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Evaluation of crosses of Holstein, Jersey or Brown Swiss sires x Holstein-Friesian/Gir dams. 3. Lifetime performance and economic evaluation

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ABSTRACT. Lifetime dairy production, reproduction and growth traits of 75 females sired by Holstein, Jersey or Brown Swiss bulls and Holstein-Friesian x Gir dams of 1/2 to 3/4 Holstein-Friesian fractions were compared. The animals were in a single herd under the same management. Milk, fat and protein yields, concentrates fed, reproduction, and weights were recorded throughout the lifetime of the cows. The data were analyzed by least squares techniques under models including the fixed effects of breed of sire, *Bos taurus* fraction and year of birth. Herd lifes for Holstein, Jersey and Brown Swiss crosses were 6.006 ± 0.812, 8.129 ± 0.863 and 7.247 ± 0.777 years. Milk yields per day of herd life were 7.150 ± 0.266, 6.757 ± 0.282 and 6.249 ± 0.254 kg. Weights of cull cows sold were 458 ± 15, 415 ± 15 and 457 ± 13 kg. Based on these and on previously reported results of the same experiment, intakes of roughage and pasture were estimated from energy requirements. Lifetime expenditures on concentrates, roughages, pastures, milking, reproduction, and heifer rearing were calculated based on mean performance of each breed of sire, as well as on receipts from animals and milk sold (the latter with four sets of prices of protein, fat and carrier). The conclusion was that in systems of artificial female calf rearing and male calf wastage, the Jersey crosses appear to offer important economic benefits to farmers, which would be even greater if payment on milk protein and fat becomes effective.

Key words: Crossbreeding, Dairy production cost, Cow size, Dairying, Life-time profit, Three-way crosses

INTRODUCTION

Holstein (H)/Gir crosses are widely used for dairying in the tropical region of Brazil, although Jersey (J) and Brown Swiss (BS) are also locally available. Experimental evidence for the milk yield of crosses of these *Bos taurus* with *Bos indicus* breeds is now relatively well documented (e.g., review by Teodoro and Lemos, 1992), but comparisons of other economically relevant traits or of total productivity throughout lifetime are rare. Therefore, a trial was set up to find out whether crossing with J or BS could further improve performance over the Holstein-Friesian (HF)/Gir crosses. Results on dairy production, reproduction and growth were reported by Teodoro et al. (2001), and Teodoro and Madalena (2002a,b). The present study reports on lifetime performance and an economic comparison is presented. Currently, Brazilian farmers receive little or no remuneration for milk fat and protein (Madalena, 2002b) although this situation may change. In this case J and BS breeds might conceivably have increased value, due to the high content of fat and protein in their milk.

MATERIAL AND METHODS

Animals and management

Lifetime performance of 75 cows was used in this study. These cows were the progeny of HF/Gir females of 1/2, 5/8 and 3/4 HF fractions, randomly mated to H (14), J (9) or BS (9) sires, mostly of USA and Canadian origin. A detailed description of the breeding values of these sires for milk yield and fat percentage was given by Teodoro and Madalena (2002a). The experimental cows were born between 1977 and 1983, at the Santa Mônica Experimental Farm of the EMBRAPA-National Dairy Cattle Research Center, where they were managed together, in a single herd. Sixteen heifer calves were transferred to the research center from another farm between six and 12 months of age. The experimental farm is located in the Municipality of Valença, State of Rio de Janeiro, in a hilly region at altitudes of 200 to 400 m above sea level.

The cows were kept on pastures of predominantly *Brachiaria decumbens* (Stapf.) and napier elephant grass. Maize and sorghum silage (and occasionally elephant grass silage and cane molasses) were fed in the dry season. Lactating cows were fed a commercial concentrate ration (varying between 16 to 22% crude protein), at an average rate of 0.31 kg/kg milk. Minerals were available in pastures. Tick burdens were kept low by spraying with chemicals based on fention, amitraz or pirethroids, which were changed when it was felt that they were becoming less effective, and by pasture rotation, effected at irregular intervals according to circumstances.

