Examination of More Frequent Genetic Evaluations for Dairy Bulls

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ABSTRACT

Genetic evaluations of Holstein bulls for February 1997 through May 1998 were examined to determine the value of more frequent evaluation for quicker identification of bulls with changing predicted transmitting abilities (PTA) and of new bulls of superior genetic merit. Changes in PTA between evaluations that were calculated quarterly rather than semiannually were reduced by 30%. About two-thirds of PTA were closer to PTA that were calculated 3 mo later than were PTA calculated 3 mo earlier. Improvements in accuracy were 94 to 96% for a subset of bulls with substantial PTA changes from 3 mo before to 3 mo after an evaluation. With quarterly evaluation, half of the bulls had initial PTA available 3 mo sooner than with semiannual evaluation, and those PTA were better predictors of later PTA than were the parent averages that would have remained the best genetic estimates for 3 mo longer. Correlations of parent averages with PTA about a year later were 0.5 to 0.6, whereas correlations with later PTA were about 0.8 for initial PTA and 0.9 for second PTA. Although later PTA are expected to be improved estimates of true genetic merit, the timely results provided by quarterly evaluation were useful in identifying bulls with PTA that changed substantially and in identifying top new bulls.
(**Key words:** genetic evaluation, evaluation frequency)

Abbreviation key: PA = parent average.

INTRODUCTION

One of the major challenges in animal breeding is to make maximum use of limited data. A bull has a finite number of daughters at any point in time, and additional information from any future daughters is expected to improve the accuracy of the prediction of true genetic merit for most bulls. However, breeding, culling, and other management decisions often cannot wait until the later information is available. Ideally for genetic improvement and management purposes, a data user could receive an up-to-the-minute evaluation. Until that day can be realized, systems must be used that require sequential collection of yield, pedigree, and other data; data editing and adjustment; and simultaneous processing of data, all of which can take days or even weeks.

A symposium on continuous evaluation in dairy cattle occurred in 1993. Perhaps the topic would have been less threatening if the word “continuous” had been replaced by “more frequent.” Lohuis et al. (6) estimated increased genetic gains of 7 to 9% from continuous evaluation. Although there was little disagreement on the scientific and theoretical merits of more frequent evaluation, presenters for the AI industry had contrasting views on the overall desirability (4, 7, 11). The pros and cons of changes in evaluations were acknowledged by Misztal et al. (8): “Although . . . variability of genetic evaluations . . . may illustrate the high prediction error variance of some evaluations, it could be disturbing to dairy producers. If genetic estimates were different every few days or weeks, breeders might benefit from considering their selection decisions more frequently than under the semiannual evaluation system.” Jensen (5) described the Danish system of monthly evaluations and stated that the “Danish cattle industry is, by tradition, used to frequent evaluations and will not accept more infrequent dissemination of updated information.”

Quarterly yield evaluations were begun by USDA’s Animal Improvement Programs Laboratory (Beltsville, MD) in May 1997 (9) with the support of the Council on Dairy Cattle Breeding. The plan was for the quarterly evaluation process to be reviewed after a year, although that intention was not generally recognized. Opinions differed on whether the quarterly evaluations should be continued or whether the semiannual schedule should be reinstated. Editorials and magazine articles (1, 2, 3) presented the arguments. The cost to the industry for marketing semen increased with frequency of evaluation. Therefore, the genetic benefit of more frequent evaluation was of considerable interest, and the Animal Improvement Programs Laboratory was asked to provide the Council with information on the genetic benefit of providing information quarterly instead of semiannually. This study was initiated as a result of that request, and early results were provided to the Council. In March 1998, the Council reaffirmed its support for quarterly national evaluations. In May 1998, the Steering Committee for the

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International Bull Evaluation Service (Uppsala, Sweden) decided to start quarterly evaluations in November 1998.

Although changes in PTA were expected to be smaller between evaluations that were calculated more frequently because fewer data were added, some in the dairy industry were concerned that PTA changes between evaluations would not decrease with reduced evaluation intervals. Therefore, documentation of relative PTA changes with different evaluation intervals should provide useful information on the value of more frequent evaluation. The objectives of this study were to investigate differences between quarterly and semiannual evaluations relative to 1) change in individual bull PTA, 2) quicker identification of significant large changes in PTA, and 3) quicker determination of new bulls with superior genetic merit.

MATERIALS AND METHODS

Data were PTA for milk, fat, and protein yields from USDA-DHIA genetic evaluations that occurred from February 1997 through May 1998 for 11,716 Holstein bulls. The bulls were born during 1985 or later, were evaluated in February 1997, and were designated as AI bulls by the National Association of Animal Breeders (Columbia, MO). The PTA also were examined for a subset of 536 Holstein bulls that were in active AI service in February 1997.

