Breed Group Effects on Milk Production of Brazilian Crossbred Dairy Cows[1]

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ABSTRACT

Lactation records (n = 2362) of 1402 crossbred cows in 22 cooperating dairy herds in southeastern Brazil were evaluated. Cows were mixtures of Zebu (Gir, Guzera, and unknown) and European breeding (mostly Holstein). Lactation milk yields were expressed as total, 305-d, or deviated 305-d yields, either adjusted or unadjusted for days in milk (DIM). Mean DIM was 280. Arithmetic means unadjusted for DIM were 1942, 1666, and 5 kg per record. Milk yields of daughters from sires of 6/8 and 7/8 European breeds were higher than yields of daughters from sires of 5/8 European breeds when data were either adjusted or unadjusted for DIM. The differences associated with breed group of sire were only slightly reduced when records were adjusted for DIM. There was no evidence of a decline in milk yield as the fraction of European breeding of the sire increased from 6/8 to 7/8. For a given breed group of sire, whether the grandsire was purebred or crossbred had no detectable effect. These results should be useful in determining strategies for crossbreeding of dairy cows in tropical areas, particularly when crossbred sires are used.
(**Key words**: milk yield, crossbreeding, Brazil)

Abbreviation key: **DMY305** = deviated MY305, **MY** = total milk yield during lactation, **MY305** = milk yield in ≤305 d.

INTRODUCTION

Crossbreeding of European dairy breeds with Zebu or native breeds from tropical areas has been used widely as a method to improve milk production in the tropics and subtropics. In general, the first generation from crossbreeding has performed well and is accepted by dairy farmers, but continuation of the program by continued upgrading to European breeds may present problems because performance of higher levels of upgrades of crossbred cattle can be disappointing. Milk production per cow may decline, fertility may be lower, and calf mortality may increase after the first cross because of loss of heterosis, recombinant genetic effects, or deterioration of environmental levels (i.e., feeding and management). The success of crossbreeding strategies that lead to high levels of European breeding (e.g., Holstein) apparently depends considerably on the management systems adopted during the upgrading process.

To maintain a crossbred population at moderate levels of European breeding (e.g., 50 to 75% or higher), use of crossbred bulls may be recommended when simplicity of the breeding program is essential, as is the case in several regions of Brazil and other developing dairy areas. Many farmers in Brazil think that, for a given sire breed composition, purebred grandsires are superior to crossbred grandsires. If this supposition is not true, then perhaps some farmers should reserve crossbred sons of their own outstanding crossbred cows for use either in natural service or AI.

Our main objective of the present research was to obtain information to help determine the kind of crossbred sires to use on crossbred females, utilizing data from the progeny-testing program for crossbred sires maintained by EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária Juiz de Fora, Brazil). One of the objectives of this progeny-testing program was the identification of the best genotypes to use in several regions of Brazil. Also, results comparing data adjusted for DIM with unadjusted data were desired.

MATERIALS AND METHODS

Data were screened according to procedures outlined by Freitas et al. (3, 4). Records of <120 d in duration were deleted. A total of 2362 usable lactation records from 1402 cows in 22 cooperating herds during 1981 to 1992 was utilized in this study. The

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TABLE 1. Distribution of records by herd and breed group of sires.

	Breed group of sires			
Herd	5/8[1]	6/8	7/8	Total
1	208	317	230	755
2	17	3	1	21
3	15	6	0	21
4	39	40	61	140
5	41	26	26	93
6	77	143	104	324
7	27	7	20	54
8	56	68	52	176
9	101	62	25	188
10	2	1	1	4
11	4	8	5	17
12	1	10	8	19
13	2	4	4	10
14	4	14	9	27
15	76	30	64	170
16	16	18	29	63
17	78	9	3	90
18	7	7	9	23
19	2	1	3	6
20	50	45	25	120
21	3	18	10	31
22	3	3	4	10
Total	829	840	693	2362

[1]Proportion of European (mostly Holstein) breeding.

program provided semen to each herd from 10 crossbred sires per year. Cows existing in the herds were crossbreds; the breed composition of individual cows for the most part was unknown. Semen was used at random within herds without consideration of the breed group of the sires. In the period studied, a total of 80 sires had daughters with production records, averaging nearly 18 daughters per sire. Breed groups of sires were 5/8, 6/8, or 7/8 European; the remaining portion was Zebu. Breed groups of paternal grandsires were either purebred Holsteins or crossbred. The European contribution to females primarily was Holstein with some Brown Swiss and Jersey; the Zebu contribution was Gir, Guzera, and unknown. Sires were sons of pure Holsteins or crossbred sires, except for sires of 5/8 European breed composition, which were sons only of crossbred sires. The distributions of records by herds and by breed groups of sires and paternal grandsires are shown in Tables 1 and 2.