Cows were machine-milked twice a day. Calves of the cows were artificially reared. Milk yield and concentrate offered were recorded fortnightly. Milk fat and protein were tested monthly on Foss Electric Milko Tester Minor and Pro Milk MK II apparatus (A/S N. Foss Electric, Hillerod, Denmark). Live weights of cows were recorded every three months. Cows were dried off two months before expected calving or when their milk yield dropped below 3 kg/day. There was no culling on yield but cows considered too old to finish a new lactation were culled. Further details on management were given by Teodoro and Madalena (2002a,b).

The weights of female progeny of some cows in this experiment were available. The three breeds of sire were represented by 19 H, 18 J and 21 BS cows, but HF fractions were only 5/8 and 3/4. Those 58 cows were inseminated with semen of 66 *Bos taurus* x *B. indicus* crossbred sires from the MLB programme (Madalena, 2002a) and yearling weights of 132 progeny were obtained.

Records on clinical disease of cows (2.4 to 8.4 years old and up to 5.5 years after first calving) were available only from July 1980 to December 1985.

Statistical analysis

Least-squares analyses were performed on lifetime traits of cows using Proc GLM of SAS (1999). Models included fixed effects of breed of sire, *B. taurus* fraction class and year of birth. The model for yearling weight of progeny also included effects of age of dam and the *B. taurus* fraction of the progeny nested within *B. taurus* fraction of the dam. The Scheffé option was used for multiple range tests.

Economic performance

Profit per day of herd life (PPD) was calculated based on lifetime means of milk production, reproduction, and weights by breed of sire group and as lifetime receipts (R) minus costs (C) divided by herd life (hl), i.e., PPD = (R - C)/hl. Receipts were sales of milk protein, fat and carrier (zero protein and fat milk) plus sales of animals (cull cows, surplus heifers, assumed to be sold at 12 months of age, and bobby calves sold soon after birth). Four sets of milk component prices were considered (Table 1) after Madalena (2002b), representing situations in which 1) milk components are not paid for, 2) fat is paid for, at a small price, but not protein, 3) both fat and protein are paid for, as well as carrier, and 4) protein receives a much higher price than fat and carrier is discounted. The first two situations are the most common in Brazil, the third is found in a few special cooperatives and the fourth represents prices in a processing oriented dairy industry such as in New Zealand. The component prices for all four price sets in Table 1 were scaled to yield a value of 1 for the price of one kg milk with 3.6% fat and 3.1% protein, so that differences in receipts would reflect just the different component prices and not differences due to scale of milk price. All prices of products and inputs were expressed in milk equivalents (me), defined as the price of 1 kg of milk containing 3.6% fat and 3.1% protein.

The following items of production cost were considered: concentrates, roughages, pastures, milking, reproduction, and other costs. Roughage and pasture intakes were estimated

Table 1. Milk component prices used in economic simulations (in milk equivalents/kg of component)[1].

Price set	Protein	Fat	Carrier[2]
1	1	1	1
2	0.9029	3.6006	0.9029
3	5.0363	7.0516	0.6324
4	24.5127	11.5846	-0.1897

[1]One milk equivalent = price of one kg of milk with 3.6% fat and 3.1% protein.
[2]Zero fat and protein milk.

subtracting the net energy (NE_L) intake in concentrates (assuming 72% total digestive nutrients, TDN) from the total NE_L requirements for lactation, maintenance, growth, and gestation, based on cow live weight and milk protein and fat produced (NAS, 2003). However, NAS maintenance requirements were multiplied by 0.895 to account for the lower requirements of *B. indicus* crossbreds (Silva et al., 2002). Roughage and pasture intakes of heifers (assuming 58% TDN) were similarly estimated based on individual weights and weight gains up to first calving. The concentrate was priced at 0.714 me/kg and silage and pasture at 0.36 and 0.33 me/kg dry matter, respectively. The cost of milking was assumed to be 2% of milk produced (based on Madalena et al., 1989 and Martins et al., 2003). The cost of reproduction was the cost per service (53 me, from Vercesi et al., 2000 and Martins et al., 2003) *vs* lifetime number of services. The "other costs" were set at 0.584 me per cow, calculated to yield a typical profit of 0.12 me per kg of milk produced by H sired cows. This value was also used for the other two sire breed crosses, as these costs per cow are unlikely to be affected by breed. The heifer cost at 12 months included a fixed rearing cost of 667 me (480 of which was milk fed to calves) plus the cost of concentrates and pasture/roughage. The cost of a replacement heifer up to first calving included also pasture/roughage intake and a fixed expenditure of 350 me per heifer (adapted from Martins et al., 2003).

