Equity of Elite Cow Status Across States

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ABSTRACT

Cows with superior genetic merit, based on an economic index for milk, fat, and yields (milk-fat-protein dollars), have been designated as elite by USDA. Because of the concern that adjustment for heterogeneous variance may have resulted in inequitable state representation for elite cows, the percentages of US cows with elite status were compared by state using evaluations of registered Holstein cows from 1990, 1991, and 1997. The numbers and percentages of eligible cows and the proportions of those cows that were designated as elite were determined by state from May 1997 evaluations of 772,302 registered and 1,499,729 grade Holstein cows; means and standard deviations for milk-fat-protein dollars were computed. Correlations were computed among the number of cows that were eligible for elite status, the number of cows that were designated as elite, the percentage of eligible cows that were designated as elite, and the mean and the standard deviation for milk-fat-protein dollars. Models were examined to for ability to predict the percentage of elite cows by state from mean and standard deviation for milk-fat-protein dollars. The number of elite cows for a state was highly correlated to the number of cows that were eligible for elite status. States with >1.0% of eligible cows designated as elite had mean milk-fat-protein dollars that were higher than the US mean of $44, but standard deviations were equal to or slightly lower than the US standard deviation of $71. The mean value for milk-fat-protein dollars was associated with the state percentage of elite cows, but variation of the index was not related. However, the standard deviation for milk-fat-protein dollars was important in explaining the percentage of elite cows if the model also contained the mean value. Differences in the variation of lactation records across states or adjustments for those differences did not appear to cause inequity in designating elite status. Corresponding results for grade cows supported findings for registered cows.
(**Key words**: elite cows, genetic evaluation, states)

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Abbreviation key: **MFP$** = economic index based on genetic merit for milk, fat, and protein yields.

INTRODUCTION

The primary purpose of genetic evaluations is to rank animals as correctly as possible by estimating the differences among them so that proper selection decisions can be made. Although every effort is taken to ensure that data edits, data adjustments, and definitions of environmental classes are objectively determined and applied, these may not seem equitable or fair to the owner of an animal that is adversely affected. A difference of 1 d in calving date could cause a cow to be considered a month older or younger for age adjustment or to be assigned to a different management group.

Powell et al. (8) demonstrated that herds with higher yield and variance had more elite cows even when apparent genetic levels were comparable, and Powell and Norman (6) suggested that the failure to account for herd variance or the use of less than optimal adjustments might bias bull evaluations. Everett et al. (2) reported that Holstein herds in the northeastern US with a high error variance within herd had a greater percentage of cows that were considered to be of superior genetic merit than did herds with low variance; as a result, in 1984, the Northeast AI Sire Comparison evaluations began to be calculated using yield records that had been log transformed (1). However, Garrick and Van Vleck (3) demonstrated that adjustment of lactation yields for heterogeneous variance with an inappropriate log transformation prior to the calculation of genetic evaluations decreased the efficiency of selection. In July 1991, the USDA implemented an adjustment of lactation records for heterogeneous variance (10) to remove the advantage or disadvantage in the evaluation system because of the variability of lactation records among herds. Although this implementation resulted in the use of higher heritability estimates for herds with high variance, the general effect was a shift in the percentage of elite cows away from the herds with high variance and an increased concentration in the herds with average variance.

Concern was expressed at the September 1996 meeting of the Council on Dairy Cattle Breeding that the adjustment for heterogeneous variance was penalizing cows in herds with high variance and favoring those in herds with low variance. The Holstein Association USA (Brattleboro, VT) compared the state origins of Holstein cows with high type-production indexes before implementation of the adjustment for heterogeneous variance in 1991 with the state origins of cows with high indexes in 1996. Changes in state representation were presented at a meeting of the Council on Dairy Cattle Breeding (1996, unpublished agenda book). Those changes were of particular interest in regard to California and Wisconsin, states with herds of high and low phenotypic variance, respectively. As a result of the findings from the study by the Holstein Association USA, the Council on Dairy Cattle Breeding established a review of the current procedure for adjustment of heterogeneous variance as high priority research (Council on Dairy Cattle Breeding, 1996, unpublished minutes).

