Use of crossbreeding with beef bulls in dairy herds: Effect on age, body weight, price, and market value of calves sold at livestock auctions

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Use of crossbreeding with beef bulls in dairy herds: Effect on age, body weight, price, and market value of calves sold at livestock auctions[1,2]

R. Dal Zotto,* M. Penasa,* M. De Marchi,*[3] M. Cassandro,* N. López-Villalobos,† and G. Bittante*

*Department of Animal Science, University of Padova, Viale dell'Università 16, 35020 Legnaro (PD), Italy; and †Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11-222, Palmerston North, New Zealand

ABSTRACT: The aim of this study was to investigate the effect of different breeds and breed crosses on age (AC, d), BW (kg), price (PR, $/kg), and market value (MV, $/calf) of purebred and crossbred calves sold for veal and beef production. The Kovieh wholesale cattle organization (Bolzano, Italy) grouped calves from several dairy herds located in the Trentino-Südtirol region in Italy and sold them by public auctions. Data on AC, BW, PR, and MV from 96,458 calves were recorded from January 2003 to December 2007 and consisted of 4 pure breeds [2 dairy, Brown Swiss (BS) and Holstein-Friesian (HF); and 2 dual-purpose, Simmental (SI) and Alpine Grey (AG)], and 8 crossbreds by crosses of Limousin (LI) and Belgian Blue (BB) with the 4 dam breeds. Least squares means for AC, BW, PR, and MV were calculated for breeds and breed crosses with a model that included fixed effects of herd of birth, age (except for AC), sex, and breed of the calf, year and season of auction, and interactions between the main effects. The coefficients of determination of the models were 0.41, 0.51, 0.84, and 0.82 for AC, BW, PR, and MV, respectively. Sex, age, and breed were the most relevant sources of variation for BW ($P < 0.001$), whereas breed and sex were the most important sources of variation for AC, PR, and MV ($P < 0.001$). Also, PR and MV were significantly influenced ($P < 0.01$) by all the effects included in the model, except for season × age interaction in the case of MV. Market value of male was greater ($P < 0.001$) than that of female calves, with the exception of BS (−$28.76/calf) and HF (−$20.70/calf) purebred males. Dual-purpose purebred calves presented greater ($P < 0.001$) PR and MV than dairy purebreds (MV of $426.97/calf and $307.96/calf for SI and AG, and $256.24/calf and $275.65/calf for BS and HF, respectively). Calves from SI and AG dams had greater ($P < 0.001$) BW, PR, and MV than calves from BS and HF dams. Calves from SI cows had greater ($P < 0.001$) BW, PR, and MV than calves from AG cows. Crossbreeding with beef bulls increased ($P < 0.001$) BW, PR, and MV of calves from dairy and dual-purpose dams. Crossbreeding with BB bulls increased PR (+$2.58 ± 0.04/kg; $P < 0.001$) and MV (+$190.84 ± 3.62/calf; $P < 0.001$) of calves much more than LI. The use of beef bull semen on dairy herds resulted in an economic revenue from selling crossbred calves.

Key words: beef and dairy breed, Belgian Blue, body weight, calf, crossbreeding, market value

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INTRODUCTION

One reason for crossbreeding is to combine favorable attributes of 2 or more breeds that are genetically different from each other but have complementary qualities (Cartwright, 1970). A common practice by farmers in the Alps is the use of beef bulls for mating dairy cows not used to breed replacements for the herd (25 to 30% of cows). This practice has been decreasing in the more specialized herds because of fertility (Dal Zotto et al., 2007) and longevity (Boettcher, 2005) problems, but in the near future it will be increased by the use of sexed semen (Hohenboken, 1999; Cerchiaro et al., 2007).

[1]The authors thank the Kovieh Cooperative of Bolzano (Italy) for providing the data used in this study and the Trento province for funding the research. The useful comments and suggestions provided by the associate editor and 2 anonymous reviewers are gratefully acknowledged.

[2]Dedicated to our friend and author Riccardo Dal Zotto, an inspiring researcher who passed away on February 11, 2009.

