Age and Seasonal Effects on Holstein Yield for Four Regions of the United States Over Time

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ABSTRACT

Multiplicative factors to adjust Holstein yield for age and season of calving were calculated and analyzed from 20 data files for region and time. Regions were 1) California, 2) Minnesota and Wisconsin, 3) New York and Pennsylvania, and 4) six southern states (Texas, Louisiana, Mississippi, Alabama, Georgia, and Florida). Time periods were calving years of 1964 to 1968, 1971 to 1975, 1976 to 1980, 1981 to 1985, and 1986 to 1990. The same statistical model was used that had been used to derive current USDA factors from 1964 to 1968 data. The number of lactation records for each data file ranged from 81,394 to 2,238,201 and increased with time. Effect of calving season on milk yield generally decreased with time; the largest decrease was for the southern region. Effect of calving age also generally decreased for recent data, and the largest decreases were for California. Updated factors to adjust yield for calving age and season are indicated for some regions.
(**Key words**: age adjustment, calving season and age, yield, environmental effect)

INTRODUCTION

Yield is affected by age and calving season, and factors have been developed to account for their effects separately (2) and together (1, 2, 3, 5, 6, 8, 9). These factors differ by breed (2, 3, 8, 9), geographical region (2, 3, 5, 9), and yield trait (1, 2, 3, 8, 9). Durães and Keown (1) also developed factors to adjust for age and month of calving separately for registered and grade cows.

In 1970, Miller et al. (6) reported the existence of an interaction between age and season of calving for Holsteins in the northeastern US. Older cows were affected more adversely by calving during summer months than were younger cows. Interactions between age and season were sufficiently large that comparisons of records and genetic evaluations could have been severely biased. Miller et al. (6) recommended the use of multiplicative factors that adjust simultaneously for both age and calving month and calculated such factors for the northeastern US using mixed model methodology with random effects for cow and lactation.

Adjustment for calving month minimizes the potential bias caused by environmental influences that are associated with different seasons within comparison or management group. Removal of this influence is beneficial because daughters of AI bulls, particularly those in sampling programs, often have many daughters that calve during the same season. Season adjustment allows animals to be compared across months in the same comparison group with less concern about bias. Unfortunately, environmental influences that are unique to each individual herd but that differ from either the mean seasonal effect or the mean regional age response are not considered. Similarly, seasonal effects that differ across years are probably not adequately considered.

Miller et al. (6) also recommended periodic reestimation of age and season factors to monitor their suitability for future years. Miller (5) later calculated factors for several regions of the US with a slightly revised model.

Current DHIA adjustment factors for age and calving month were designed for 11 regions of the US for Holsteins and for 1 to 6

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regions for other breeds; the factors then were smoothed into 64 sets by breed, region, and trait (9). The lactation records used to derive these adjustment factors for age and season were from cows that calved from 1964 to 1968. Several US dairy industry groups (including the National Association of Animal Breeders, the National DHIA, and members of the Purebred Dairy Cattle Association) have encouraged the USDA to reexamine the factors to determine whether they are still appropriate for current management conditions.

The objective of this study was to determine whether the environmental influences of calving age and month on yield have changed and whether adjustment factors need to be updated.

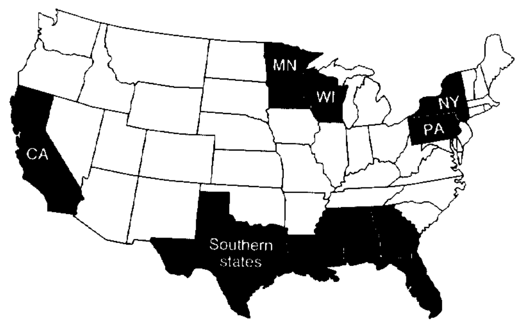

Figure 1. States assigned to four regions for study of age and seasonal effects on milk and fat yields.

MATERIALS AND METHODS

Data

Data included official DHI lactation records that were usable for calculation of USDA-DHIA genetic evaluations (12) for Holsteins that calved from 1964 to 1990. To minimize distortion of results from geographical shifts of cow populations, only one or two states were included in most of the regions examined. States with large cow populations were selected to keep sampling effects from obscuring age and seasonal trends. Regions (Figure 1) were 1) California, 2) Minnesota and Wisconsin, 3) New York and Pennsylvania, and 4) six southern states (Alabama, Florida, Georgia, Louisiana, Mississippi, and Texas). Time periods were calving years of 1964 to 1968, 1971 to 1975, 1976 to 1980, 1981 to 1985, and 1986 to 1990. Lactation records from calving years of 1964 to 1968, which were the same as those used to compute current USDA adjustments for age and season (9), were included to serve as a basis for comparison for later years.