Mean absolute differences in PTA between evaluations were documented. Theory suggests that the variability of change in PTA is directly related to the increase in reliability between earlier and later evaluations. Based on part-whole data, the expected absolute difference between PTA from different evaluations is 0.7979 times the square root of the difference in reliabilities times the sire genetic standard deviation (10). Thus, expected relative absolute differences are simply ratios of the square root of increases in reliabilities for different evaluation intervals.

To determine the impact of quarterly versus semiannual evaluation on the accuracy of estimating genetic merit, mean absolute differences in PTA relative to evaluations that were calculated 3 mo earlier and 3 mo later were examined. For example, the mean absolute difference in PTA from May to August 1997 was compared with the mean absolute difference from February to August 1997. A smaller mean absolute difference was considered to be an indication of evaluation improvement. After excluding bulls with the same absolute difference in PTA for 3-mo and 6-mo evaluation intervals, the percentage of bulls with evaluation improvement for quarterly (3 mo) compared with semiannual (6 mo) evaluation was calculated. Mean PTA differences and mean absolute PTA differences between evaluations for a subset of bulls with substantial PTA changes (120 kg for milk, 5 kg for fat, or 4 kg for protein) over 6 mo also were examined to determine whether an interim evaluation would have identified the direction of the change.

To examine the usefulness of more frequent evaluation in identifying new bulls of superior genetic merit, mean and absolute differences in PTA between evaluations were studied for the top 20 bulls for milk, fat, and protein in May or August 1997 among bulls with initial evaluations in the corresponding month. Mean and absolute differences between PTA and parent average (**PA**), the mean of parent PTA, also were examined, and correlations of PA with initial and later evaluations were calculated.

RESULTS

Changes in Bull PTA

As expected, mean absolute PTA differences between evaluations were smaller for shorter evaluation intervals because fewer data were added to produce the change (Table 1). Changes for active AI bulls were about 50% larger because more data were added for this subset of bulls. Changes for a given interval were smaller for more recent periods because relatively fewer data were added as a result of the requirement that bulls had to have been evaluated in February 1997, which would exclude the newest bulls. Changes in PTA also were expected to be smaller because of smaller increases in reliability over time for older bulls. To further illustrate, mean absolute differences between May 1998 PTA and PTA from previous evaluations are shown in Table 2 for 13,542 Holsteins bulls that were evaluated in May 1998 and a subset of 610 bulls that were in active AI service at the time of the previous evaluation. Those differences were similar to the differences reported in Table 1 for the corresponding intervals that begin with the February 1997 evaluation and are more representative of the amount of change in PTA than are other differences in Table 1.

If evaluations are calculated twice as often, the opportunity exists for twice as many PTA to change. Nevertheless, absolute PTA differences were smaller (about 70% as large) between consecutive evaluations at twice the evaluation frequency (Tables 1 and 2). For about 4000 bulls with an increased reliability for 3- and 6-mo evaluation intervals, the expected relative absolute differences between evaluations (measured as the mean of the square roots of the reliability increases for the two 3-mo evaluation intervals divided by the 6-mo increase) were 0.69 for February through August 1997 and 0.68 for the May through November 1997.

Prediction of PTA was improved (smaller absolute PTA difference between evaluations) by more frequent evaluation for nearly two-thirds of the bulls with PTA changes

TABLE 1. Mean absolute differences in PTA between USDA-DHIA genetic evaluations for 11,176 Holstein AI bulls that were born during 1985 or later and had February 1997 evaluations and for a subset of 536 bulls that were in active AI service in February 1997.

	Milk		Fat		Protein	
Evaluation interval	All bulls	Active AI bulls	All bulls	Active AI bulls	All bulls	Active AI bulls
	(kg)					
15 mo						
February 1997 to May 1998	50	78	1.9	3.0	1.5	2.5
12 mo						
February 1997 to February 1998	46	70	1.8	2.7	1.4	2.2
May 1997 to May 1998	41	65	1.6	2.4	1.3	2.0
9 mo						
February 1997 to November 1997	42	64	1.6	2.4	1.3	2.0
May 1997 to February 1998	37	57	1.4	2.1	1.1	1.7
August 1997 to May 1998	31	54	1.2	1.9	1.0	1.7
6 mo						
February 1997 to August 1997	38	54	1.5	2.1	1.2	1.7
May 1997 to November 1997	32	48	1.2	1.8	1.0	1.5
August 1997 to February 1998	26	42	1.0	1.5	0.8	1.3
November 1997 to May 1998	25	44	1.0	1.6	0.8	1.4
3 mo						
February 1997 to May 1997	26	39	1.0	1.6	0.8	1.2
May 1997 to August 1997	27	36	1.1	1.4	0.9	1.1
August 1997 to November 1997	19	31	0.8	1.1	0.6	1.0
November 1997 to February 1998	18	31	0.7	1.1	0.6	0.9
February 1998 to May 1998	17	31	0.7	1.1	0.5	0.9

