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ABSTRACT

Original data consisted of 31,777 records of progeny of 1442 sires for calvings between 1975 and 1983. Unadjusted means for milk yield (kg), days in milk, days dry, calving interval, days carried calf, and age at calving were 4281, 267, 88, 421, 145, and 36.6. Estimated total variance for first lactation milk yield by Henderson's method 3 was 1,385,436 kg^2 with sire and error variances accounting for 1.8 and 98.2%. Heritabilities for milk yield, lactation length, age at calving, and days carried calf were .07, .06, 2.59, and .01. High estimate for age was attributed to confounding of sires with season of calving. Genetic and phenotypic correlations between traits were milk and lactation length, .76 and .72; milk and age at calving, .17 and −.04; milk and days carried calf, −2.11 and .13; lactation length and age at calving, −.13 and −.06; lactation length and days carried calf, .87 and 16.; age at calving and days carried calf, −.60 and −.03. Sires with at least 10 daughters were evaluated by best linear unbiased prediction procedures. First lactation sire values for milk ranged from 359 to −340 kg with an average difference between sires of 12 kg. Sire values using all lactations ranged from 505 to −286 kg with an average difference between sires of 13 kg. Rank correlation between all and first lactation evaluations was .77.

INTRODUCTION

A majority of cows and a major portion of semen exported from the United States goes to warm climate regions of the world. Canada also exports the same products to many of the same countries. About 90% of cows and over 80% of semen exported have been Holstein. Recognition of high production of the Holstein breed has stimulated interest in setting up dairy industries in tropical and subtropical countries. Toward achieving this goal, artificial insemination (AI) centers and progeny testing schemes on a limited scale have been set up in these countries. Over the last decade, records of performance have been collected on Holsteins in Colombia through a breed association (Associacion Colombiana de Holstein-Friesian). Objectives of this study were a) to estimate variance (covariance) components for deriving heritabilities and genetic and phenotypic correlations by Henderson's Method 3 and b) to assess the genetic merit of sires present in the data by estimating their breeding values.

MATERIALS AND METHODS

Associacion Colombiana de Holstein-Friesian, Bogota, sponsored a Dairy Herd Improvement (DHI) program. Records were routinely processed at the DHI regional center, Provo, UT and completed records forwarded to the United States Department of Agriculture (USDA). Tapes of records were made available. Original data consisted of 31,777 records of progeny of 1442 sires for calvings from 1975 to 1983. Records were edited for completeness. Only lactation records > 60 d in length and up to 305 d and coded as terminating normally were considered. Other reasons for rejection were duplicate records, no birth date, calving age < 18 or > 200 mo, and no sire or cow identification. There were 24,134 records used to evaluate general performance. For sire evaluation, all sires were required to have 10 or more daughters. Between 1975 and 1980, there were only 3 to 5 herds represented with an average yield of 7000 kg. Such records, 5% of total, also were edited out. Over 60% of records had

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no sire identification and as such were not used for variance component estimation and sire evaluation. Edits left 2116 all lactations and 1526 first lactation records of progeny of 60 sires. Fat tests were not recorded. Most of the sires were in AI studs in the US and Canada. A small proportion of the semen came from a national AI stud and from Europe.

About 90% of the herds were from a plateau around the capital city of Bogota, which is at an altitude of about 2600 m. Days are warm year-round, but nights are cool. Average daily temperatures range from 9 to 20°C. Annual rainfall averages 1059 mm with bimodal distribution. Although there is no distinct dry season, March to May and October to November are the wettest months. Rainfall in other months is below that considered adequate for good pasture growth. Constant high humidity and rainfall provide a stressful environment for livestock, especially in breeding efficiency. Principal feed for the herds was year-round grazing of grass pastures. Some herds were supplemented with dried brewers grain and other by-products. Cows were milked twice a day by machine.

The system of breeding in Colombia involved "block" usage of sires, where breeders made heavy use of some sires they liked and hedged the risk of their selections by use of a high number of other sires to produce a few progeny each. This sire by herd confounding resulted in a high method 1 (11) estimate of heritability for milk yield (1).

(Co)variance components were estimated by Henderson's method 3 (11), using a two-way cross classified mixed model with first lactation records only. The model was:

$$y_{ijk} = h_i + s_j + e_{ijk}$$

where:

y_{ijk} = age-season adjusted milk record of k^{th} cow, a daughter of j^{th} sire, freshening in i^{th} herd-year,
h_i = effect associated with i^{th} herd-year,
s_j = effect of j^{th} sire, and
e_{ijk} = residual term.

