Animal Model Evaluations for Mexican Holsteins

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ABSTRACT

Genetic evaluations for milk yield of Holsteins in Mexico were computed from lactation and pedigree information from Holstein de México. The US animal model system for national evaluations was adapted for Mexico. The primary change was in defining unknown-parent groups. Paths of unknown parents of bulls and sires of cows were combined and separate unknown-parent groups defined for parents of US, Canadian, and Mexican registration. Records with fewer than 305 d were expanded around management group mean; a lower limit of 50% of management group mean was imposed on these records. Based on 123,397 lactation records by 50,538 cows, evaluations were computed for 68,020 cows (including those without lactation records) and 4573 bulls. Estimate of breeding value improvement in 1986 from a quadratic curve was 87 kg milk. Animal model estimates of breeding value by birth year were similar to Modified Contemporary Comparison estimates. Correlations with previous evaluations were .90 for bulls and .85 for cows. Differences resulted from added data as well as changes in evaluation method. Cows born in 1985 with US sires had predicted breeding values for milk 380 kg higher than those with Canadian sires and 336 kg higher than those with Mexican sires. Equations were developed to convert milk PTA between Mexico and the US. No sire by country interaction was found; correlations of US and Mexican PTA were .90 (expected) and .91 (actual).
(Key words: animal model, genetic trend, Mexico)

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Abbreviation key: DYD = daughter yield deviation, INTERBULL = International Bull Evaluation Service, MCC = Modified Contemporary Comparison, MCD = Modified Contemporary Deviation, REL = Reliability, RPT = Repeatability, YD = yield deviation.

INTRODUCTION

Genetic evaluations of Holsteins in Mexico have been computed by USDA since 1976 under an agreement with Holstein de México, Queretaro, Mexico. An animal model system was implemented in July 1989 for US national evaluations (6, 7). Therefore, Mexican evaluation procedures also were converted to an animal model system. Mexican data differ from US data because fat and protein yields are not recorded. In addition, earliest reported calving year for Mexican cows is 1970. Pedigree information, which is essential for effective use of the animal model, was available for bulls and for cows with lactation records.

Previous research (3) found that country of origin is an important indicator of genetic merit. In the USDA animal model evaluation system for Holsteins, separate unknown-parent groups are defined for animals of Canadian and US origin. For Mexico, a third category (Mexican origin) would be necessary.

Estimates of genetic trend for US Holsteins from the animal model are larger than those from the Modified Contemporary Comparison (MCC) (4). The increase in genetic trend likely results from the more complete incorporation of pedigree information and, thus, better ties among data across generations. Correlations between animal model PTA and MCC genetic evaluations were greater than .9 in the US (4). Animal model evaluations for Mexican Holsteins also would allow study of effect of methodology changes on evaluations in a separate population.

The purposes of this study were to develop an animal model system for genetic evaluation of Mexican Holsteins, estimate genetic trend for the Mexican population based on animal model evaluations, compare animal model and MCC Mexican evaluations, and determine if genetic differences existed based on origin of sire.

MATERIALS AND METHODS

Model

The model included fixed management (m) and random herd-sire interaction (c), permanent environmental (p), animal (a), and residual (e) effects as in the US system (6, 7):

$$y_{ijkl} = m_{ij} + c_{i'k} + p_{kl} + a_{kl} + e_{ijkl}$$

where y_{ijkl} = milk yield of daughter l of sire k in management group j in herd i and i′ refers to a cow's first herd if she has changed herds. Management groups were defined as for Holsteins in the US (7) except that registered and grade cows were not separated. Initially, a 2-mo calving period within a herd was examined to determine if there were at least five lactation records for the particular parity group (first or later). If not, the calving period was expanded in 2-mo increments until five lactation records were present or 6 mo had been combined. If the requirement for five lactation records was not satisfied by the 6-mo calving period, then parities were combined and the minimum number of required lactations records redefined as three. If three lactation records still were not available, the calving period continued to be expanded in 2-mo increments until three records were present or 12 mo had been combined. The herd-sire interaction effect limited the impact and reliability (REL) from a single herd and also was important if bulls had distinctly unequal numbers of daughters per herd. Animal effect was breeding value and included effects for unknown-parent groups. Variance components scaled to a phenotypic variance of 1 were genetic, .25; herd-sire interaction, .14; permanent environmental, .16; and residual, .45, which resulted in heritability of .25 and repeatability of .55. Variance component values were the same as those used in the animal model system for US data.