The number of records analyzed varied from 4 to 755 in the various herds (mean, 107.4). All herds were represented by records from all three breed groups of sires, except that one herd had no records from daughters by sires that were 7/8 European. The number of records during the 12-yr period ranged from 20 to 362; the mean was 196.8. The two breed groups of the paternal grandsire were represented by daughters with records in every year; the three sire breed groups were represented in every year also, except that sires of 7/8 European breed composition were not represented in 1981 or 1982 (Tables 1 and 2). Overall, 829 records (35.1%) were from daughters sired by the 5/8 sire group, 840 (35.6%) by the 6/8 sire group, and 693 (29.3%) by the 7/8 sire group. Crossbred grandsires were represented by 1049 records (44.4%), and purebred grandsires were represented by 1318 records (55.6%).

Traits considered in this study were total milk yield (**MY**) during a lactation, MY during ≤305 d of lactation (**MY305**), and deviated MY305 (**DMY305**). Estimates of DMY305 were obtained by subtracting the herd-year-season (HYS) average from each

TABLE 2. Distribution of records by breed groups of sire and paternal grandsire and by year.

	Breed group of sire			Breed group of paternal grandsires		
Year	5/8[1]	6/8	7/8	Purebred	Crossbred	Total
1981	16	4	0	4	16	20
1982	28	8	0	8	28	36
1983	110	37	11	40	118	158
1984	101	98	56	137	118	255
1985	104	120	89	177	136	313
1986	104	149	109	239	123	362
1987	106	111	138	230	125	355
1988	87	79	99	165	100	265
1989	55	49	45	75	74	149
1990	54	74	61	109	80	189
1991	50	100	68	108	110	218
1992	14	11	17	21	21	42
Total	829	840	693	1313	1049	2362

[1]Proportion of European (mostly Holstein) breeding; purebred represents pure Holstein.

record of MY305. The average was estimated as HYS = M + (N/N+c)(M′ – M) where M = the population average, N = number of animals with records in the HYS, M′ = mean of MY305 from contemporary cows in the herd without including the yield of the cow herself, and c = ratio of variances between and within cows. The value 1.0 was used for c as representing repeatability of 0.5 (5, 19). The estimate of repeatability obtained from the present study was 0.48, which was deemed to be not different from 0.5. Seasons were dry (April to September) and rainy (October to March). Thus, DMY305 was calculated as DMY305 = {MY305 – HYS)/HYS} × M.

Data were analyzed by the method of least squares ANOVA. Two mathematical models were used and then combined in the statistical analyses. First, $Y_{ijklmn} = \mu + SG_i + PGSG_j + (SG \times PGSG)_{ij} + T_k + M_l + H_m + A + DIM + e_{ijklmn}$ where Y_{ijklm} = response of interest, μ = population mean, SG_i = effect of crossbred group of sires of daughters, $PGSG_j$ = effect of breed group of paternal grandsires of daughters, $(SG \times PGSG)_{ij}$ = interaction between groups of sires and paternal grandsires, T_k = effects of year of calving, M_l = effects of month of calving, H_m = effects of herd, A = effects of age of daughters at parturition, to the third order of polynomial regression, DIM = DIM to the third order of polynomial regression, and e_{ijklmn} = residual, with usual assumptions for error.

The second mathematical model used was $Y_{ijklm} = \mu + G_i + D(G)_{ij} + T_k + M_l + A + DIM + e_{ijklm}$, where G_i = effects of SG × PGSG × H class, and $D(G)_{ij}$ = daughter within G_i. This model was used to obtain appropriate error terms for SG, PGSG, and SG × PGSG for a combined ANOVA. All effects except the residual were considered as fixed in the first model. In the second, G_i, $D(G)_{ij}$, and residual terms were considered random. Then DIM was deleted from each model to determine the effects on breed group means of adjusting lactation yields for this variable, as reported by Madalena et al. (9).

The inclusion of age in the model, as just described, suggests that a single set of age effects exists for animals represented by the different breed groups. It is well known that age effects are not homogeneous among breeds or among breed groups. The effects of adjusting the present data by use of the pooled (average) age effects is not known but should provide a basis for future research.

Solutions for these models could not be obtained if sire effects were included. Such omission would not

TABLE 3. Combined least squares ANOVA of data adjusted for DIM or not adjusted.