between evaluations (Table 3). However, most PTA changes were small, and the ability to predict large PTA changes more quickly is of much greater importance. For bulls with substantial PTA changes (>120 kg of milk, >5 kg of fat, or >4 kg of protein over 6 mo), improvement in PTA prediction ranged from 94 to 96% with more frequent evaluation.

Identification of New Superior Bulls

The changes in PTA from a subsequent 3-mo evaluation are in Table 4 for the top 20 bulls for milk, fat, and protein in May or August 1997 for bulls with an initial evaluation in the corresponding month. Also shown are statistics for the first and second evaluations relative to the May 1998 evaluation, which was assumed to have the most accurate PTA because the May 1998 evaluation was more recent. Changes between PA 3 mo before the first evaluation and May 1998 PTA are presented in Table 4.

Mean evaluations decreased from initial to second evaluation. As expected, PTA from the second evaluation were more similar to May 1998 PTA than were PTA from the first evaluation as indicated by both mean differences and mean absolute differences. For some bulls, first evaluations that were available with a quarterly evaluation schedule might not have been available with semiannual evaluation because of an insufficient number of daughter records. For those bulls, the best estimate of genetic merit would have been PA until the next semiannual evaluation. However, PTA from the first evaluation available with a quarterly evaluation schedule were considerably

TABLE 2. Mean absolute differences in PTA between May 1998 and previous USDA-DHIA evaluations for 13,542 Holstein AI bulls that were born during 1985 or later and for a subset of 610 bulls that were in active AI service at the time of the previous evaluation.

	Milk		Fat		Protein	
Evaluation interval	All bulls	Active AI bulls	All bulls	Active AI bulls	All bulls	Active AI bulls
	(kg)					
12 mo (May 1997 to May 1998)	44	70	1.7	2.5	1.4	2.2
9 mo (August 1997 to May 1998)	37	64	1.4	2.3	1.2	2.0
6 mo (November 1997 to May 1998)	33	56	1.3	2.0	1.0	1.7
3 mo (February 1998 to May 1998)	25	38	1.0	1.4	0.8	1.2

TABLE 3. Numbers of bulls with PTA changes[1] and percentages of bulls with improved[2] PTA prediction by an interim evaluation 3 mo earlier compared with the evaluation 6 mo earlier for 11,176 Holstein AI bulls that were born during 1985 or later and had USDA-DHIA genetic evaluations in February 1997 and for a subset of bulls with substantial[3] PTA changes.

	Milk		Fat		Protein	
Interim evaluation date	Bulls with changed PTA	Bulls with improved prediction	Bulls with changed PTA	Bulls with improved prediction	Bulls with changed PTA	Bulls with improved prediction
	(no.)	(%)	(no.)	(%)	(no.)	(%)
All bulls						
May 1997	11,590	60	8992	61	8400	62
August 1997	11,619	63	9540	65	8926	61
November 1997	11,559	62	8335	63	7547	63
February 1998	11,516	65	8294	67	7578	68
Bulls with substantial PTA changes						
May 1997	599	95	439	95	554	96
August 1997	527	94	397	96	477	94
November 1997	524	95	425	94	492	96
February 1998	627	95	474	96	594	96

[1]Bulls with the same absolute difference in PTA between evaluations were excluded.

[2]Smaller mean absolute differences in PTA between evaluations.

[3]Absolute difference in PTA of >120 kg for milk, >5 kg for fat, or >4 kg protein for a given evaluation date.

closer to May 1998 PTA than were PA. The May 1998 PTA were higher than PA because of selection for positive Mendelian sampling. Based on the milk-fat-protein dollar index, 6 and 10 of the top 20 bulls with an initial evaluation in May and August 1997, respectively, were in active AI service after May 1998.