[3]Corresponding author: massimo.demarchi@unipd.it

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Crossbreeding between dairy and beef cattle breeds has been investigated by several authors in the past (Cundiff, 1970; Nelson et al., 1982), and more recently, there has been a major research on this subject in the United States (Cundiff et al., 2001). In a recent study, Wolfová et al. (2007) confirmed that carcasses from beef × dairy crosses were much more valuable than carcasses from purebred dairy animals. Moreover, crossbreds showed better eating characteristics of the meat (Davies et al., 1992) and greater dressing percentage (Güngör et al., 2003) than purebreds.

In the Trentino-Südtirol region (northeast Italy), the majority of purebred and crossbred calves from dairy herds are sold at about 3 wk of age by a wholesale cattle organization that carries out public auctions (about 500 calves/wk). Purebred calves from dairy breeds [mainly Brown Swiss (**BS**) and Holstein-Friesian (**HF**)] are destined to veal production (Cozzi, 2007). These animals are fed a milk replacer and a small amount of roughage and are slaughtered at 5 to 6 mo of age. On the contrary, the majority of the purebred dual-purpose [mainly Simmental (**SI**) and Alpine Grey (**AG**)] and crossbred calves are destined to beef production as young intact bulls and heifers using high concentrate diets.

The objective of this study was to compare the effect of different breeds and breed crosses on age at auction (**AC**, d), BW (kg), price (**PR**, $/kg), and market value (**MV**, $/calf) of purebred and crossbred calves sold for veal and beef production.

MATERIALS AND METHODS

Animal Care and Use Committee approval was not obtained for this study because the data were from an existing database. The analyzed records were registered by the Kovieh Cooperative during public livestock auctions in Bolzano (Italy) from January 2003 to December 2007. The authors did not have direct control over the care of the animals included in this study.

Data

Data were provided by Kovieh, a wholesale cattle organization located in Bolzano province (Italy) close to the Austrian border. Information available was AC (d), BW (kg), PR ($/kg), and MV ($/calf) from 4 pure breeds, BS, HF, SI, and AG, and 8 crossbred types derived from mating the 4 dam breeds (BS, HF, SI, and AG) with 2 sire beef breeds, Limousin (**LI**) and Belgian Blue (**BB**). According to the European Union legislation, every animal is provided with a passport since birth, and information on sire and dam is registered. Only calves with registered breeds of sire and dam, AC between 7 and 50 d, and BW between 29 and 126 kg have been considered. After editing of the data set as above, 96,458 calves sold during 239 weekly auctions from January 2003 to December 2007 were analyzed.

Statistical Analysis

An ANOVA was performed on AC, BW, PR, and MV with the GLM procedure (SAS Inst. Inc., Cary, NC) using the following linear model:

$$\begin{aligned} y_{ijklmno} = \mu + herd_i + year_j + season_k + sex_l + age_m \\ + breed_n + (breed_n \times sex_l) + (breed_n \times year_j) \\ + (breed_n \times season_k) + (breed_n \times age_m) \\ + (sex_l \times year_j) + (sex_l \times season_k) + (sex_l \times age_m) \\ + (year_j \times season_k) + (year_j \times age_m) \\ + (season_k \times age_m) + e_{ijklmno}, \end{aligned}$$

where $y_{ijklmno}$ is observation ijklmno for AC, BW, PR, or MV; μ is the overall mean; $herd_i$ is the fixed effect of the ith herd of birth of the calf (i = 1 to 8,634); $year_j$ is the fixed effect of the jth year of auction (j = 2003 to 2007); $season_k$ is the fixed effect of the kth season of auction (k = spring, summer, autumn, winter); sex_l is the fixed effect of the lth sex of the calf (l = female and intact male); age_m is the fixed effect of the mth class of age of calf at auction (young: 7 to 15 d; intermediate: 16 to 31 d; and old: 32 to 50 d); $breed_n$ is the fixed effect of the nth breed (n = BS, HF, SI, AG, LI×BS, LI×HF, LI×SI, LI×AG, BB×BS, BB×HF, BB×SI, BB×AG); and $e_{ijklmno}$ is the random residual associated with observation ijklmno. Also, first-order interactions between the main effects were considered. Random residuals were assumed to be identically, independently, and normally distributed with mean zero and variance, σ_e^2. The effect of age at auction was not included in the analysis of AC. A multiple comparison of means was performed for the main effect of breed, using Bonferroni's test ($P < 0.05$).