Source of variation	df	Adjusted for DIM			Not adjusted for DIM		
		MY[1]	MY305	DMY305	MY	MY305	DMY305
Sire group (SG)[2]	2	249[3]	242	109	1049	1234*	704
Paternal grandsire group (PGSG)[4]	1	12	78	1	955	172	9
SG × PGSG	1	108	195	141	1193	382	311
Herd (H)	21	3870**	3866**	849**	9962**	6904**	259
Daughter (SG × PGSG × H)	1367	195	247	220**	635**	357**	325**
Year of calving	11	1342*	1762**	227	2276**	2889**	312
Month of calving	11	295	347	628**	1327**	1139**	500**
Age of cow							
Linear[5]	1	33,482**	21,128**	16,287**	16,561**	23,004**	17,764*
Quadratic	1	36	6	1092*	10	18	971*
Cubic	1	887	261	542	340	201	628
DIM							
Linear[5]	1	377,590*	27,827**	24,990**	. . .	. . .	. . .
Quadratic	1	1140	101,959**	98,878**	. . .	. . .	. . .
Cubic	1	44	19,933**	21,377**	. . .	. . .	. . .
Residual	941	677	280	186	295[6]	185[6]	197[6]
Total	2362						

[1]MY = Total milk yield, MY305 = milk yield in 305 d or less, and DMY305 = deviated MY305.

[2]Sire breed groups were crossbred sires of 5/8, 6/8, and 7/8 European (mostly Holstein) breeding.

[3]Mean squares; all mean squares × 10^3.

[4]Paternal grandsire groups were purebred and crossbred sires.

[5]Mean squares are from sequential sums of squares for age and days; all other mean squares are derived from partial sums of squares.

[6]Associated with 944 df.

*$P \le 0.05$.

**$P \le 0.01$.

TABLE 4. Least squares means for milk yield of daughters listed by type of breed group of grandsire and of sires when records were adjusted or for DIM or not adjusted.[1]

	Breed group of sires adjusted for DIM			Breed group of sires not adjusted for DIM		
Type	5/8	6/8	7/8	5/8	6/8	7/8
			MY[2]			
Crossbred	1928[3,4]	2003	2001	1857[4]	2016	1863
Purebred	. . .	1962[5]	1981	. . .	2008[5]	2060
			MY305			
Crossbred	1766	1841	1832	1568[4]	1731	1689
Purebred	. . .	1773[5]	1846	. . .	1633[5]	1707
			DMY305			
Crossbred	171	213[5]	215	–23[4]	103	72
Purebred	. . .	181	253	. . .	42[5]	116

[1]Sire breed groups were crossbred sires of 5/8, 6/8, and 7/8 European (mostly Holstein) breeding.

[2]MY = Total milk yield, MY305 = milk yield in 305 d or less, and DMY305 = deviated MY305.

[3]Milk yields are in kilograms. Standard errors of means ranged from 15.2 to 18.9 kg for three sire breed groups adjusted for DIM (n = 9) and 19.7 to 30.3 kg when not adjusted for DIM; ranges for two grandsire breed groups were 12.2 to 15.3 (n = 6) and 15.7 to 24.6 kg.

[4]For crossbreds, grandsire groups, whether adjusted for DIM or not adjusted, the orthogonal contrasts of 5/8 versus 6/8 plus 7/8 were significant ($P < 0.05$); 6/8 versus 7/8 did not differ ($P > 0.05$).

[5]The contrast of 6/8 versus 7/8 was not significant ($P > 0.25$) for the purebred group of grandsires.

affect estimates of the breed group effects. Sire effects thus are included in daughter effects, and the latter would serve as an appropriate error term for breed group effects.

RESULTS AND DISCUSSION

The arithmetic means for MY, MY305, and DMY305 were 1942, 1666, and 5 kg. The least squares ANOVA for these traits are summarized in Table 3. The variable DIM was included or omitted as indicated; mean DIM was 280 d with standard deviation of 85.1 d.

The differences in MY, MY305, and DMY305 of daughters of the different breed groups of sire and paternal grandsire were small and generally were not statistically significant overall, regardless of whether or not records were adjusted for DIM, although several orthogonal contrasts were significant. An exception was for crossbred sire groups for MY305 not adjusted for DIM, which was significant ($P < 0.05$). Least squares means for sire and paternal grandsire groups are presented in Table 4. Orthogonal contrasts showed that the three measures of yield of daughters of 6/8 and 7/8 breed groups of crossbred sires were higher than yield of daughters of the 5/8 group ($P < 0.05$) but that the daughters of the 6/8 and 7/8 breed groups did not differ from each other when data were not adjusted for DIM (Table 4). When data were adjusted, differences between breed groups were smaller; again, only the contrast of 5/8 versus 6/8 plus 7/8 was significant for MY. Although MY, MY305, and DMY305 of daughters of 7/8 sire groups were higher than those of daughters of 6/8 sire groups (with exception of unadjusted MY), differences were not significant. Little difference would be expected between milk yield means of daughters for the 6/8 and 7/8 sire groups, and none was found. The comparison of these two groups with the 5/8 sire group was noteworthy because of suggestions that, for tropical areas, the 5/8 sire breed group was superior (2, 10). No evidence of an interaction among groups existed, suggesting that, for a given breed composition of sire, it was not important whether the paternal grandsire was a purebred or a crossbred. For the six MY measures, the average difference between purebred and crossbred paternal grandsires was <1 kg. This comparison involved only the 6/8 and 7/8 sire groups.