The number and selling prices of cull cows were recorded. The number of males sold was estimated as the total lifetime number of calvings (nc) x 1/2 x survival rate (0.90), with their price set at 30 kg me per head. The number of surplus heifers was estimated as 1/2 (0.85) nc - 1 (one needed for replacement, in a stabilized herd). Their selling price was assumed to be 1.06 times their cost for heifers from all three breeds of sire.

Means by breed of sire for some previously reported traits were used in the economic calculations, in addition to means for traits analyzed in this study (Table 2).

RESULTS AND DISCUSSION

Lifetime performance

As previously reported J and BS crosses had higher protein and fat concentrations in milk than H crosses. The J crosses calved earlier and were lighter than the other two groups (Table 2). The J crosses also had a longer herd life but the H crosses had the highest milk yield per day of herd life (Table 3). As previously discussed (Teodoro and Madalena, 2002a), the J and BS crosses compensated their lower yield with better reproduction and higher solid contents, relative to the H crosses, so that the yields of protein and fat per day of herd life were

Table 2. Previously published means for breed of sire groups used in this study[1].

Trait	Breed of sire		
	Holstein	Jersey	Brown Swiss
Age at first calving (year)	3.07	2.68	3.17
Milk fat concentration (%)	3.37	3.73	3.77
Milk protein concentration (%)	3.02	3.10	3.16
Maximum cow weight (kg)	487	439	499
Average cow weight (kg)	464	413	478
Weight at first calving (kg)	400	359	407
Weight at 4 months of age (kg)	94	82	80

[1]Source: Teodoro et al. (2001), Teodoro and Madalena (2002a,b).

Table 3. Least-squares means (LSM) and standard errors (SE) for breed of sire group lifetime traits.

Trait	Breed of sire					
	Holstein		Jersey		Brown Swiss	
	LSM	SE	LSM	SE	LSM	SE
Herd life (year)	6.006	0.812[a]	8.129	0.863[b]	7.247	0.777[a]
Total number of lactations	5.480	0.764[a]	7.989	0.812[b]	6.865	0.731[a]
Days in lactation/days herd life	0.789	0.021	0.775	0.022	0.733	0.020
Milk yield per day of herd life (kg/day)	7.150	0.266[a]	6.757	0.282[b]	6.249	0.254[a]
Fat yield per day of herd life (kg/day)	0.258	0.011	0.262	0.011	0.237	0.010
Protein yield per day of herd life (kg/day)	0.209	0.008	0.208	0.008	0.193	0.008
Number of services per year of herd life	3.048	0.478[a]	1.583	0.519[b]	2.273	0.445[a]
Weight at culling (sale) (kg)[1]	458	15[a]	415	15[b]	457	13[a]
Weight of yearling female progeny[2]	146.7	2.9	153.3	2.6	150.2	2.5
Number of cows	27		22		26	
Number of yearling female progeny	34		49		49	

[a,b]Means with different superscripts differ significantly ($P < 0.10$). [1]Based on 21 Holstein, 19 Jersey and 22 Brown Swiss cows sold. [2]Based on 19 Holstein, 18 Jersey and 21 Brown Swiss cows with progeny data.

similar for all three groups. The higher fertility of the J crosses was reflected by fewer services per year of herd life (Table 3). Note that this number includes all services performed, both for cows that stayed in the herd and for those culled.

Weight at culling (sale) of J crossbreds was the lowest (Table 3). However, the breed of sire of the cows did not significantly affect the yearling weight of their (bucket fed) progeny nor growth rate up to 2 years of age ($P > 0.21$).