Contrast estimates (±SE) for AC, BW, PR, and MV within sire and dam breeds, and their interactions were obtained, and a 5% level was referred to for testing if estimates were significantly different.

RESULTS AND DISCUSSION

The number of calves from different breeds and breed crosses sold at weekly auctions are displayed in Table 1. Purebred calves represented 62.9% of the total data set and ranged from 10% (9,610 animals) for AG to 27.1% (26,133 animals) for BS. The number of calves sired by beef bulls represented the remaining 37.1% and varied from 3.8% for AG to 18.1% for BS cows, reflecting the different use of crossbreeding by farmers of the different breeds of cows. The number of calves sired by LI bulls was always less than the number of calves sired by BB bulls. This is particularly true in the case of SI dams, with 285 calves sired by LI and 7,990 by BB bulls.

Results from the ANOVA are summarized in Table 2. The coefficients of determination were 0.41, 0.51, 0.84,

Table 1. Number of calves[1] of different breeds and breed crosses[2] sold at auctions

	Dam breed			
Sire breed	BS	HF	SI	AG
BS	26,133			
HF		10,395		
SI			14,516	
AG				9,610
LI	1,563	526	285	285
BB	15,929	5,845	7,990	3,381

[1]100% = 96,458 calves.
[2]BS = Brown Swiss; HF = Holstein-Friesian; SI = Simmental; AG = Alpine Grey; LI = Limousin; BB = Belgian Blue.

and 0.82 for AC, BW, PR, and MV, respectively. All the main effects included in the model significantly explained the variability of the 4 traits ($P < 0.001$). The 2 genetic effects (breed and sex) were the most important with the addition of age for BW. Also, the main effects of year and season were relevant in explaining the variability for PR and MV. Due to the high number of data analyzed, the majority of the interactions were highly significant ($P < 0.001$). Among them, breed × sex was the most important for all the traits and is discussed.

Age of calves at auction varied, on average, from 23 d for BB×BS and LI×BS to 26 d for AG calves (Figure 1); BW ranged from 61 kg for HF to 69 kg for BB×BS and BB×SI (Figure 2); PR from \$3.93/kg for BS to \$9.51/kg for BB×SI (Figure 3); and MV from \$256.24/calf for BS to \$662.39/calf for BB×SI (Figure 4). Dual-purpose purebred calves showed greater ($P < 0.05$) PR and MV than dairy purebreds. Market values were \$256.24/calf and \$275.65/calf for BS and HF, and \$426.97/calf and \$307.96/calf for SI and AG, respectively. The greater MV for SI compared with the other pure calves (Figure 4) was not only due to the more favorable PR but also to the greater ($P < 0.05$) BW reached by SI animals. Also, SI calves exceeded the average MV of BS and HF by \$161.02/calf. This advantage can counterbalance a decreased milk production of 358 kg in terms of income (\$0.45/kg was the price of milk in Italy during the period of the study). In terms of income over feed costs, the amount of milk counterbalanced would probably be more than double taking into account the reduction in feed requirements, especially in terms of concentrate consumption. In the case of the AG breed, the superiority of its calves for MV is much less pronounced than that of the SI breed. Nevertheless, for a correct comparison with specialized dairy breeds from the technical and economical point of view, it is necessary to consider that the AG cows are much lighter than those of the other 3 breeds; this leads to more cows, calves, and lactations per hectare of cultivated land (Bittante et al., 2005). The greater fertility and longevity of the dual-purpose and BS breeds with respect to HF is responsible for a reduced replacement rate with the opportunity to mate a substantial number of cows with beef bulls. Thus, crossbreeding with beef bulls can further counterbalance a significant part of the greater amount of milk produced by HF cows.

