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DESCRIPTION OF NATIONAL GENETIC EVALUATION SYSTEMS

Country (or countries)	United States of America
Main trait group	Female fertility [heifer conception rate (**HCR**), calving to first insemination (**CFI**), cow conception rate (**CCR**), daughter pregnancy rate (**DPR**)]
Breed(s)	AYS (RDC), BSW, GUE, HOL (B&W, R&W), JER, MSH (RDC); all breeds and crossbred cows evaluated together in a multitrait, multibreed AM for HCR, CCR, and DPR
Trait definition(s) and unit(s) of measurement	**HCR:** Maiden heifer's ability to conceive (trait 1) defined as percentage of inseminated heifers that become pregnant at each service; an HCR of 1 implies that daughters of this bull are 1% more likely to become pregnant as a heifer than daughters of a bull with an evaluation of 0 **CFI:** Lactating cow's ability to start cycling (trait 2) defined as days from calving to first insemination; estimated as a linear function of PTA for CCR and DPR instead of directly from raw data **CCR:** Lactating cow's ability to conceive (trait 3) defined as percentage of inseminated cows that become pregnant at each service; a CCR of 1 implies that daughters of this bull are 1% more likely to become pregnant during that lactation than daughters of a bull with an evaluation of 0 **DPR:** Lactating cow's interval calving–conception (trait 5) defined as percentage of nonpregnant cows that become pregnant during each 21-day period; DPR of 1 implies that daughters from this bull are 1% more likely to become pregnant during that estrus cycle than a bull with an evaluation of 0; lactation DPR is calculated from DO using the nonlinear formula DPR = 100{21/[max(days open, 71) – 50]}; cows that become pregnant in the first opportunity period have DPR = 100 and those still open in the last opportunity period have DPR = 0
Method of measuring and collecting data	Collected by Dairy Herd Information Affiliates using ICAR-approved methods
Time period for data inclusion	**HCR:** Calvings from 2003 and later **CCR:** First calvings from 2003 and later **DPR:** First calvings from 1960 and later
Age groups (e.g. parities) included	**HCR:** Only breedings for which heifer is at least 1 but <2.2 years old included **CCR:** First 5 parities included; only breedings for which cow is at least 2 years old included **DPR:** First 5 parities included

Other criteria (data edits) for inclusion of records	**HCR:** All confirmed (failure or success) breedings* up to 7 included; herd-year conception rate must be between 10 and 90%; known sire required; known ET heifers excluded **CCR:** All confirmed (failure or success) breedings* up to 7 included; herd-year must report at least 1 breeding for at least 50% of milking cows and conception rate must be between 10 and 90%; known sire required; known ET cows excluded **DPR:** Records for pregnancy rate considered complete at 250 DIM; date pregnant set to 50 DIM for cows that become pregnant before 50 DIM; some extremely early pregnancy dates obtained by calculation from date of next calving inaccurate because of short gestation lengths or unreported abortions; lower (50) and upper (250) limits affecting 5 and 14% of records, respectively, applied after adjusting DO for season effects *Service coded as failure if another reproductive event (breeding–AI or NS, heat, or diagnosis of "not pregnant") subsequently reported or as success if validated with a pregnancy check or resulting calving date
Criteria for extension of records (if applicable)	**DPR:** DIM ≥ 130 and <250 predicted
Sire categories	All sires (AI and NS) evaluated together
Environmental effects, pre-adjustments	**HCR, CCR:** Region-breeding month; service number; mating type **DPR:** Season adjustments based on month fresh
Method (model) of genetic evaluation	**HCR, CCR, DPR:** Multitrait, multibreed BLUP AM; all breeds and crossbreds evaluated
Environmental effects[3] in the genetic evaluation model	**HCR:** Management group (flexible HYS-registry status) (F), heifer age at first breeding (F), PE (R); released PTA includes regression coefficient multiplied by expected future inbreeding (EFI) and coefficient of heterosis when mated to purebred as a post-processing step **CCR:** Management group (flexible HYS, includes registry status for HOL) (F), parity (F), cow age at first breeding (F), PE (R); released PTA includes regression coefficient multiplied by EFI and coefficient of heterosis when mated to purebred as a post-processing step **DPR:** Management group (flexible HYS, includes registry status for HOL) (F), parity × age (F), regression on inbreeding (F), PE (R), herd × sire interaction (R); released PTA includes regression coefficient multiplied by EFI and coefficient of heterosis when mated to purebred as a post-processing step