Martinez et al. (10) studied 14 crossbred herds from the southeastern region of Brazil, the same population from which the crossbred sires in our study was obtained. Those researchers observed that MY increased as the percentage of European breeding of the cows increased to 50% when cows were managed under pasture management that was typical of this region of Brazil. Martinez et al. (10) suggested that increasing the fraction of European breeding beyond 50% might be beneficial in well-managed herds. Milk yields in herds in their study ranged from 1670 to 2294 kg for first lactation and from 1926 to 2677 kg in later lactations. Our yields were slightly lower than those obtained by Martinez et al. (10). This difference may reflect a loss of heterosis among daughters of crossbred sires, as shown by Alexander et al. (1), who studied records of the Australian Friesian Sahiwal breed, and by Syrstad (17), who evaluated results of several studies on European-Zebu crossbred cows. Those scientists (1, 17) observed that milk yield of F_2 animals in the tropics decreased about 24% compared with that of F_1 animals. Also, in southeastern Brazil, Freitas et al. (2) observed decreases in MY in a crossbred herd associated with increases in the fraction of European breeding. There seemed to be no advantage in including a third European breed (Red Dane) in the crossbreeding scheme. Thorpe et al. (18), with crossbred data of Ayrshires, Brown Swiss, and Sahiwal cattle in the Lowland Tropics of Kenya, concluded that two-breed rotational crossbreeding was an attractive option for Kenya but depended on the availability of two breeds of purebred sires.

Performance of 2/8, 4/8, 5/8, 6/8, and 7/8 Holstein-Guzera crossbred cows and purebred Holstein-Friesian cows was compared by Madalena et al. (8). Those cows were divided into two groups of cooperator farms, representing high and low management levels. Herds were located in southeastern Brazil. Differences in MY between 4/8, 6/8, 7/8, and purebred Holsteins were small for first lactation in high management herds; the 2/8 and 5/8 groups had very low MY. In herds with poor management, the 4/8 group had the highest MY, and the 5/8 group had the lowest. However, Lobo et al. (6), studying Pitangueiras (5/8 Red Poll), and McDowell (11), using crossbreds in India, observed good performance by 5/8 European-Zebu crossbreds. Several studies from Brazil (7, 13, 14, 16) showed that genetic groups between 4/8 and 6/8 Holstein-Zebu had similar MY. In general, those studies represented poor environments and poor management. In El Salvador, Reaves et al. (15) found a linear increase in MY305 (no evidence of curvilinearity) as the percentage of Holstein (up to 93.75%) and Brown Swiss (up to 87.5%) breeding increased. These records were adjusted for DIM.

In Table 4, least squares means are shown for data that were adjusted or not adjusted for DIM. Madalena et al. (9) suggested that procedures that remove variation in DIM are inappropriate for evaluation of genetic groups such as those represented in our study. Estimates of heterosis and additive differences among breeds were lower when records were adjusted. Our estimates of differences in sire breed groups were slightly lower when data were adjusted, but interpretation of results was unaffected by adjustment. In developing areas of dairy production in tropical and subtropical regions, DIM often is heritable (9); DIM in temperate, developed areas generally is not heritable. McGlothlen et al. (12) found that, on the average and over 14 good yr, upgrading of Butana (a Zebu breed) in Sudan to either 71% Holstein or Ayrshire breeding in tropical Sudan resulted in increased MY305. This increase occurred whether data were adjusted for calving interval or not adjusted. The data set of McGlothlen et al. (12) represented 4121 lactation records of 892 cows with a mean MY305 of 2508 kg. Over 13 poor yr, however, MY305 yields were greatest from three sire breed crosses: 8/16 Holstein, 4/16 Ayrshire, and 4/16 Butana. Estimates of heterosis were greater when records were adjusted for calving interval in additional analyses. All records were adjusted for DIM. Because results from studies of MY305 of crossbred cows in tropical and subtropical areas are not totally consistent, continued statistical analyses of large data sets seem warranted. Analyses of data should be performed with models that included or did not include DIM, age, and days open, in all combinations.

CONCLUSIONS

Although the exact breed composition of the cattle of this study is unknown, it appears that crossbred sires with high levels of European breeding (6/8 and 7/8) were used without loss of milk production, as has sometimes been reported. In fact, these groups were associated with higher MY than were sires of the 5/8 group. For a given level of European breeding of sire, whether the paternal grandsire was a crossbred or purebred was irrelevant. The adjustment of records for DIM had little effect on the magnitude of the differences among breed groups and no effect on the interpretation of results.

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