Crossbred calves had a younger AC (-1.45 ± 0.12 d; $P < 0.001$) and greater BW ($+3.96 \pm 0.16$ kg; $P < 0.001$), PR ($+\$2.65 \pm 0.03$/kg; $P < 0.001$), and MV ($+\$192.98 \pm 2.04$/calf; $P < 0.001$) than purebreds, and among crossbred combinations those from BB were significantly superior than those from LI sires for AC (-0.65 ± 0.21 d; $P < 0.01$), BW ($+2.66 \pm 0.28$ kg;

Table 2. Results from ANOVA for age at auction (AC, d), BW (kg), price (PR, \$/kg), and market value (MV, \$/calf)

		Trait							
		AC		BW		PR		MV	
Effect	df	*F*-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value	*F*-value	*P*-value
Herd	8,633	6.43	<0.001	5.91	<0.001	1.88	<0.001	3.48	<0.001
Year	4	31.35	<0.001	16.19	<0.001	285.39	<0.001	216.95	<0.001
Season	3	13.68	<0.001	45.14	<0.001	210.62	<0.001	207.53	<0.001
Sex	1	202.11	<0.001	957.64	<0.001	1,496.47	<0.001	2,194.06	<0.001
Age	2	—	—	450.51	<0.001	124.31	<0.001	13.11	<0.001
Breed	11	66.14	<0.001	343.97	<0.001	6,665.37	<0.001	5,509.82	<0.001
Breed × sex	11	21.18	<0.001	13.45	<0.001	273.94	<0.001	263.96	<0.001
Breed × year	44	1.63	0.005	2.79	<0.001	55.24	<0.001	53.96	<0.001
Breed × season	33	3.25	<0.001	3.28	<0.001	39.21	<0.001	16.63	<0.001
Breed × age	22	—	—	8.26	<0.001	12.32	<0.001	7.39	<0.001
Sex × year	4	0.78	0.537	1.07	0.368	131.89	<0.001	86.76	<0.001
Sex × season	3	2.21	0.084	1.48	0.216	14.68	<0.001	8.08	<0.001
Sex × age	2	—	—	5.84	0.003	18.96	<0.001	17.87	<0.001
Year × season	12	9.81	<0.001	6.65	<0.001	248.52	<0.001	156.54	<0.001
Year × age	8	—	—	3.74	<0.001	3.24	0.001	4.91	<0.001
Season × age	6	—	—	4.17	<0.001	3.01	0.006	1.98	0.064
R^2		0.41		0.51		0.84		0.82	
RMSE[1]		6.87		7.21		1.14		91.83	

[1]RMSE = root mean square error.

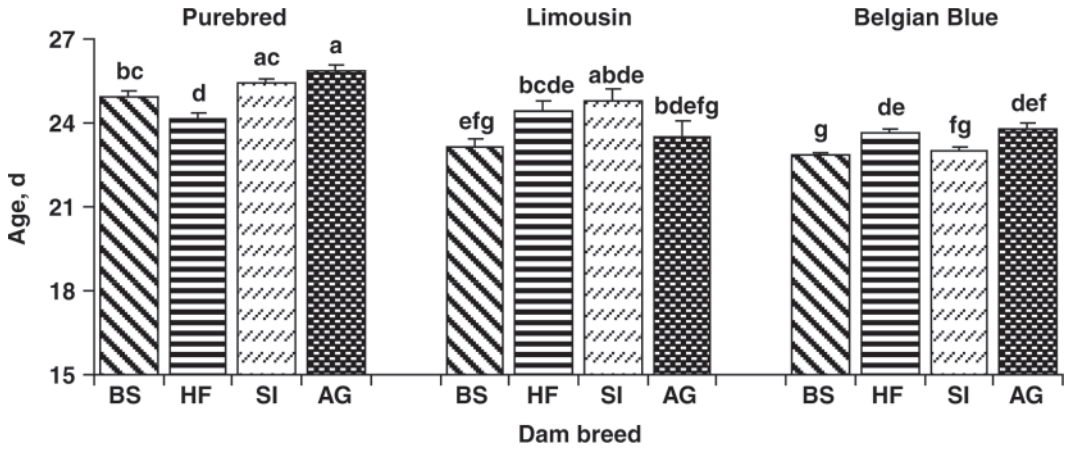

Figure 1. Least squares means (with SE) of age at auction (d) of calves of different breeds and breed crosses (BS = Brown Swiss; HF = Holstein-Friesian; SI = Simmental; AG = Alpine Grey). [a–g]Least squares means with different letters differ ($P < 0.05$).