Residual variance was assumed to be a function of lactation length. Records with fewer than 305 d in milk were expanded around the management group mean (5), which resulted in the same genetic variance as for 305-d records. This expansion was accomplished by multiplying the deviation from the management group mean by a factor larger than 1 and adding the result to the management group mean. Factors ranged from 2.4 for the shortest lactations to 1.0 when near 305 d. For records with extremely low yield, this procedure could make adjusted lactation yield substantially lower, even negative. Norman and Dickinson (1) showed that limiting impact for especially deviant low records improved accuracy but not so for deviant high records. Therefore, a lower limit for milk yield was set at 50% of management group mean. An investigation with US Ayrshire data (USDA, 1990, unpublished results) showed no benefit from raising this lower limit, and few (3277) lactations of Mexican cows were below this limit.

Unknown-Parent Groups

Selection paths of sire of cow and sire and dam of bulls were combined to have sufficient data for accurate estimation of group effects. Groups were by country of registration (US, Canada, and Mexico) within birth year groups (before 1976, 1976 to 1980, and after 1980). For dams of cows, shorter birth year groups (2 yr per group starting in 1970) were defined. Numbers of animals with parents in each group and group solutions are in Table 1.

Data

Lactation records (123,397) of 50,538 cows with a first lactation were provided by Holstein de México. The number of cows currently being milked is indicated by the 10,612 records of lactations in progress received for 1990. Distribution of cows by year of first lactation is in Table 2. In addition to pedigree information for Mexican bulls provided by Holstein de México, pedigree records for US bulls from USDA files and pedigree records for Canadian bulls from Agriculture Canada's bull evaluation file were used. Pedigree records for dams of bulls were constructed from bull pedigree records using the dam and maternal grandsire. The maternal granddam was coded as unknown.

Evaluation Methodology

With the exceptions of expansion of deviations for short lactation records and redefinition of unknown-parent groups already mentioned, the same procedure as for US yield evaluations was used. The genetic base was established by setting the mean breeding value of cows born in 1985 to 0. A convergence criterion (defined as sum of squared differences from previous round over sum of squared solutions) of less than 10^{-8} was achieved in 105 rounds of iteration. Prior solutions of 0 were used. A relaxation factor was applied to speed convergence. This factor was increased each round to a maximum of .85 at round 6 and remained at that value.

Evaluation Analysis

Genetic trend was estimated by fitting a quadratic curve to mean breeding values of all cows by birth year. The MCC results were from 1989 Mexican evaluations; therefore, differences from animal model results are due to effects of an additional year's data as well as different evaluation methods. A study of US data (4) applied both evaluation methods to the same data.

Conversion formulas were developed using the Goddard and Wilmink methods (2) and were of the form:

$$\text{estimated evaluation}_{\text{importing country}} = a + b(\text{evaluation}_{\text{exporting country}})$$

where a (the intercept) accounts for general genetic differences between the two populations (and difference in base definition, which does not apply here) and b (the regression coefficient) accounts for scaling. For the Goddard method, daughter yield deviation (DYD) for the importing country was used as the dependent variable. As this was the first opportunity to use DYD information from both importing and exporting countries, use of DYD from both countries also was examined.

RESULTS

Solutions for unknown-parent groups (Table 1) generally followed the expected pattern for a

TABLE 1. Numbers of animals with parent in unknown-parent groups and group solutions for milk yield by birth year, country of registration, and selection path.