Elite Holstein cows are the top 1% of cows in an economic index among eligible cows (5). To be eligible for elite status, a cow must be registered and have a high probability of being alive based on the last calving date and termination code for the latest lactation; the cow also must average at least three management groupmates across lactations. In February 1997, the economic index for determining elite status was changed from an index based on genetic merit for milk, fat, and protein yields (**MFP$**) (5) to net merit dollars, which considers productive life and SCS in addition to yield (9).

In January 1993, USDA began to assign a high ranking status to grade (unregistered) cows that met all requirements for elite eligibility except for registry status and that met the MFP$ criterion for registered cows (7). Use of data from grade cows is considered to be important in assessing the effects of methodology changes on evaluations because data from registered cows, especially cows of high genetic merit, can be biased (7). There has been little incentive to introduce bias to evaluations of grade cows.

The objectives of this study were to determine whether state representation for elite cows was equitable with regard to cow merit and to determine the importance of the cow population size, the mean and variance of MFP$, and the registry status for each state as factors that affect the percentage of cows that are designated as genetically elite by USDA.

MATERIALS AND METHODS

State representation among elite Holstein cows was compared for USDA-DHIA genetic evaluations from July 1990, July 1991, and May 1997. For July 1990 and July 1991 evaluations, the economic index used to determine elite status was MFP$:

MFP$ (July 1990) = ($0.060/kg)PTA for milk
+ ($3.26/kg)PTA for fat
+ ($3.15/kg)PTA for protein,

and

MFP$ (July 1991) = ($0.097/kg)PTA for milk
+ ($2.60/kg)PTA for fat
+ ($3.02/kg)PTA for protein,

where all PTA are expressed in kilograms. Because evaluations for productive life and SCS were not calculated before 1994, the MFP$ index established in February 1997 (9),

MFP$ (May 1997) = ($0.068/kg)PTA for milk
+ ($1.76/kg)PTA for fat
+ ($4.41/kg)PTA for protein,

was used in this study to designate elite status for cows evaluated in May 1997 rather than net merit dollars.

For May 1997 evaluations, the number and percentage of elite cows were determined by state, and the means and standard deviations for MFP$ were computed for eligible cows. At the January 1997 meeting of the Council on Dairy Cattle Breeding, the sale of cows of high genetic merit was suggested as being a possible influence on the state proportions of elite cows. Data from elite cows in May 1997 were examined to determine how many elite cows had relocated to different herds and states; the state of a cow was considered to be the state of the most recent herd of the cow. Corresponding statistics also were examined for high ranking grade cows. Although the terms “elite” and “high ranking” traditionally have been reserved for the registered and grade populations, respectively, in this study, elite refers to both types of registry status to simplify presentation of results. For May 1997 evaluations, 772,302 registered and 1,499,729 grade Holstein cows were eligible for elite status.

For states with >1000 eligible registered cows and for states with >10,000 eligible registered cows, correlations were computed among the state variables of number of cows that were eligible for elite status, number of cows that were designated as elite, percentage of eligible cows that were designated as elite, mean MFP$, and standard deviation for MFP$. The

TABLE 1. Percentages of US elite[1] Holstein cows for states with >10,000 eligible[2] cows in May 1997, numbers and percentages of US cows that were eligible for elite status in May 1997, and percentages of elite cows that relocated to different states or herds in May 1997.

State	Elite cows			Eligible cows in May 1997		Elite cows that relocated in May 1997	
	July 1990	July 1991	May 1997			State	Herd
	(%)			(no.)	(%)		
Wisconsin	9.6	12.8	18.2	131,889	17.1	3.3	8.5
Pennsylvania	11.5	12.1	13.9	122,996	15.9	2.7	7.6
New York	9.4	8.8	8.1	92,863	12.0	1.6	4.9
California	9.1	6.8	6.1	42,147	5.5	1.9	4.4
Ohio	7.3	7.2	5.9	41,395	5.4	4.6	9.0
Minnesota	3.0	3.7	4.7	34,425	4.5	2.7	9.3
Michigan	6.1	5.7	5.2	27,899	3.6	1.8	7.0
Illinois	3.1	3.4	3.0	20,793	2.7	5.1	8.5
Maryland	2.4	2.5	2.3	19,753	2.6	1.1	2.8
Iowa	1.6	2.2	5.0	19,533	2.5	3.6	10.1
Vermont	2.2	2.2	2.1	16,556	2.1	9.3	11.1
Virginia	2.7	3.0	2.1	15,965	2.1	4.2	6.0
Indiana	1.7	1.8	1.0	16,142	2.1	1.2	7.4
Texas	2.8	2.6	2.2	12,955	1.7	0.6	8.2
Washington	3.8	2.8	2.2	11,843	1.5	1.7	3.4
Missouri	1.2	1.4	1.2	10,836	1.4	1.1	0.8
US	100.0	100.0	100.0	772,302	100.0	3.0	7.2