The number of lactation records in the 20 regional data files ranged from 81,394 to 2,238,201 (Table 1). Derivation of previous factors (USDA, 1974, unpublished research) indicated that generally at least 50,000 lactations were needed to produce constants that were free of large fluctuations caused by sampling variation. The change in records over time for each region reflects increases in the numbers of cows enrolled in official DHI record-keeping programs through 1984 (4, 10) and increases in the percentage of records that were usable for genetic evaluation through 1990 (4).

Accuracy of adjustments derived for age and month of calving were dependent on accuracy of projection factors because completed records with <305 DIM and records for cows sold with <305 DIM were projected (11). Norman et al. (7) indicated that 95% of Holsteins were milked at least 271 d and 67% were milked at least 305 d. Lactation records in progress were not included.

Methods

To determine whether age and season effects changed over time, the same model used for deriving current USDA factors (5, 8) was applied:

$$y_{ijklnop} = m_i + g_j + a_{jk} + (mg)_{ij} + h_{ln} + c_{lo} + e_{lnop}$$

where $y_{ijklnop}$ = 305-d yield of milk or fat for lactation record p, m_i = fixed effect of calving month i, g_j = fixed effect of age group j, a_{jk} = fixed effect of age k in age group j, $(mg)_{ij}$ = interaction of age group j and calving month i, h_{ln} = effect of year n in herd l, c_{lo} = random effect of cow o in herd l (population with mean 0 and variance σ_c^2), e_{lnop} = random residual effect (population with mean 0 and variance σ_e^2). A variance ratio (σ_e^2/σ_c^2) of 1.25 was assumed for both milk and fat yields. This ratio

TABLE 1. Number of lactation records used to calculate adjustment factors for age and month of calving by region and calving year.

	Region			
Calving years	California	Minnesota-Wisconsin	New York-Pennsylvania	Southern states[1]
1964 to 1968	122,676	552,942	991,936	81,394
1971 to 1975	345,024	857,405	1,099,413	147,892
1976 to 1980	606,764	1,178,656	1,473,672	210,317
1981 to 1985	1,015,680	1,772,935	2,061,522	320,953
1986 to 1990	1,326,751	2,151,931	2,238,201	405,511

[1]Alabama, Florida, Georgia, Louisiana, Mississippi, and Texas.

is equivalent to a repeatability within herd of .44 (8). Effects of cows and herd-years were absorbed, and solutions for other effects were obtained. Similar to the models of Miller (5) and Norman et al. (8), age was partitioned into major and minor groups to remove gross interaction of age and calving month while maintaining large numbers of observations per group (Table 2). The large numbers of lactation records for the minor age groups for southern states (Table 2), the region with the fewest records, indicate why the derived factors were consistent across ages.

TABLE 2. Groups of ages for analysis and numbers of lactation records by age group for the regions and time periods with the fewest and greatest numbers of records.

Age group		Lactation records	
Major	Minor	Fewest[1]	Greatest[2]
	(mo)	(no.)	(no.)
1	18 to 21	554	6663
	22	524	13,584
	23	1058	39,311
	24	1857	77,997
	25 to 26	4171	171,605
	27 to 28	3729	130,501
2	29 to 30	3405	88,541
	31 to 32	2990	60,420
	33 to 34	2930	54,324
3	35 to 37	5449	149,231
4	38 to 42	7581	244,552
5	43 to 49	9444	222,812
	50 to 62	13,886	376,589
6	63 to 70	5838	168,795
	71 to 75	3678	87,120
	76 to 80	2400	71,609
	81 to 83	1414	35,506
	84 to 86	1449	33,787
	87 to 90	1404	38,164
	91 to 96	1800	45,155
	97 to 120	4188	92,418
	121 to 144	1286	23,459
	145 to 200	322	5815

[1]Southern states, 1964 to 1968.

[2]New York and Pennsylvania, 1986 to 1990.

A second model without an interaction of age and calving month also was used to examine the trends for the main effects of age and calving month. This model provided all the results in the accompanying figures.