Selection path	Birth year	Number of animals with parent in group	Solution
			(kg)
Mexican dams of cows	<1970	4111	–546
	1970–1971	2280	–732
	1972–1973	2697	–729
	1974–1975	2080	–768
	1976–1977	2793	–757
	1978–1979	3047	–739
	1980–1981	2673	–649
	1982–1983	2509	–446
	1984–1985	1844	–334
	>1985	1835	–305
Mexican sires of cows and dams and sires of bulls	<1976	322	–496
	1976–1980	207	–124
	>1980	80	313
Canadian sires of cows and dams and sires of bulls	<1976	1681	–887
	1976–1980	275	–588
	>1980	209	–454
US sires of cows and dams and sires of bulls	<1976	1804	–451
	1976–1980	980	–269
	>1980	333	–40

positive genetic trend. Dams of cows showed the largest improvement in recent years. Table 2 suggests an increasing number of cows on test or at least an increasing number of cows with records usable for genetic evaluations. Counts of cows evaluated with the Mexican animal model evaluation system (including cows without lactation records) are in Table 3 by birth year. In contrast to Table 2, the highest frequencies were not in the latest year, because recent years have only cows with lactation records whereas earlier years also have cows without lactation records.

Effects of merging 2-mo management groups without at least five lactation records until the required number of records was reached are shown in Table 4. Before merging, 22% of cows were in 2-mo management groups with fewer than five lactation records. After merging, only 3% were in management groups with fewer than five records. Table 5 shows definition of management groups by number of calving months included in the group after merging. The large herd size in Mexico is reflected in the high proportion of management groups that were only 2 mo long.

In processing pedigree information, 19,064 parents were assigned to unknown-parent groups because they each had only one progeny and did not create ties with other animals with lactation records. There were 13,307 dams without lactation records and 4573 sires that did provide ties so were retained. Including parents that do not provide ties could have reduced convergence rate, because their limited amount of information might have made their evaluations unstable. Values of the convergence criterion as previously described resulted in maximum change in evaluations for iteration round 105 of less than 3 kg for cows, less than 1 kg for sires and dams, and .02 kg for unknown-parent solutions.

Figure 1 shows the mean cow breeding values by birth year and country of sire registration. Although data were not as current for MCC evaluations, linear annual increase in estimated cow breeding value from birth years 1975 through 1985 was 67 kg milk for both MCC and animal model evaluations. Genetic trend has increased in recent years and was estimated as 87 kg milk in 1986 over all groups. Daughters of US sires born in 1985 were 380 kg superior for breeding value for milk yield to daughters of Canadian sires and 336 kg superior to those of Mexican sires. Mean milk yield of cows born in 1985 (genetic base group) was 7249 kg.

Changes over time occurred for sires' country of origin (Table 6). Percentage of Mexican

TABLE 2. Distribution of Mexican Holstein cows by year of first lactation.

Calving year	Number	Percentage	Cumulative number	Cumulative percentage
1970	36	.1	36	.1
1971	237	.5	273	.5
1972	743	1.5	1016	2.0
1973	1521	3.0	2537	5.0
1974	2183	4.3	4720	9.3
1975	2014	4.0	6734	13.3
1976	1845	3.7	8579	17.0
1977	1948	3.9	10,527	20.8
1978	2242	4.4	12,769	25.3
1979	2294	4.5	15,063	29.8
1980	2894	5.7	17,957	35.5
1981	3531	7.0	21,488	42.5
1982	3972	7.9	25,460	50.4
1983	3894	7.7	29,354	58.1
1984	3195	6.3	32,549	64.4
1985	3300	6.5	35,849	70.9
1986	3101	6.1	38,950	77.1
1987	3897	7.7	42,847	84.8
1988	3617	7.2	46,464	91.9
1989	4074	8.1	50,538	100.0

cows sired by bulls from Canada has decreased markedly, whereas percentage with Mexican sires has increased. Percentage with US sires was highest with an increase to 63% in 1981 and a decrease to about 50% since then. Mean PTA milk tended to be lowest for daughters of Canadian bulls and highest for daughters of US bulls.