Another way to evaluate the potential usefulness of more frequent evaluation is through correlations of genetic estimates for all newly evaluated AI bulls (Table 5). Correlations of PA with May 1998 evaluations were about 0.5 to 0.6 compared with nearly 0.8 for first evaluation and 0.9 for second evaluation. Although earlier PTA were expected to be less accurate than later PTA, more frequent evaluation could assist in earlier identification of genetically superior bulls and thus allow more timely semen collection, marketing, and assessment of daughters for identification accuracy and type traits. In addition, savings can be realized by ceasing semen collection for bulls with lower PTA, moving those bulls to lower cost housing, or even culling them.

CONCLUSIONS

Differences in PTA between evaluations increased with the evaluation interval. However, as PTA changes for individual bulls are not linear, the relationship between absolute changes and interval length was not linear. Doubling the frequency of evaluation (halving

TABLE 4. Mean differences and mean absolute differences in PTA or parent average[1] (PA) between USDA-DHIA evaluations for the top 20 bulls for milk, fat, and protein in May or August 1997 among bulls with an initial evaluation in the corresponding month.

	Milk		Fat		Protein	
Evaluation comparison	$\overline{X}$	$\lvert\overline{X}\rvert$	$\overline{X}$	$\lvert\overline{X}\rvert$	$\overline{X}$	$\lvert\overline{X}\rvert$
	(kg)					
Initial evaluation in May 1997						
August 1997 PTA – May 1997 PTA	–15	101	–2.25	3.79	–1.84	2.74
May 1998 PTA – May 1997 PTA	–51	146	–2.77	5.31	–3.56	4.65
May 1998 PTA – August 1997 PTA	–37	110	–0.52	3.83	–1.72	3.67
May 1998 PTA – February 1997 PA	176	218	4.42	7.73	1.86	4.17
Initial evaluation in August 1997						
November 1997 PTA – August 1997 PTA	–41	93	–2.25	5.06	–2.74	4.60
May 1998 PTA – August 1997 PTA	–22	116	–1.41	6.21	–3.40	4.58
May 1998 PTA – November 1997 PTA	19	104	0.84	3.47	–0.66	3.02
May 1998 PTA – May 1997 PA	228	257	0.32	8.34	2.84	8.91

[1]Mean of parent PTA.

TABLE 5. Correlations of parent average[1] (PA) or PTA from first or second evaluation with PTA in May 1998 for bulls with an initial evaluation in May or August 1997.

Evaluation date	Measure of genetic merit	Correlation with May 1998 PTA		
		Milk	Fat	Protein
Initial evaluation in May 1997				
February 1997	PA	0.61	0.57	0.61
May 1997	PTA	0.79	0.76	0.76
August 1997	PTA	0.90	0.88	0.88
Initial evaluation in August 1997				
May 1997	PA	0.50	0.56	0.54
August 1997	PTA	0.81	0.78	0.79
November 1997	PTA	0.91	0.90	0.90

[1]Mean of parent PTA.

the evaluation interval) reduced mean absolute differences in PTA by about 30%, which was near expectation. With more frequent evaluation, the number of PTA changes between consecutive evaluations increased, but the size of the change decreased.

About two-thirds of the bulls had better predictions of genetic merit (as indicated by smaller absolute PTA difference between evaluations) from an evaluation intermediate to semiannual evaluations. However, the ability of more frequent evaluation to provide earlier information for bulls that change substantially in PTA over a 6-mo interval is of greater interest. For such bulls, about 95% of intermediate PTA were more similar to PTA from a subsequent evaluation than were PTA from an evaluation 3 mo earlier.

Initial PTA were not as similar to PTA several evaluations later as were PTA from a second evaluation 3 mo later. However, initial PTA were considerably better predictors of later PTA than were PA, which would have remained as the best genetic estimates for another 3 mo without quarterly evaluation. Half of the top 20 bulls for the milk-fat-protein dollar index among newly evaluated bulls in August 1997 were in active AI service after May 1998. Early evaluation appeared to be useful despite limited data available for calculation of evaluations in identification of animals with superior genetic merit, especially considering the numerous reasons why a bull might no longer be in active AI service (e.g., poor semen production, injury, or poor daughter type).

Stability is a desired feature of an evaluation system, but achieving stability of evaluations by ignoring available data is not appropriate. During discussions of the merits and difficulties with quarterly versus semiannual evaluations, one suggestion was to minimize the problems by releasing PTA only for newly evaluated animals and those with substantial changes in PTA. Although that proposal had immense appeal, consensus on the definition of a substantial change would be difficult to reach, and, therefore, PTA for all animals are released with each evaluation. More frequent evaluation reduces the degree of change between consecutive evaluations, is valuable in providing early information (especially for bulls with PTA that are changing substantially), and is useful in identifying top young bulls sooner.

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