluations prior to national implementation.

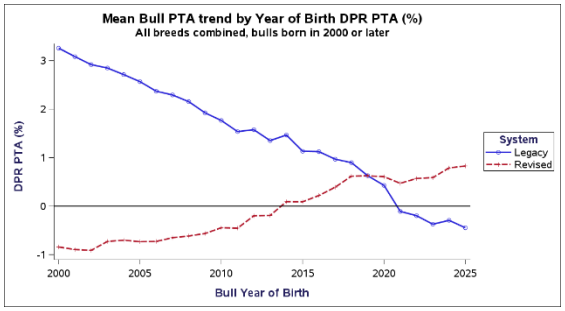


Figure 1. Daughter pregnancy rate (DPR) genetic trend for all bulls born 2000 or after for the legacy system (blue) and the revised system (red).

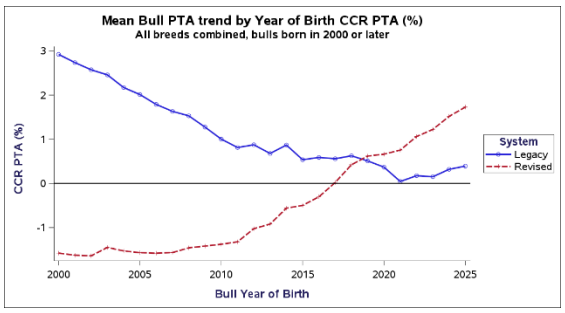


Figure 2. Cow conception rate (CCR) genetic trend for all bulls born 2000 or after for the legacy system (blue) and the revised system (red).

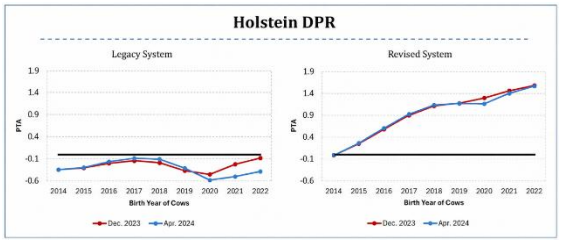


Figure 3. Daughter pregnancy rate (DPR) average sire PTA of cows with phenotypes by birth year of cows for Holstein in the legacy system (left) and the revised system (right) when comparing a previous run, December 2023 (red) to a subsequent run, April 2024 (blue).

The revised evaluations produced genetic trends and run-to-run PTA behavior that were more consistent with biological expectations while maintaining stability among highly reliable animals. Although some reranking occurred following implementation, the limited changes observed for high-reliability bulls indicate that the revisions primarily affected animals for which additional information or revised modeling had the greatest impact. These results suggest that the revised evaluation more appropriately reflects both current management practices and the accumulation of new performance data.

The addition of FSC further expands the U.S. reproductive performance evaluation by providing a measure of reproductive performance beginning at first insemination, regardless of voluntary waiting period.

Conclusions

The U.S. reproductive performance evaluations were revised to better reflect current dairy management and to address undesirable behaviors from one evaluation to the next. The revised system incorporated updated phenotype processing, editing, modeling procedures, and the new FSC trait. Across consecutive evaluations, the revisions produced more biologically plausible trends, more balanced PTA changes in young bulls, and high-ranking consistency among animals with high reliability. The revised evaluations met Interbull validation requirements and were implemented for the August 2026 evaluation.

Acknowledgments

The authors would like to thank U.S. Dairy Producers, member sectors and collaborators, as well as the USDA Animal Genomics and Improvement Laboratory (AGIL) for contributions to this project. The support and input from an internal CDCB team were essential throughout the review process.

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