$P < 0.001$), PR (+\$2.58 ± 0.04/kg; $P < 0.001$), and MV (+\$190.84 ± 3.62/calf; $P < 0.001$; Table 3). In a recent study, Barham and Troxel (2007) reported that the breed effect was highly significant in explaining the selling price of feeder cattle sold at Arkansas auctions, and a difference of \$33.28 per 45.45 kg was found between the highest (Hereford × Charolais) and the lowest (Longhorn) price.

The impact of the 2 beef breeds on MV of crossbred calves is displayed in Figure 5. The use of LI semen on BS and AG dams increased the value of crossbreds by nearly \$126. For LI×SI the value was slightly greater (+\$30.18) than SI purebreds. As reported by Comerford et al. (1987) the LI breed tended to have calves with less calving difficulty and greater survival rates than other breeds combinations. Recently, the use of BB semen has exceeded that of LI because the double muscling of the breed is responsible for yielding well-conformed carcasses with reduced fat content (Hanset et al., 1987; Uytterhaegen et al., 1994). On average, the value of BB-sired calves was \$190.84 greater than LI-sired calves and \$288.40 greater than purebred calves. When compared with the purebred counterparts, the use of BB bulls on BS and AG cows enhanced the value of crossbreds \$324.06 and \$321.20, respectively, and \$272.92 when used on HF dams. Also, BB×SI crossbreds largely exceeded SI purebred calves (+\$235.42, i.e., much more than LI×SI calves). In general, with both the beef breeds the beneficial effect of crossbreeding from the economical point of view was maximum with BS and AG and minimum with the SI cows. It is possible that crossbreeding the dairy breeds, especially with BB, increased the proportion of calves weaned and fattened for beef production vs. veal, whereas this cannot be done in the case of SI because the purebred and crossbred calves are used for beef and not for veal.

Calves from the 2 dual-purpose dam breeds (SI and AG) performed better than those from the 2 specialized dairy dam breeds (BS and HF) for BW (+1.09 ± 0.23 kg; $P < 0.001$), PR (+\$1.16 ± 0.04/kg; $P < 0.001$), and MV (+\$80.89 ± 2.88/calf; $P < 0.001$; Table 3). Brown Swiss and HF produced calves with comparable PR and MV ($P > 0.05$). Nevertheless, calves from BS had less AC (−0.42 ± 0.18 d; $P < 0.05$) and greater BW (+1.00 ± 0.21 kg; $P < 0.001$) than those from HF dams. Simmental breed produced calves heavier (+2.09 ± 0.38 kg; $P < 0.001$) and with greater PR (+\$0.72 ± 0.06/kg; $P < 0.001$) and MV (+\$59.40 ± 4.80/calf; $P <$

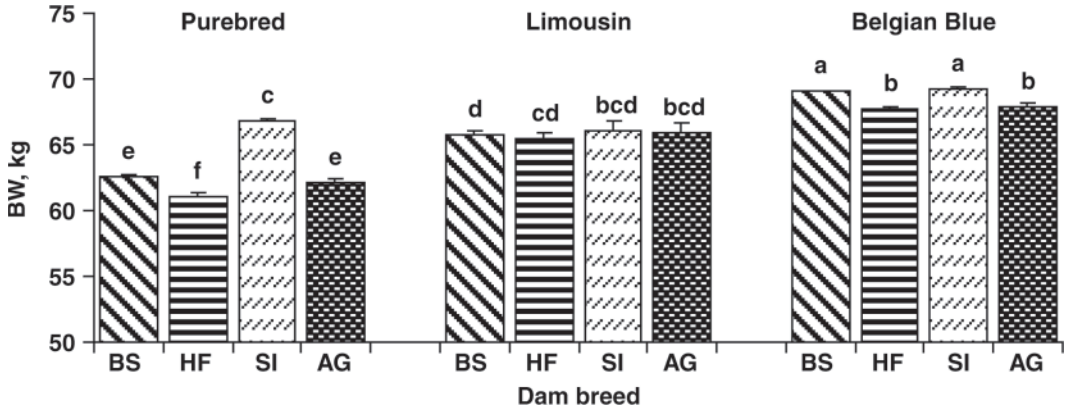

Figure 2. Least squares means (with SE) of BW (kg) of calves of different breeds and breed crosses (BS = Brown Swiss; HF = Holstein-Friesian; SI = Simmental; AG = Alpine Grey). [a–f]Least squares means with different letters differ ($P < 0.05$).