Age factors were determined by linear interpolation between the estimated age midpoints. Multiplicative factors were derived by adding the mean to the additive effects and then converting the sum to a ratio. Although factors were calculated for both milk and fat yields, only results for milk yield are presented.

Because of the initial results from this study, additional examinations were made separately for registered and unregistered cows, as well as for cows with and without reported first parity, to help to explain the cause of unexpected findings.

RESULTS AND DISCUSSION

The effect of calving year on factors used to adjust Holstein milk yield for calving month is shown in Figure 2. Consistent with earlier results (1, 6, 9), milk yield was lowest for cows calving during July and August and generally highest for cows calving between November and February. The factors derived (shown in Figures 2, 3, 4, and 5) have a reciprocal relationship with yield. Overall effect of calving month was least for California.

The influence of calving season on milk yield generally has decreased for recent calving years for California, Minnesota and Wisconsin, and the southern states but remained about the same for New York and Pennsylvania. Differences between factors for the calving months that had the highest and lowest factors (lowest and highest yields, respectively) decreased from the mid-1960s to the late 1980s by 17% for California, 16% for Minnesota and Wisconsin, and 34% for the southern states.

Within region, effect of calving season on milk yield decreased most for February through April for California, for July and August for Minnesota and Wisconsin, and for December through April and August through September for the southern states. Across regions, the largest decrease for seasonal effect was for February through April for the southern states. Seasonal effect did increase during recent years for June, November, and December for California and June for the southern states.

Factors to adjust milk yield of Holstein cows calving in Minnesota and Wisconsin for age at calving are shown in Figure 3. The factor for the calving age of cows with mean yield was set to 1.0. The calving age with the lowest factor (maximum yield) was 78 mo during the mid 1960s and shifted to 67 mo during the 1980s. However, differences between the factors for 67 and 78 mo during the 1960s and 1980s were extremely small.

Age factors for cows calving at ≤72 mo, which are those cows of most interest to dairy producers, are presented in Figure 4 for all regions. Although the curve for current USDA factors for age adjustment based on calvings during the 1960s (5) was flattest for the Midwest, regional curves have become more similar during recent years. As herd management for heifers improved, regional differences would be expected to decrease. For all regions,

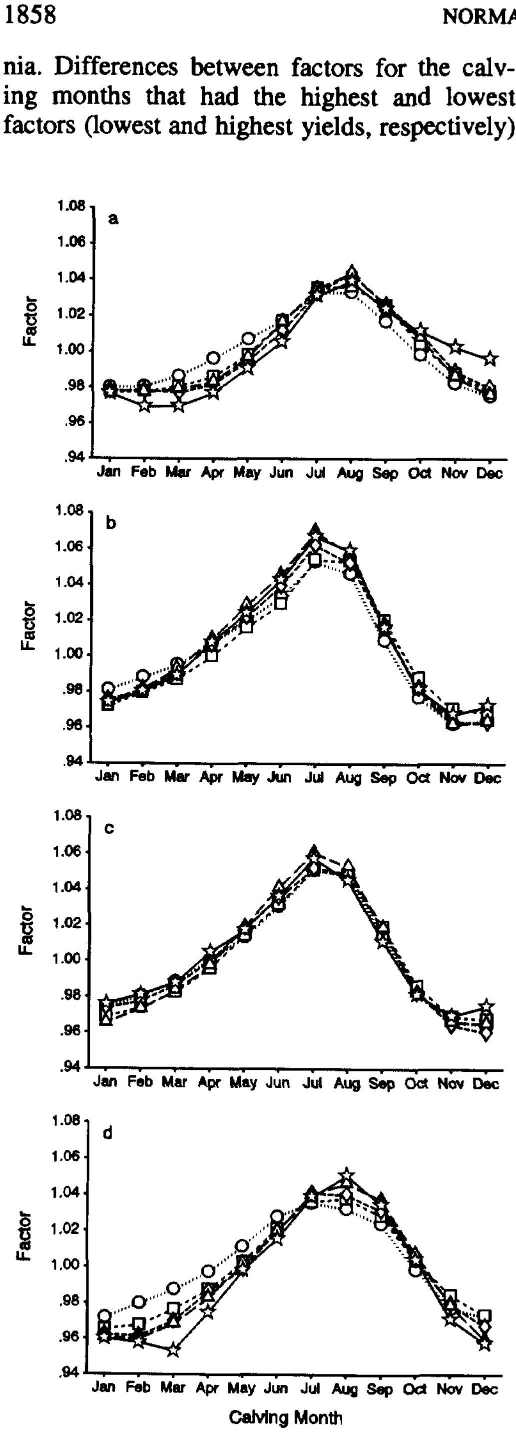

Figure 2. Factors to adjust Holstein milk yield for calving month based on calving years of 1964 to 1968 (☆), 1971 to 1975 (△), 1976 to 1980 (◊), 1981 to 1985 (□), and 1986 to 1990 (O) for a) California, b) Minnesota and Wisconsin, c) New York and Pennsylvania, and d) southern region.