The s_j and e_{ijk} were assumed uncorrelated and distributed randomly and independently with means zero and variances σ_s^2 and σ_e^2. Herd-year effects were assumed fixed. Covariance between two traits, i and j, $\sigma_{i,j}$ was obtained from the relationship: Cov(i,j) = [Var(i) + Var(j) −Var(i−j)] /2 after method 3 had been applied to i,j and the difference (i−j). Genetic covariance between traits i and j was estimated as four times the estimated sire covariance between the two traits, $4\hat{\sigma}_{s_i,s_j}$. Phenotypic covariance was $\hat{\sigma}_{s_i,s_j} + \hat{\sigma}_{e_i,e_j}$, where σ_{e_i,e_j} is environmental covariance, and heritability of a trait was computed as $\hat{h}^2 = 4\hat{\sigma}_s^2/(\hat{\sigma}_s^2 + \hat{\sigma}_e^2)$. The same model was used to estimate sire values. Herd-year equations were absorbed into sire equations and sire solutions obtained by direct inversion and postmultiplication. Age-season adjustment factors from Mexico data (15) were determined as most appropriate.

Sire values using all lactations were estimated by the model:

$$y_{ijkl} = h_i + s_j + c_{jk} + e_{ijkl}$$

where:

y_{ijkl} = l^{th} age-season adjusted milk record of jk^{th} cow, a progeny of j^{th} sire, freshening in i^{th} herd-year,
h_i = effect of i^{th} herd-year,
s_j = effect of j^{th} sire,
c_{jk} = additional effect associated with jk^{th} cow nested within j^{th} sire, and
e_{ijkl} = residual term.

The s_j, c_{jk}, and e_{ijkl} were distributed randomly and independently with means zero and variances σ_s^2, σ_c^2, and σ_e^2. Herd-year effect was assumed fixed. Also, s_j, c_{jk} and e_{ijkl} were uncorrelated with no relationships assumed among sires and among cows other than those with the same sire. Cow equations were absorbed into the equations for herd-years, and sires and solutions were obtained directly.

RESULTS AND DISCUSSION

General Performance

Unadjusted means and standard deviations (SD) for several traits are in Table 1. Cows were milked for about the same length of time as for Holstein cows in Mexico (2) and Puerto Rico (5). Long calving intervals and high age at first calving suggested that cows were under low nutrition stress due to influence by high humidity on forage quality. Pearson de Vaccaro (18) reviewed effect of age on performance of Holsteins in the tropics and reported ages at first calving ranging from 30 to 38 mo in South America. Also, high standard deviation for milk yield is a reflection of large environmental fluctuations.

Variances

Total variance and estimates of variance components for several traits are in Table 2. Variance for milk yield was 1,389,808 kg^2, which was close to the 1,405,711 kg^2 variance in milk reported by Van Vleck et al. (23). It therefore appears that amount of variation required for selection to be effective is in the Holstein population in Colombia. Results were similar for Holsteins in Mexico (2, 16). Sire component of variance for milk yield, 1.7%, is in the low range of estimates reported generally. However, Camoens et al. (6) and McDowell et al. (16) also reported estimates in the 2.0% range for Holsteins in Puerto Rico and Mexico but using all lactations. Higher estimates of 7 to 8% have been documented using first lactation records from Venezuela (20) and Mexico (2).

Sire component of variance for lactation length was similar to estimates by Cunningham (7) and Musi (17) but lower than the 8.5% obtained by Abubakar et al. (2). McDowell et al. (16) and Camoens et al. (6) reported negative estimates for this trait and concluded that genotype contributed no detectable rate in accounting for variation.

Age at calving had a higher sire component of variance than reported previously (9, 12, 19, 22). However, Hickman and Henderson (12) and Abubakar et al. (2) also obtained a high estimate for this trait and attributed it to a confounding of sires with season of calving. Sire component for days carried calf was small as expected. Discussion of error variances will not be meaningful here since the magnitude of such estimates is dependent on the sizes of models used.

Heritabilities and Correlations

Heritabilities and genetic and phenotypic correlations are in Table 3. Heritability for milk yield, .07, was low in comparison with the range of .12 to .59 for temperate areas (13). Nevertheless, the estimate falls within the range (.03 to .64) reported by McDowell (14) for

TABLE 1. Unadjusted means ($\bar{X}$) and standard deviations (SD) for several traits.

Trait	No. of records	$\bar{X}$	SD
Milk yield, kg	24,134	4281	1891
Days in milk	24,134	267	68
Days dry	24,134	88	68
Calving interval, d	18,256	421	100
Days carried calf	15,260	145	70
Age at first calving, mo	9176	36.6	10.8

TABLE 2. Percentages of variance for sire and error and the total variance for several traits.

Trait	Sire	Error	Total
	(%)	(%)	
Milk yield	1.7	98.3	1,389,808 (kg^2)
Lactation length	1.6	98.4	2048 (d^2)
Age at first calving	39.3	60.7	63,978 (d^2)
Days carried calf	.2	99.8	4043 (d^2)

TABLE 3. Heritabilities (diagonal), genetic correlations (above diagonal), and phenotypic correlations for several traits.

Trait	Milk	Lactation length	Age at first calving	Days carried calf
Milk	.07	.76	.17	−2.11
Lactation length	.72	.06	−.13	.87
Age at first calving	−.04	−.06	2.59	−.60
Days carried calf	.13	.16	−.03	.01

unselected native cattle in the tropics. The low estimate also could be a function of small numbers of records used for analysis.