Country comparisons based on registration of bulls do not give complete information. In fact, of the 441 Mexican and Canadian registered bulls, 97 originated in the US. A few US bulls originated in Canada. To achieve a fairer comparison of sources of genetics, bulls were classed by country of parents' registration. Highest bull PTA milk was for bulls with both parents from the US and lowest PTA for those with Canadian parents. There were age differences in these groups of bulls. As expected from the changes in proportion of sires from the three countries, bulls with Canadian parents tended to be older because most of these were Canadian bulls that tended to be used most heavily in the early years. Bulls with Mexican parents tended to be younger, because most US and Canadian bulls are not used in Mexico until they have evaluations in their home countries. Because of differences in distribution on birth dates, differences by country of registration are affected by genetic trend.

A more appropriate comparison is presented in Table 7. These bulls were born in 1972 or later, and age differences were much less than for all bulls. The positive US influence is clear. Little difference in mean PTA milk was found for the three lowest groups (those with no US parent). Mean daughter milk yield illustrates yield levels and relationship of bull PTA to daughter performance. The REL tended to be higher for bulls with at least one Canadian parent and lower for bulls with a Mexican dam.

Animal model evaluations were matched with MCC evaluations for 45,168 cows. On average, PTA milk was 259 kg lower than the

TABLE 3. Numbers and percentages of Mexican Holstein cows evaluated by birth year.

Birth year	Number	Percentage	Cumulative number	Cumulative percentage
1960	96	.1	96	.1
1961	105	.2	201	.3
1962	145	.2	346	.5
1963	264	.4	610	.9
1964	291	.4	901	1.3
1965	401	.6	1302	1.9
1966	606	.9	1908	2.7
1967	745	1.1	2653	3.8
1968	981	1.4	3634	5.2
1969	1149	1.6	4783	6.9
1970	1625	2.3	6408	9.2
1971	2261	3.2	8669	12.4
1972	2901	4.2	11,570	16.6
1973	2350	3.4	13,920	20.0
1974	2410	3.5	16,330	23.4
1975	2739	3.9	19,069	27.4
1976	3072	4.4	22,141	31.8
1977	3382	4.9	25,523	36.6
1978	3728	5.3	29,251	42.0
1979	4251	6.1	33,502	48.1
1980	4945	7.3	38,447	56.5
1981	4723	6.9	43,170	62.8
1982	4926	7.2	48,096	70.6
1983	4564	6.7	52,660	77.4
1984	4170	6.1	56,830	83.5
1985	4308	6.3	61,138	89.9
1986	4194	6.2	65,332	96.0
1987	2680	3.9	68,012	100.0
1988	8	0	68,020	100.0

TABLE 4. Number of contemporary groups by size based on number of lactation records included before and after merging.

Group size	Before merging	After merging
1	1973	0
2	1307	41
3	958	192
4	863	212
5	673	694
6	589	694
7	527	638
8	494	586
9	398	492
10	361	437
11	319	385
12	284	360
13	282	318
14	256	291
15	247	273
16	209	239
17	197	238
18	175	200
19	166	182
≥20	1861	2140

TABLE 5. Numbers of lactation records in management groups by group length based on number of calving months included.

Group length (mo)	Number of records included
2	111,757
4	15,918
6	6114
8	339
10	144
12	130

corresponding MCC Cow Indexes, primarily because of the new genetic base. Repeatability (RPT) averaged only 33.5% compared with 42.5% for REL. This increase was the result of an increase in data because of the additional year's lactations and inclusion of progeny data for cows. Correlation between evaluations was .85, perhaps as high as expected because of the additional information. Correlation between parent averages under the two systems was .83 as was correlation between animal model yield deviation (YD) and MCC Modified Contemporary Deviation (MCD). However, YD and MCD are not directly comparable, because YD does not contain effects of permanent environment and herd-sire interaction. The animal model equivalent of MCD is a deviation from management group mean; correlation of that deviation with MCD was .85.