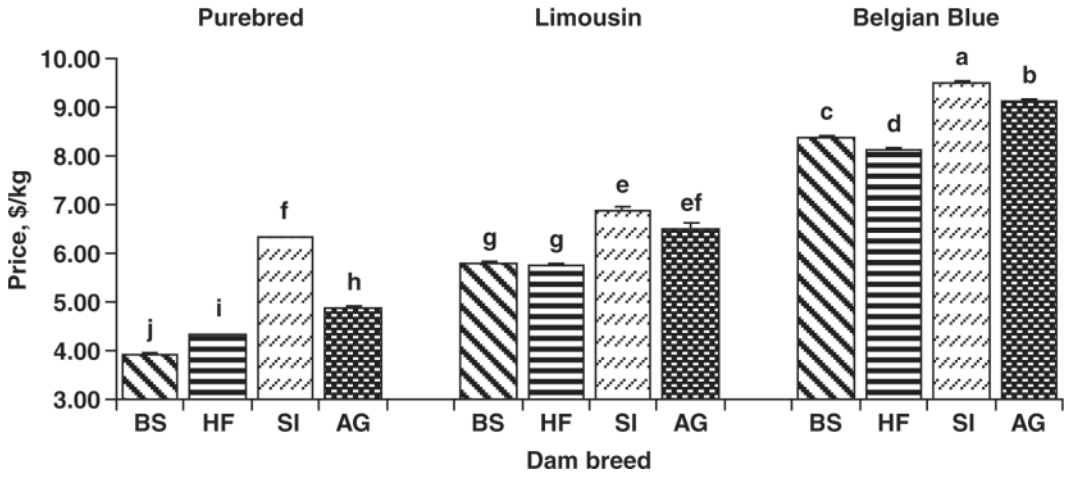

Figure 3. Least squares means (with SE) of price ($/kg) of calves of different breeds and breed crosses (BS = Brown Swiss; HF = Holstein-Friesian; SI = Simmental; AG = Alpine Grey). [a–j]Least squares means with different letters differ ($P < 0.05$).

0.001) than those from AG dams. In general, these results confirmed that dual-purpose cows produced calves with better commercial values than specialized dairy cows because of heavier calves and particularly greater price achieved at auction (Bittante et al., 2005). Also, this increase in value depends on the fact that the majority of dual-purpose calves are weaned and used for beef production, whereas dairy calves are almost all used for veal production.

Interactions between the sire and dam breeds (Table 3) showed that crossbreeding with beef bulls reduced differences between calves from dairy and dual-purpose dams. Even if purebred BS calves presented greater AC and BW and less PR and MV than purebred HF (Figures 1 to 4), crossbred calves from BS cows presented less AC and greater PR and MV than those from HF. Whereas purebred SI calves are characterized by superior BW, PR, and MV than AG (Figures 2 to 4), in the case of crossbred calves the differences between the 2 dual-purpose dam breeds are less pronounced. The superiority of crossbred calves from dual-purpose respect to those from dairy dams was more pronounced for BB-sired than LI-sired calves in the case of MV. The superiority of crossbred calves from BS compared with HF dams was more pronounced for BB-sired than LI-sired calves for BW, PR, and MV. Finally, the breed of sire showed significant interactions with the 2 dual-purpose breeds only in the case of AC.