Lactation length is somewhat difficult to compare given that it is usual in dairy studies to use records adjusted to a specific lactation length (305 d) or to consider normally terminated records as 305-d records. In this study, actual records were used because information was inadequate for derivation of acceptable factors (24). Heritability estimated in this study was higher than estimates by McDowell et al. (16) and Camoens et al. (6) where negative sire components of variance were obtained with Mexico and Puerto Rico data. High estimates also have been obtained by others (2, 17, 20). Low heritability of days carried calf is in agreement with earlier reports for fitness traits (8). Age at calving had a heritability (2.59) much outside the acceptable range. Other estimates have ranged from near zero to 1.05 (9, 10, 12, 19, 22). Similarly high values were reported by Abubakar et al. (2) and Hickman and Henderson (12). Allaire and Lin (4) used a model that partitioned time of birth into sequential monthly intervals and obtained a smaller heritability estimate for age. This confirms that there may be possible confounding of sire with season of calving.

Genetic correlation between milk yield and lactation length (Table 3) was positive and similar to values reported by (2, 7, 17). Genetic correlation between milk and days carried calf was negative, suggesting that selecting for milk yield would decrease days carried calf. This was in contrast to observations of Abubakar et al. (2). In agreement with some reports (6, 16, 17), a positive phenotypic correlation between milk yield and lactation length was obtained. All other phenotypic correlations were small.

Sire Values

Predicted sire values for first and all lactation milk yield and rank of sires are in Table 4. Sire codes corresponded to country of origin. Codes starting with 40 were Canadian while 75 were European and Colombian sires. The remaining 70% were principally US sires. Predicted sire values obtained were smaller with those from Mexico (2) or generally from temperate areas. However, estimates were comparable to those reported for Holsteins in other countries (17, 20) and also for Jamaica Hope cattle in Jamaica (3, 21). These studies also reported small average differences between sires in sire values, which is in agreement with the 12-kg difference in this study. It is noteworthy that a majority of the sires had less than 50 daughters, although no relationship was detected between number of daughters and sire values. Due to large environmental fluctuations in Colombia, selection of sires may be obscured by other confounding factors not detected. This is further supported by the fact that despite large estimated total variance for milk yield, heritability for this trait was low. Caution should therefore be exercised in interpreting these results.

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TABLE 4. Predicted sire values (SV) for first lactation and all lactations milk yield (kg) and rank of sires with 10 or more daughters.

Sire code[1]	No. of daughters	First lactations		All lactations	
		SV	Rank	SV	Rank
1562026	17	358	1	456	2
1562242	11	311	2	257	5
1458744	33	309	3	290	4
751006616	44	269	4	152	12
40325846	24	206	5	127	15
1512026	54	159	6	135	14
751006390	14	143	7	116	18
751006415	11	141	8	123	16
1509637	29	139	9	505	1
751006655	13	138	10	182	8
1565870	21	134	11	159	11
1506982	66	123	12	−21	35
1673062	23	119	13	311	3
1596441	33	114	14	117	17
1491007	17	112	15	28	29
1528579	22	103	16	170	9
1578139	13	101	17	206	7
1590283	13	92	18	29	28
751006936	58	91	19	−286	60
751006578	11	78	20	−19	34
1487095	12	65	21	57	23
1563649	18	64	22	66	21
1575152	14	64	22	55	24
1495851	11	63	24	166	10
1632698	81	56	25	91	20
751006101	15	49	26	35	27
1563453	12	45	27	38	26
1629385	18	43	28	−213	52
1557246	22	43	28	−6	32
1450228	17	38	30	107	19
1716951	36	3	31	−4	31
751006406	16	0	32	0	30
1531866	49	−18	33	142	13
1661902	15	−22	34	−37	36
40303261	23	−31	35	−81	39
1525369	10	−43	36	−17	33
1530625	19	−45	37	−113	41
751005357	24	−45	37	63	22
1483844	81	−47	39	−91	40
1647190	18	−49	40	−248	56
751006635	31	−65	41	−48	37
1592942	16	−87	42	−173	45
1441440	13	−119	43	54	25
1669851	18	−125	44	−265	58
1638035	25	−139	45	−195	48
751007124	11	−139	45	−201	49
1536957	18	−146	47	−255	6
1590689	28	−148	48	−164	44
1497798	15	−152	49	−220	54
751005313	20	−157	50	−177	46
1426616	11	−161	51	−219	53
751007023	13	−170	52	−192	47
1684664	12	−181	53	−75	38
1629391	44	−188	54	−231	55
751005126	18	−202	55	−207	50

(continued)

TABLE 4. (continued) Predicted sire values (SV) for first lactation and all lactations milk yield (kg) and rank of sires with 10 or more daughters.

Sire code[1]	No. of daughters	First lactations		All lactations	
		SV	Rank	SV	Rank
1664046	16	−204	56	−208	51
1604603	10	−213	57	−114	42
1493435	17	−264	58	−139	43
751006331	124	−273	59	−258	57
751006003	26	−340	60	−271	59

[1] Codes starting with 14, 15, 16, or 17 represent sires from the US, codes starting with 40 represent sires from Canada, and Codes starting with 75 represent sires from Colombia and Europe.

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