Adjustment for heterogeneous variance in evaluation model	**HCR:** Breeding average given extra weight for each observation, with weight increasing less than linearly because of PE effects using the formula *n*/[1 + (*n*–1) repeatability] for a lactation with *n* breedings **CCR:** Lactation average given extra weight for each observation, with weight increasing less than linearly because of PE effects using the formula *n*/[1 + (*n*–1) repeatability] for a lactation with *n* breedings **DPR:** Lactation average given extra weight for each opportunity period, with weight increasing less than linearly because of PE effects using the formula *n*/[1+(*n*–1) repeatability] for a lactation with *n* opportunity periods; number of opportunity periods is *n* = max [1, (days open – 50)/21]
Use of genetic groups and relationships	**HCR, CCR, DPR:** Unknown parents grouped by birth year, breed, and, for HOL, separately for U.S. and foreign animals; unknown sires and dams of cows grouped separately, but unknown parents of bulls in a combined group; earliest groups combined for HCR and CCR; relationship matrix accounts for effects of inbreeding on Mendelian sampling variance
Blending of foreign/Interbull information in evaluation	Not applicable
Genetic parameters in the evaluation	See Appendix GE for h^2 and genetic variance estimates and "calculation of reliability" section below for use in calculation; **HCR:** PE variance, 0.025; RP, 0.12 **CCR:** PE variance, 0.012; RP, 0.07 **DPR:** PE variance, 0.012, RP, 0.13
System validation	Means and SDs for all variables calculated and examined overall; means for new bulls, changes for high bulls, largest changes, and key statistics for recent AI bulls checked; genetic trends for each breed validated by methods 1 and 3
Expression of genetic evaluations	PTA, % for HCR, CCR, and DPR; PTA, days for CFI **HCR, CCR:** All-breed PTAs adjusted to within-breed bases as within-breed PTA = (all-breed PTA – breed mean) **CFI:** PTA = 1.2(PTA CCR) – 2.7(PTA DPR) **DPR:** All-breed PTAs adjusted to within-breed bases as within-breed PTA = (all-breed PTA – breed mean) × (breed SD/HOL SD)
Definition of genetic reference base	**HCR, CCR, DPR:** Cows born in 2010 (stepwise, 5 years)
Next base change	December 2019 (when base will be cows born in 2015)
Calculation of reliability	**HCR, CCR, DPR:** Daughter equivalents from progeny, parents, and own records combined using the same methods as for yield traits **CFI:** 0.37(CCR reliability) + 0.63(DPR reliability)
Criteria for official publication of evaluations	At least 10 daughters with usable fertility data

Number of evaluations/ publications per year	3 (April, August, December)
Use in total merit index[4]	**DPR:** 11% of total in net merit dollars (**NM$**, all breeds); 10% of total in Total Performance Index (**TPI**, HOL)
Anticipated changes in the near future	None
Key reference on methodology applied	VanRaden, P.M., A.H. Sanders, M.E. Tooker, R.H. Miller, and H.D. Norman. 2002. Daughter pregnancy rate evaluation of cow fertility. AIPL Res. Rep. DPR1(11-02). Kuhn, M.T., and P.M. VanRaden. 2004. Use of early lactation days open records for genetic evaluation of cow fertility. J. Dairy Sci. 87:2277–2284. VanRaden, P.M., A.H. Sanders, M.E. Tooker, R.H. Miller, H.D. Norman, M.T. Kuhn, and G.R. Wiggans. 2004. Development of a national genetic evaluation for cow fertility. J. Dairy Sci. 87: 2285–2292. Wiggans, G.R., and R.C. Goodling, Jr. 2005. Accounting for pregnancy diagnosis in predicting days open. J. Dairy Sci. 88: 1873–1877. Kuhn, M.T., J.L. Hutchison, and G.R. Wiggans. 2006. Characterization of Holstein heifer fertility in the United States. J. Dairy Sci. 89:4907–4920. VanRaden, P.M., M.E. Tooker, J.B. Cole, G.R. Wiggans, and J.H. Megonigal, Jr. 2007. Genetic evaluations for mixed-breed populations. J. Dairy Sci. 90:2434–2441. Kuhn, M.T., and J.L. Hutchison. 2008. Prediction of dairy bull fertility from field data: Use of multiple services and identification and utilization of factors affecting bull fertility. J. Dairy Sci. 91:2481–2492. Kuhn, M.T., J.L. Hutchison, and H.D. Norman. 2008. Modeling nuisance variables for prediction of service sire fertility. J. Dairy Sci. 91:2823–2835. VanRaden, P.M., M.E. Tooker, J.R. Wright, C. Sun, and J.L. Hutchison. 2014. Comparison of single-trait to multi-trait national evaluations for yield, health, and fertility traits. J. Dairy Sci. (in press).

Key organisation: name, address, phone, fax, e-mail, web site	**Evaluation calculation and distribution:** Council on Dairy Cattle Breeding 10300 Baltimore Ave. Bldg. 005, Room 304, BARC-West Beltsville, Maryland 20705-2350, USDA voice: 301-525-2006; no fax e-mail: duane.norman@cdcb.us web site: https://www.cdcb.us **Evaluation methodology:** Animal Improvement Program Animal Genomics and Improvement Laboratory Agricultural Research Service, U.S. Dept. of Agriculture 10300 Baltimore Ave. Bldg. 005, Room 306, BARC-West Beltsville, Maryland 20705-2350, USA voice: 301-504-8334; fax: 301-504-8092 e-mail: aipl.inquiry@ars.usda.gov web site: http://aipl.arsusda.gov

Parameters used in genetic evaluation

Country (or countries): United States of America

Main trait group: Female fertility (HCR, CFI, CCR, DPR)

Breed(s): AYS (RDC), BSW, GUE, HOL (B&W, R&W), JER, MSH (RDC)

Trait	Definition	ITB	h^2	Genetic variance	Official proof standardisation formula[a]
Maiden heifer's ability to conceive	Heifer conception rate (HCR)	X	0.01	SD = 4.81 (all breeds)	
Lactating cow's ability to start cycling	Calving to first insemination (CFI)	X	0.066	SD = 9.1 (all breeds)	
Lactating cow's ability to conceive 1	Cow conception rate (CCR)	X	0.016	SD = 5.81 (all breeds)	
Lactating cow's ability to conceive 2	—	—	—	—	
Lactating cow's interval calving-conception	Daughter pregnancy rate (DPR)	X	0.014	BSW SD = 3.05 GUE SD = 3.04 HOL SD = 3.02 JER SD = 3.02 RDC SD = 3.01	

[a] Expressed as follows:
StandEval = ((Eval − a)/b) × c + d, where a = mean of base adjustment, b = SD of base, c = SD of expression (include sign if scale is reversed), and d = base of expression.