Table 3. Contrast estimates (est.) ± SE within sire and dam breeds and their interactions for age at auction (AC, d), BW (kg), price (PR, $/kg), and market value (MV, $/calf)

	Trait, est. ± SE			
Contrast	AC	BW	PR	MV
Sire breeds				
[1] PB[1] vs. (LI+BB)[2]	1.45 ± 0.12***	−3.96 ± 0.16***	−2.65 ± 0.03***	−192.98 ± 2.04***
[2] LI vs. BB[3]	0.65 ± 0.21**	−2.66 ± 0.28***	−2.58 ± 0.04***	−190.84 ± 3.62***
Dam breeds				
[3] (BS+HF) vs. (SI+AG)[4]	−0.53 ± 0.18**	−1.09 ± 0.23***	−1.16 ± 0.04***	−80.89 ± 2.88***
[4] BS vs. HF[5]	−0.42 ± 0.18*	1.00 ± 0.21***	−0.02 ± 0.03	4.91 ± 2.68
[5] SI vs. AG[6]	−0.01 ± 0.29	2.09 ± 0.38***	0.72 ± 0.06***	59.40 ± 4.80***
Sire × dam breeds				
[1] × [3]	−0.41 ± 0.12***	−1.19 ± 0.16***	−0.23 ± 0.03***	−15.47 ± 2.02***
[1] × [4]	0.92 ± 0.14***	0.31 ± 0.17	−0.27 ± 0.03***	−18.24 ± 2.17***
[1] × [5]	−0.35 ± 0.19	1.95 ± 0.27***	0.54 ± 0.04***	44.70 ± 3.38***
[2] × [3]	−0.09 ± 0.21	−0.09 ± 0.28	0.07 ± 0.04	10.77 ± 3.59**
[2] × [4]	−0.23 ± 0.21	−0.54 ± 0.27*	−0.12 ± 0.04**	−14.66 ± 3.38***
[2] × [5]	1.01 ± 0.35**	−0.57 ± 0.49	−0.01 ± 0.08	−3.63 ± 6.28

[1]PB = purebred calves.
[2]PB vs. (LI+BB) = contrast between purebred and crossbred calves. LI = Limousin; BB = Belgian Blue.
[3]LI vs. BB = contrast between crossbred calves from the 2 beef breeds.
[4](BS+HF) vs. (SI+AG) = contrast between calves from dairy and dual-purpose dams. BS = Brown Swiss; HF = Holstein-Friesian; SI = Simmental; AG = Alpine Grey.
[5]BS vs. HF = contrast between calves from dairy dams.
[6]SI vs. AG = contrast between calves from dual-purpose dams.
*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

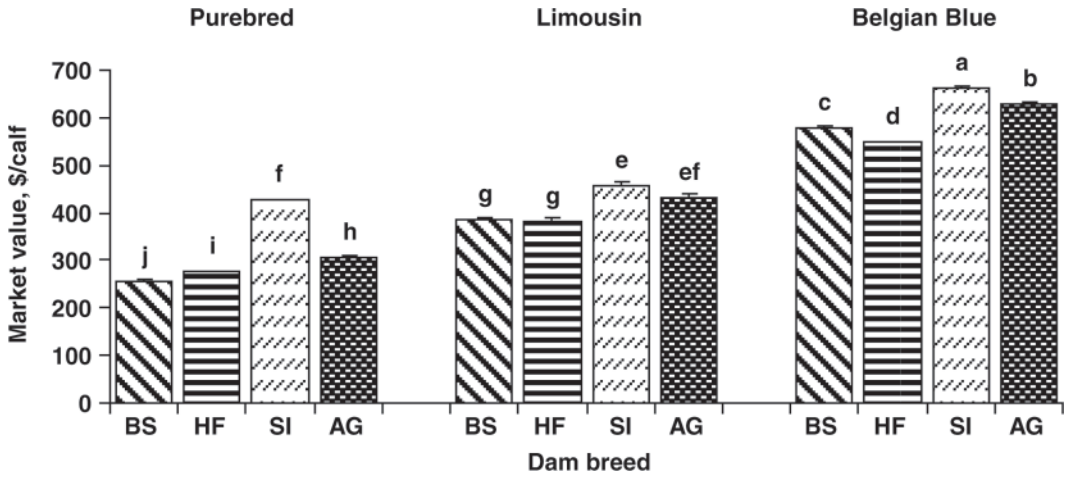

Figure 4. Least squares means (with SE) of market value ($/calf) of calves of different breeds and breed crosses (BS = Brown Swiss; HF = Holstein-Friesian; SI = Simmental; AG = Alpine Grey). [a–j]Least squares means with different letters differ ($P < 0.05$).