[1]Elite status was determined as top 1% of eligible Holstein cows based on an economic index of genetic merit for milk, fat, and protein yields (MFP$) where MFP$ (July 1990) = ($0.060/kg)PTA for milk + ($3.26/kg)PTA for fat + ($3.15/kg)PTA for protein, MFP$ (July 1991) = ($0.097/kg)PTA for milk + ($2.60/kg)PTA for fat + ($3.02/kg PTA for protein, and MFP$ (May 1997) = ($0.068/kg)PTA for milk + ($1.76/kg)PTA for fat + ($4.41/kg)PTA for protein, and PTA are expressed in kilograms.

[2]Eligible cows were registered and alive according to the last calving date and termination code for the latest lactation and averaged at least three management groupmates across lactations.

state groups defined for registered cows were used for grade cows so that the same states would be included, regardless of registry status. Coefficients of determination were computed for models that predicted the state percentage of elite cows from mean and standard deviation of MFP$ separately and in combination.

RESULTS

A comparison of the proportion of elite registered cows in July 1990, July 1991, and May 1997 is given in Table 1 for states with >10,000 registered cows that were eligible for elite status. California and Washington represented states with herds that had higher phenotypic variance; Illinois, Iowa, Minnesota, Virginia, and Wisconsin represented states with herds that had lower variance (10). A comparison of recent state percentages of elite cows with those before the implementation of the adjustment for heterogeneous variance showed 9.1 and 3.8% of the elite US cows in California and Washington, respectively, in July 1990 and 6.1 and 2.2% in May 1997 (a decrease of about one-third); 11.5% in 1990 and 13.9% in 1997 for Pennsylvania (an increase of about one-quarter); and 9.6% in 1990 and 18.2% in 1997 for Wisconsin (almost a doubling). Although this comparison could be interpreted as an indication that the adjustment for heterogeneous variance had resulted in an underrepresentation for states with high variance herds (e.g., California and Washington) and overrepresentation for states with low variance herds (e.g., Wisconsin), the proportion of US cows that were eligible for elite status in each state was not considered.

The comparison of state percentages of elite cows in July 1990 and in July 1991, just after implementation of the adjustment for heterogeneous variance, showed smaller changes for states with herds of high and low variance: a decrease of one-quarter for California and Washington and an increase of only one-third for Wisconsin. Those smaller changes in state representation indicate that factors other than the use of an adjustment for heterogeneous variance in genetic evaluation (for example, changes in relative numbers of eligible cows) influenced the distribution of elite cows across states.

A primary consideration in the number of elite cows in a state is the number of cows that were eligible for elite status. Changes in the state percentages of US elite cows are expected to correspond to changes in state percentages of US eligible cows if other factors remain fixed. State changes in cow population size or registry status of cows would directly affect the number of eligible cows. The numbers and proportion of cows that were eligible for elite status in May 1997 by state are presented in Table 1; corresponding values for July 1990 and July 1991 were not available. The positive relationship between percentages of elite and eligible cows in May 1997 is clear. Most (11 of 16) of these states with larger cow populations had equal or higher percentages of elite cows than of eligible cows. States with high (California and Washington) or low (Illinois, Iowa, Minnesota, Virginia, and Wisconsin) phenotypic variance all had a greater proportion of elite cows than of eligible cows, except for Virginia, which had equal percentages for both groups. States with herds of intermediate variance tended to have smaller percentages of elite cows than of eligible cows. No linear relationship was found between the state phenotypic variance and the percentage of US cows that were eligible for elite status.

Also shown in Table 1 are the percentages of elite cows that had information on previous lactation in other herds and states. Nationally, 7.2% of elite registered cows had relocated to different herds, and 3.0% had relocated to different states; for elite grade cows, 2.0% had relocated to different herds, and only 0.1% had relocated to different states (not shown). In May 1997, 51.4% of elite registered cows were in first lactation; therefore, these statistics on the movement of elite cows are conservative. In general, states with herds of high variance had lower percentages of elite registered cows that relocated to different states or herds than the national mean, and states with herds of low variance had higher percentages. No relationship was found between the percentages of elite registered cows that relocated to different states or herds and the differences between percentages of elite and eligible cows.