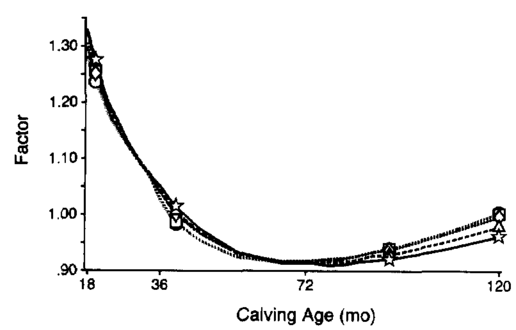

Figure 3. Factors to adjust milk yield of Holsteins in Minnesota and Wisconsin for calving age based on calving years of 1964 to 1968 (☆), 1971 to 1975 (△), 1976 to 1980 (◊), 1981 to 1985 (□), and 1986 to 1990 (O).

cows calving from 36 to 54 mo during more recent years had yield that was more similar to that of cows calving from 60 to 72 mo than

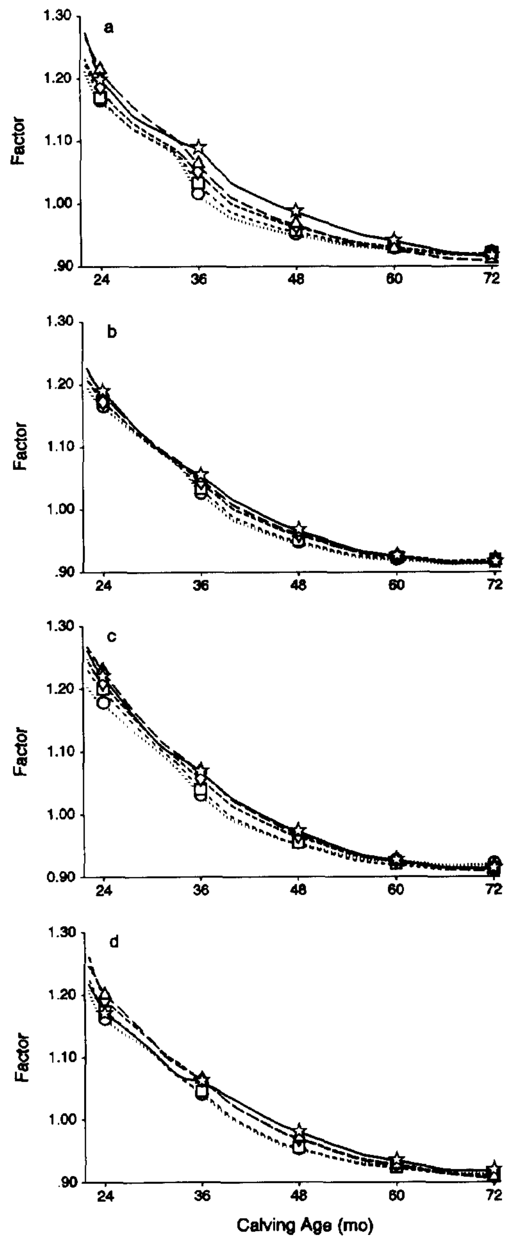

Figure 4. Factors to adjust milk yield for calving age of Holsteins that calved at ≤72 mo based on calving years of 1964 to 1968 (☆), 1971 to 1975 (△), 1976 to 1980 (◇), 1981 to 1985 (□), and 1986 to 1990 (○) for a) California, b) Minnesota and Wisconsin, c) New York and Pennsylvania, and d) southern region.

was that of their counterparts from earlier years; the greatest change occurred for cows calving in California. For cows calving at 24 mo, effects of calving age also generally decreased for recent data. Improvement in management or indirect selection for cows that mature early may have accounted for a portion of this decrease. The trend for age adjustment curves was less consistent for the southern states, likely because of sampling variation from fewer lactation records.