The PTA for 574 bulls averaged 153 kg lower than did PD for the same bulls in 1989. Correlation between PTA and PD was .90. Mean REL was 59% compared with a mean of 47% for RPT. The increase in the estimated accuracy for bull evaluations resulted mostly from including relatives other than daughters in calculation of REL. However, there were also changes in available daughter information because of another year of data and dropping lactation records after fifth. In addition, each daughter included was required to have a first lactation (a calving at not more than 36 mo of age and no previous dry period).

Many bulls selected as service sires for Mexican cows are from the US, and most of those bulls are not yet evaluated based on Mexican data. Therefore, being able to compare US and Mexican evaluations directly is important. By International Bull Evaluation Service (INTERBULL) policy, official conversion formulas are the right and responsibility of the importing country. The conversion formula below with Mexico as the importing country has been accepted by Holstein de México as official.

Conversion formulas were developed using data from 72 bulls with evaluations that had REL of at least 75% in both Mexico and the US. Correlations between the two sets of PTA were .91 compared with an expected correlation of .90 based on REL in the two countries. Thus, no evidence of a difference in ranking (genotype-country interaction) exists between the US and Mexico for milk yield. Conversion formulas for milk yield by the Goddard method are

$$\text{estimated } PTA_{\text{Mexico, kilograms}} = 196 + .36(PTA_{\text{US, pounds}})$$

$$\text{estimated } PTA_{\text{US, pounds}} = -555 + 2.51(PTA_{\text{Mexico, kilograms}})$$

The intercepts (a) and regression coefficients (b) in these equations are nearly the same as from use of DYD for both countries (a = 196, b = .35 for Mexico as the importing country;

TABLE 6. Distribution of cows by sire's country of registration and mean cow PTA milk by cow birth year.

Cow birth year	Percentage of cows sired by bulls from			PTA Milk for daughters of bulls from		
	US	Canada	Mexico	US	Canada	Mexico
				(kg)		
1970	16	69	15	−539	−419	−428
1971	23	61	16	−238	−411	−435
1972	24	60	16	−283	−421	−398
1973	30	59	11	−249	−398	−454
1974	33	56	11	−207	−378	−423
1975	34	49	17	−236	−370	−419
1976	36	44	21	−223	−383	−368
1977	41	35	24	−187	−364	−358
1978	49	28	23	−189	−373	−353
1979	59	20	21	−150	−305	−332
1980	62	15	23	−111	−255	−247
1981	63	16	23	−72	−245	−240
1982	61	18	22	−27	−231	−199
1983	55	22	24	+4	−179	−138
1984	50	14	35	+43	−158	−130
1985	50	19	32	+90	−106	−79
1986	52	17	31	+108	−92	−36
1987	46	17	38	+113	−89	−29

a = −553, b = 2.42 for Mexico as the exporting country). Corresponding Wilmink values were 194, .41, −547, and 2.47. Thus, the three methods provided similar results. The Goddard equations are recommended, because this method is one of the procedures approved by INTERBULL and is a more direct calculation than is the Wilmink method (2). The primary factor affecting size of b is the difference between kilograms and pounds for Mexican-US conversions, although a difference in realized heritability would be a factor. Use of the US to Mexico formula would provide PTA that would account for the generally lower yield variance in Mexican herds and would be more reflective of differences in daughter yield than would using US PTA directly.

CONCLUSIONS

The animal model system used for US dairy yield evaluations was adapted for Mexican data. Unknown-parent groupings were modified to accommodate parents of US, Canadian, or Mexican registration. Deviations for records of fewer than 305 d were expanded to stabilize genetic variance of deviated records. Genetic trend in 1986 was estimated as 87 kg milk/yr.