Table 2 shows the means and standard deviations of MFP$ for eligible registered cows and the percentages of eligible cows that were designated as elite for states with >10,000 eligible registered cows. States are presented in descending order of percentage elite before rounding. A positive relationship was found between the percentage of eligible cows designated as elite and mean MFP$. All states with a percentage of elite cows of >1.0 had means for MFP$ of eligible cows that were higher than the US mean ($44); all states with a percentage of elite cows of <1.0 had means that were lower than the US mean. States with a percentage of eligible cows designated as elite of >1.0 in Table 2 generally had standard deviations that were equal to or slightly lower than the US standard deviation ($71), but the correlation (–0.31) between standard deviation for MFP$ and percentage of elite cows was not significant ($P = 0.23$) for states with >10,000 eligible cows. The corresponding correlation was 0.28 ($P = 0.06$) for states with >1000 eligible cows. The differences between state percentages of US elite and eligible cows (Table 1) also were related to mean MFP$. States with a percentage of elite cows that was equal to or higher than the percentage of eligible cows had a mean MFP$ that was higher than the US mean; states with a percentage of elite cows that was less than the percentage of eligible cows had a mean MFP$ that was lower than the US mean. States with herds of low and high variance had a percentage of elite cows that was higher than 1.0 and a mean MFP$ that was higher than the US mean.

TABLE 2. Means and standard deviations of an economic index based on genetic merit of milk, fat, and protein yields (MFP$) for Holstein cows that were eligible[1] for elite status[2], and percentages of eligible cows that were designated as elite for states with >10,000 eligible cows in May 1997.

State	MFP$		Eligible cows designated as elite
	($)		(%)
	$\overline{X}$	SD	
Iowa	56	71	2.0
Washington	60	68	1.5
Michigan	54	72	1.4
Texas	50	71	1.3
Illinois	47	69	1.1
California	48	71	1.1
Ohio	53	69	1.1
Wisconsin	45	70	1.1
Minnesota	48	71	1.1
Virginia	53	64	1.0
Vermont	50	68	1.0
Maryland	37	71	0.9
Missouri	27	76	0.9
Pennsylvania	39	72	0.9
New York	38	72	0.7
Indiana	26	76	0.5
US	44	71	1.0

[1]Eligible cows were registered and alive according to the last calving date and termination code for the latest lactation and averaged at least three management groupmates across lactations.

[2]Elite status was determined as the top 1% of eligible Holstein cows based on MFP$ = ($0.068/kg)PTA for milk + ($1.76/kg)PTA for fat + ($4.41/kg)PTA for protein, and PTA are expressed in kilograms.

By definition, elite registered cows in the US are 1% of the eligible registered cows. For grade cows, only 0.2% of eligible grades nationally were considered to be elite based on the MFP$ required for

TABLE 3. Correlations between state variables for US elite[1] Holstein cows for states with >1000 eligible[2] registered cows and states with >10,000 registered eligible cows in May 1997.

State variable	Correlated state variable	Registry status	Correlations: >1000 Eligible registered cows	>10,000 Eligible registered cows
Number of elite cows	Number of eligible cows	Registered	0.97***	0.96***
		Grade	0.97***	0.96***
Percentage of eligible cows that were elite	Number of eligible cows	Registered	0.19	–0.04
		Grade	0.20	0.44
Percentage of eligible cows that were elite	Mean MFP$	Registered	0.68***	0.77**
		Grade	0.79***	0.59*
Percentage of eligible cows that were elite	SD MFP$	Registered	0.28	–0.32
		Grade	0.28	–0.10

[1]Elite status was determined as the top 1% of eligible registered Holstein cows based on an economic index of genetic merit for milk, fat, and protein yields (MFP$) where MFP$ = ($0.068/kg)PTA for milk + ($1.76/kg)PTA for fat + ($4.41/kg)PTA for protein, and PTA are expressed in kilograms; the MFP$ criterion for registered cows was used to determine the elite status of grade cows.

[2]Eligible cows were alive according to the last calving date and termination code for the latest lactation and averaged at least three management groupmates across lactations.