The decline in milk, fat and protein yields with increased *B. taurus* fraction was apparent (Table 4), in agreement with reports in the literature for this level of milk yield (Madalena, 1998). In *B. taurus* x *B. indicus* crossbreeding experiments reviewed by this author, milk yield per day of calving interval was greater in the F_1s than in the backcrosses, but levelled off for *Bos taurus* fractions above one-half, when yield reached a level of about 10 kg/day. No signifi-

Table 4. Least-squares means (LSM) and standard errors (SE) for *Bos taurus* fraction.

Trait	*Bos taurus* fraction					
	3/4		13/16		7/8	
	LSM	SE	LSM	SE	LSM	SE
Milk yield per day of herd life (kg/day)	7.511	0.350[a]	6.462	0.226[b]	6.183	0.255[b]
Fat yield per day of herd life (kg/day)	0.293	0.014[a]	0.239	0.009[b]	0.226	0.010[b]
Protein yield per day of herd life (kg/day)	0.232	0.01[a]	0.193	0.007[b]	0.185	0.008[b]
Number of cows	13		37		25	

[a,b]Means with different superscripts differ significantly ($P < 0.10$).

cant differences among cows with different *Bos taurus* fractions were observed for any of the other traits analyzed ($P > 0.05$).

Incidence of diseases

The overall frequencies of cows treated for mastitis, retained placenta/metritis, other diseases, and for any disease were 0.444, 0.167, 0.403, and 0.514, respectively. Breed of sire did not significantly affect these proportions ($P > \chi^2 > 0.48$), nor the expenditure on medicines ($P > 0.51$), which had the following means: 42 ± 69, 1 ± 7, 8 ± 19, and 51 ± 74 me in a period of 3.5 years. These costs increased by 13 ± 2, 0.4 ± 0.2, 2 ± 1, and 15 ± 2 me for each increase of one year of age.

Energy requirements

Energy requirements per day of herd life for the three breed of sire groups are presented in Table 5. The Jersey crosses spent less energy for maintenance than the H crosses and the same amount of energy for lactation, while the BS crosses used more for maintenance and less for lactation than the other two crosses.

Table 5. Daily energy requirements (NE_L) per day of herd life of cows of three sire breeds[1].

Item	Breed of sire					
	Holstein		Jersey		Brown Swiss	
	Mcal	%	Mcal	%	Mcal	%
Maintenance	8.3	60.1	7.6	58.5	8.5	62.0
Growth	0.5	3.6	0.5	3.8	0.5	3.6
Gestation	0.3	2.2	0.2	1.5	0.3	2.2
Lactation	4.7	34.1	4.7	36.2	4.4	32.1
Total	13.8	100.0	13.0	100.0	13.7	100.0

[1]Based on the National Academy of Sciences (2003).

Economic evaluation

Table 6 shows that under the present circumstances (price sets 1 and 2) the H crosses have higher receipts from milk, but under better remuneration for protein and fat (set 4) the J crosses would have higher receipts, reflecting the higher concentration of those components in their milk, while the BS, although improving their receipts under better payment for components would lag behind the other crosses due to their lower yield.

Table 6. Receipts from milk components (in kg milk equivalents per cow per day of herd life) by price set for each breed of sire.

Component	Price set	Breed of sire		
		Holstein	Jersey	Brown Swiss
Protein	1	0.21	0.21	0.19
	2	0.19	0.19	0.17
	3	1.05	1.05	0.97
	4	5.12	5.10	4.73
Fat	1	0.26	0.26	0.24
	2	0.93	0.94	0.85
	3	1.82	1.85	1.67
	4	2.99	3.04	2.75
Carrier	1	6.68	6.29	5.82
	2	6.03	5.68	5.25
	3	4.23	3.98	3.68
	4	-1.27	-1.19	-1.10
Milk	1	7.15	6.76	6.25
	2	7.15	6.81	6.28
	3	7.10	6.87	6.32
	4	6.84	6.94	6.37

1, 2, 3, 4: price sets described in Table 1.