Different age factors resulted from data from different calving years (Figure 4). If these differences were caused by management changes across time, use of different sets of factors for each separate time period would be appropriate. If these differences were due entirely to genetics, use of different sets of factors would be detrimental to genetic evaluation because some of the effects of genetic change for maturity rate would be attributed to age. As more generations are included in the data, the opportunity to observe genetic change in maturity rate improves. Differences between effects of age and genetic change in maturity rate should be investigated with an animal model to determine the extent to which genetics is involved.

The age adjustment curves for California (Figure 4a) showed an unexpected pattern. Instead of a gradual transition across calving ages, the rate of change for factors slowed gradually until 33 mo (most recent years) to 36 mo (earliest years), and then factors decreased sharply for the next 3 mo. This flex in the age curve was apparent for all calving years and could not be attributed to sampling variation because factors were based on large numbers of records. Less pronounced flexes also were evident for Minnesota and Wisconsin and for New York and Pennsylvania.

To determine whether incorrect birth dates might have contributed to the unexplained flex in the age adjustment curves, subsets of the California lactation records were examined separately for registered and unregistered cows. Birth dates for registered cows were expected to be more accurate than those for unregistered cows. Age adjustment curves (Figure 5) for all calving years were similar for registered and unregistered California Holsteins, except for registered cows calving from 1964 to 1968, for which the curve was erratic

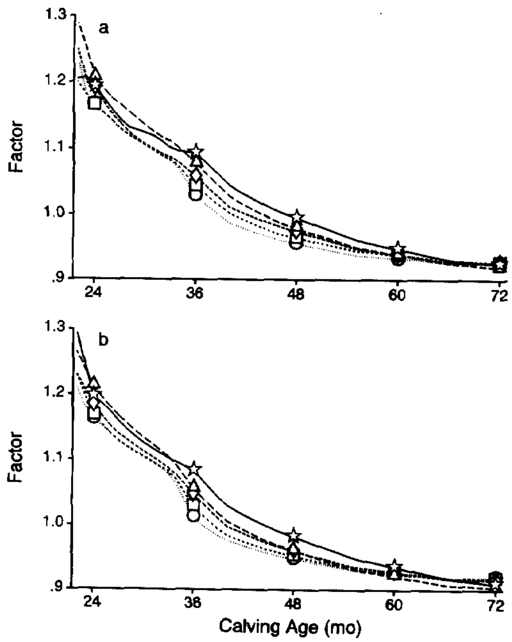

Figure 5. Factors to adjust milk yield for calving age of California Holsteins that calved at ≤72 mo based on calving years of 1964 to 1968 (☆), 1971 to 1975 (△), 1976 to 1980 (◊), 1981 to 1985 (□), and 1986 to 1990 (○) for a) registered and b) grade cows.

and based on only 43,611 lactation records. Inaccurate birth dates do not appear to be the cause of these unusual flexes in the age factors. Differences between factors for Midwestern registered and unregistered cows that were found by Durães and Keown (1) may have been caused by differences between geographic locations of the two populations within the region.

To determine whether failure to consider parity might have contributed to the flex in the age adjustment curves, a subset of the California lactation records for calving years of 1986 to 1990 was examined only for those cows that had first parity present. Curves derived from this subset were compared with those from the same years for all cows (whether first parity was present or not), as well as with curves for cows that had first parity missing. The curves appeared to be identical. However, this unexpected flex was very unlikely to have a true biological basis and was probably due to either the effect of parity or confounding with some other effect, for example, calving interval. Future research should investigate the interrelationship between these variables prior to development of new factors for age adjustment.

CONCLUSIONS

The influences of age and month of calving on yield were examined for four regions of the US to determine whether these environmental influences had changed over time. Effect of calving season generally has decreased (California, Minnesota and Wisconsin, and the southern states) but remained the same for New York and Pennsylvania; the decrease was greatest for the southern states. Seasonal yield in California has shifted over time compared with that of earlier years, and yield response was more favorable for cows calving during the fall; this advantage was reduced for those calving during the spring.

Effects of calving age on yield also generally have decreased over time, and geographical differences have decreased. No differences were apparent for age curves calculated from lactation records of registered and unregistered cows.

The changes over time for effects of age and month of calving on yield were large enough in some regions to indicate that new adjustment factors are justified. An industry-funded effort was initiated in January 1994 to derive new factors for use in US genetic evaluations and DHIA management programs, and these have been completed.

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