$^*P \leq 0.05$.

$^{**}P \leq 0.01$.

$^{***}P \leq 0.001$.

registered elite cows. Those percentages (1% for registered cows and 0.2% for eligible grade cows) were the same as those reported by Powell and Norman (7) for USDA-DHIA genetic evaluations in January 1986 but less than the 1.4% and 0.5% reported by Norman and Powell (4) for January 1981 evaluations of registered and grade cows, respectively. For both of those studies, elite status was determined based on an economic index that included genetic merit for milk and fat yields. Powell and Norman (7) found that mean PTA for both milk and fat were lower for eligible grade cows than for eligible registered cows. Although mean PTA for milk in this study was higher for eligible grade cows than for eligible registered cows, PTA for fat and protein were higher for registered cows, which resulted in a higher national mean MFP$ for eligible registered cows ($44) than for grade cows ($39). However, the smaller standard deviation of MFP$ for grade cows ($59) compared with that for registered cows ($71) indicated less variation among grade cows and, as a result, fewer eligible grade cows that were designated as elite.

The high correlations between the numbers of registered eligible and elite cows within each state (Table 3) show that the assessment of changes in elite representation by state without considering changes in the number of eligible cows can lead to inappropriate conclusions. Correlations between the number of eligible registered cows within a state and the percentage of elite cows were small and not significant ($P > 0.05$). Thus, states with larger cow populations did not appear to have an advantage or a disadvantage in the proportion of eligible cows that were designated as elite. The key state statistic for registered Holsteins in explaining the percentage of

TABLE 4. Coefficients of determination (R^2) for models to predict state percentage of eligible[1] Holstein cows that were designated as elite[2] from state mean and standard deviation for an economic index based on genetic merit for milk, fat, and protein yields (MFP$) for states with >1000 eligible registered cows and states with >10,000 eligible registered cows in May 1997.

Independent state variable	Registry status	R^2: >1000 Eligible registered cows	>10,000 Eligible registered cows
		(%)	
Mean MFP$	Registered	46	59
	Grade	62	35
SD MFP$	Registered	8	10
	Grade	12	3
Mean and SD MFP$	Registered	74	76
	Grade	76	66

[1]Eligible cows were alive according to the last calving date and termination code for the latest lactation and averaged at least three management groupmates across lactations.

[2]Elite status was determined as the top 1% of eligible registered Holstein cows based on MFP$ = ($0.068/kg)PTA for milk + ($1.76/kg)PTA for fat + ($4.41/kg)PTA for protein, and PTA are expressed in kilograms; the MFP$ criterion for registered cows was used to determine the elite status of grade cows.

elite cows was mean MFP$, but the variation of MFP$ alone was not an important factor. Those observations for registered cows were supported by corresponding correlations for grade cows.

The R^2 in Table 4 support the previous conclusions for relative importance of the state mean and variation of MFP$ in the prediction of the state percentage of eligible cows that are designated as elite. However, for the model that included both mean and standard deviation, the standard deviation was an important factor and substantially raised the R^2. The conclusions were the same for both registered and grade cows: state differences in variation of MFP$ had predictive value for percentage of elite cows only after mean MFP$ had been considered.

CONCLUSIONS

The number of elite cows for a state was highly correlated with the number of cows that were eligible for elite status. This result, although obvious, should be considered when the numbers of elite cows per state or other region are compared over time because relative numbers of eligible cows can change. For states with >10,000 eligible registered cows, states with >1.0% of eligible cows designated as elite had mean MFP$ that were higher than the national mean but standard deviations equal to or lower than the national standard deviation. Mean MFP$ was correlated ($P \leq 0.05$) with the state percentage of elite cows, but variation of MFP$ was not related ($P > 0.05$). However, the state standard deviation of MFP$ was important in explaining the percentage of elite cows if the model also contained mean MFP$. No evidence supported that differences in variation of lactation records across states or adjustments for those differences cause inequity in designating elite status to cows.

A smaller percentage of grade cows than of registered cows attain elite status nationally, primarily because of less genetic variation. Previous research (4, 7) had shown that service sires for grade cows were more homogeneous; thus, few grade cow pedigrees show a succession of sires that are genetically outstanding for yield traits. Analysis of data from grade cows, which are considered to be less biased than data from registered cows, supported the findings for registered cows.

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