The overall fraction of cows that left the herd that were culled (old) was 0.827 (the remaining 0.173 died). Breed of sire did not significantly affect that fraction ($\chi^2 = 0.73$, $P = 0.70$) nor the reasons for disposal ($\chi^2 = 5.83$, $P = 0.21$). The overall fractions of "reasons for disposal" were: age (0.253), reproduction (0.440), mastitis and udder health (0.147), and other causes (0.160). The overall mean price of cull cows was 3.816 me/kg of live weight. The sire breeds did not significantly differ ($P = 0.38$). Table 7 shows that receipts from culled cows were higher for H than for BS crosses because of the shorter herd life of the former cross, while the J crosses had the smallest receipts for sales of cull cows, both because of lower weight at sale and longer herd life. Higher fertility of the J crosses resulted in more surplus heifers sold compared to the other two breeds of sire, leading to higher receipts, as breed of sire did not affect the mean yearling weight of the progeny. Receipts from bobby calves were negligible.

The costs per day of herd life for different items of expenditures are shown in Table 8 by breed of sire. Feed costs of J cross cows were only 0.94 of the corresponding costs of the H

Table 7. Mean number of animals sold (per cow in her lifetime) and corresponding receipts (in kg milk equivalents per cow per day of herd life) by breed of sire.

Item	Breed of sire					
	Holstein		Jersey		Brown Swiss	
	Number	Receipts me/cow/day	Number	Receipts me/cow/day	Number	Receipts me/cow/day
Cull cows	0.83	0.69	0.83	0.46	0.83	0.57
Surplus heifers	2.33	0.88	3.40	1.15	2.92	1.03
Bobby calves	1.47	0.03	2.60	0.03	2.09	0.03

me = milk equivalent.

cross cows, reflecting the lighter weights maintained by the J cross cows. The J crosses also had lower reproduction costs, due to fewer services per day of herd life. The cost of a replacement heifer was substantially less for the J compared to the H crosses, due to the younger ages at first calving and smaller live weights of the J cross heifers. Because of the greater number of surplus heifers from the J cross the cost of this category was also higher than for the other two crosses but so was the profit from sales of the surplus heifers. Receipts from surplus heifers sold (Table 7) constituted an important source of income, amounting to 0.10 of total receipts for the H cross for the situation represented by price sets 1 and 2 (Table 9) and to 0.13 for the other two crosses.

Table 8. Costs by type of expenditure (in kg milk equivalents per cow per day of herd life) by breed of sire.

Type of expenditure	Breed of sire		
	Holstein	Jersey	Brown Swiss
Concentrates for cows	1.54	1.45	1.34
Roughage/pasture for cows	2.84	2.67	2.93
Milking	0.14	0.14	0.12
Reproduction	0.44	0.23	0.33
Other cow costs	0.58	0.58	0.58
Replacement heifer	1.51	0.97	1.26
Surplus yearling heifers	0.84	1.09	0.98
Total cost	7.89	7.13	7.54

Table 9 shows that an increase in relative prices of fat and protein (price sets 3 and 4,) would result in a reduction in receipts and profit for the H crosses, due to lower concentration of the milk components, while the opposite would occur for the J and BS crosses. However, although the profit for the J crosses would always be higher than the profit for H crosses, ranging from 1.4 to 2.6 times in superiority, depending on the component price, the profit for the BS crosses would always be much lower than for the H crosses.

It should be emphasized that the data from this research correspond to a system of

Table 9. Total receipts and profits by price set (in kg milk equivalents per cow per day of herd life) by breed of sire.

Price set[1]	Breed of sire					
	Holstein		Jersey		Brown Swiss	
	Receipt	Profit	Receipt	Profit	Receipt	Profit
1	8.75	0.86	8.40	1.27	7.88	0.34
2	8.75	0.86	8.45	1.32	7.91	0.37
3	8.70	0.81	8.51	1.39	7.95	0.41
4	8.44	0.55	8.59	1.46	8.00	0.46

[1]Described in Table 1.

artificial rearing of heifer calves and wastage of male calves. Thus, the results should not be extrapolated to the more common system of restricted suckling of both male and female calves in dual-purpose systems. Nonetheless, in the circumstances considered, the J crosses appear to offer important economic benefits to farmers, which would be even greater if payment for production is based on milk protein and fat yields rather than milk yield alone.

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