TABLE 7. Mean bull birth year, daughter milk yield, PTA milk, and reliability (REL) by country of parent registration.

Country of parent registration		Bull birth year	Number of bulls	Daughter milk yield	Bull PTA milk	REL
Sire	Dam					
				(kg)		(%)
US	US	1976	292	7426	+157	55
US	Canada	1976	28	6993	−72	58
US	Mexico	1978	68	6860	−132	50
Canada	US	1976	20	6964	−108	61
Canada	Canada	1976	56	6540	−312	57
Canada	Mexico	1976	38	6391	−300	52
Mexico	Mexico	1977	12	6238	−334	46

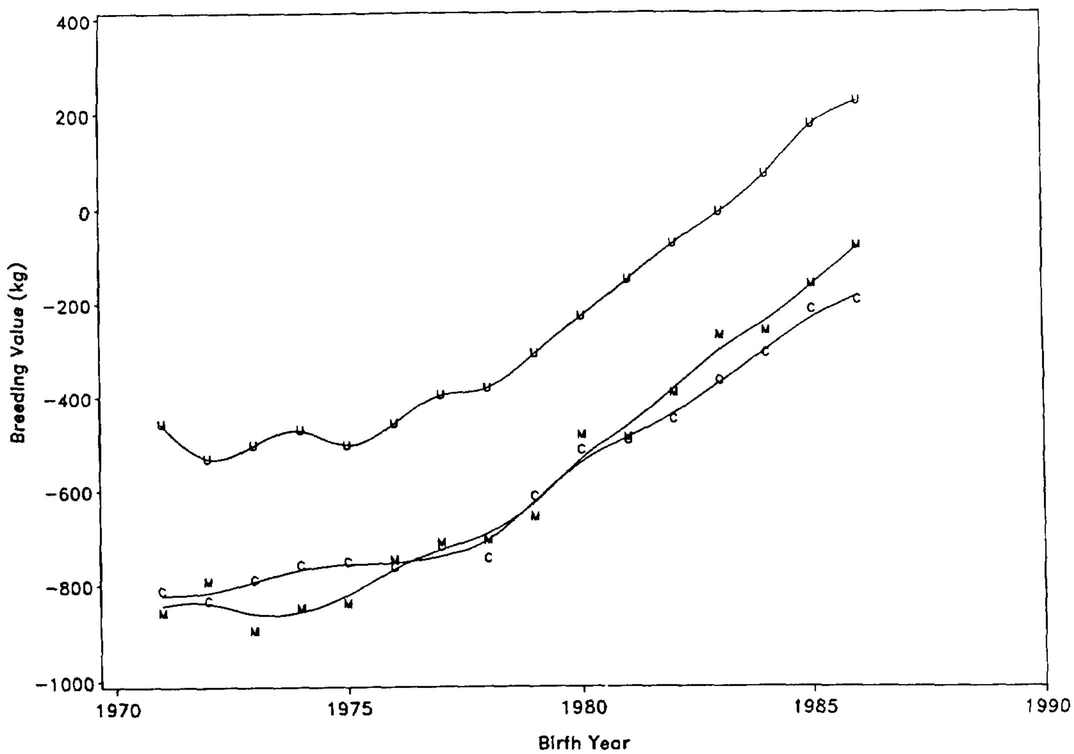

Figure 1. Mean breeding values of cows by birth year and country of sire registration (C = Canadian, M = Mexican, and U = US).

Correlations between animal model and MCC genetic estimates were .90 for bulls and .85 for cows. These correlations were considered high, because not only did methodology differ but an added year of data contributed to differences. Cows with US sires had higher genetic estimates than did those with Canadian or Mexican sires. Highest PTA bulls were US and those with US parents. Conversion formulas were calculated to facilitate selection of bulls from among those evaluated in either the US or Mexico.

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