The sex effect showed that male calves were younger at auction (−1.85 ± 0.13 d; $P < 0.001$) and had greater BW (+4.49 ± 0.15 kg; $P < 0.001$), PR (+$0.89 ± 0.02/kg; $P < 0.001$), and MV (+$86.61 ± 1.85/calf; $P < 0.001$) than female calves. Figure 6 illustrates the interaction between sex and breed of calves for MV. In the case of purebred calves from the 2 specialized dairy breeds, the average value of males was slightly less than females (−$28.76/calf and −$20.70/calf for BS and HF, respectively). This seemed to be due to a negligible sex effect for calves destined to veal production, considering that animals are slaughtered at 5 to 6 mo of age (i.e., before they reach the puberty). Moreover, it is possible that part of the purebred heifer calves was bought by dairy farmers for replacements and not for beef production. In all other cases, male exceeded female calves from $77.56 (LI × BS) to $141.58 (LI × SI). Although sex has a strong impact on MV of purebred and LI-sired calves, the superiority of males in BB-sired calves is not largely influenced by the breed of the dam. Barham and Troxel (2007) highlighted a significant influence of calf sex in determining the selling price, and a difference of $5.12 per 45.45 kg was found between bulls and heifers. However, these differences were less than those reported in our study for purebred dual-purpose and crossbred calves.

In conclusion, purebred calves from dual-purpose breeds obtained greater PR and MV than purebred calves from dairy breeds. Thus, they contributed positively to the farm income. Holstein-Friesian showed greater PR and MV than BS calves. Simmental exhibited superior BW, PR, and MV than AG calves, but it should be considered that cows of the latter breed are lighter than cows of the former. Crossbreeding with LI bulls increased BW, PR, and MV of calves from dairy and AG breeds, but had less impact on SI cows. Crossbreeding with BB bulls increased PR and MV of calves of dairy and dual-purpose breeds much more than LI bulls. The greatest increase in MV was produced when BB semen was used on BS and AG cows and the least when used on SI cows. Market value of male was greater than that of female calves with the exception of purebred dairy calves. Results highlighted that breed complementarity (Cartwright, 1970) occurred and the use of crossbreeding on cows not used to breed replacements in dairy herds can result in greater

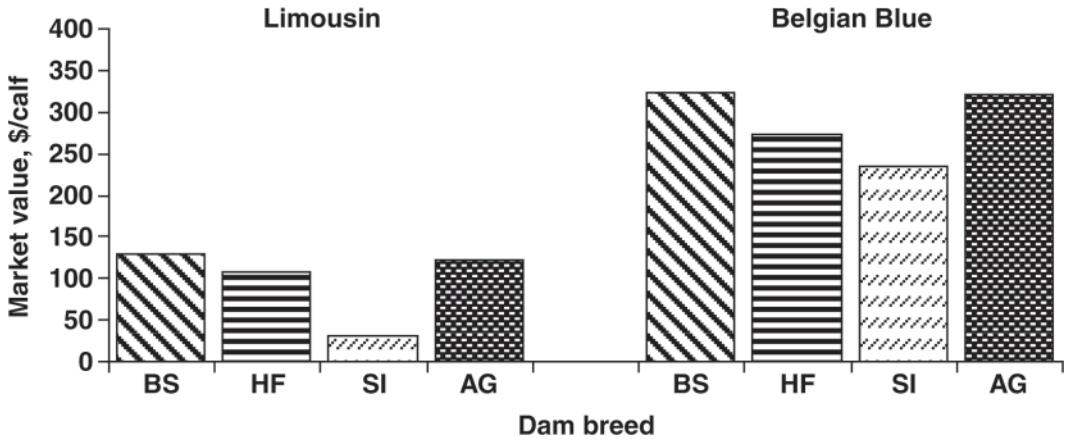

Figure 5. Increase of market value ($/calf) of crossbred with respect to purebred calves (BS = Brown Swiss; HF = Holstein-Friesian; SI = Simmental; AG = Alpine Grey).

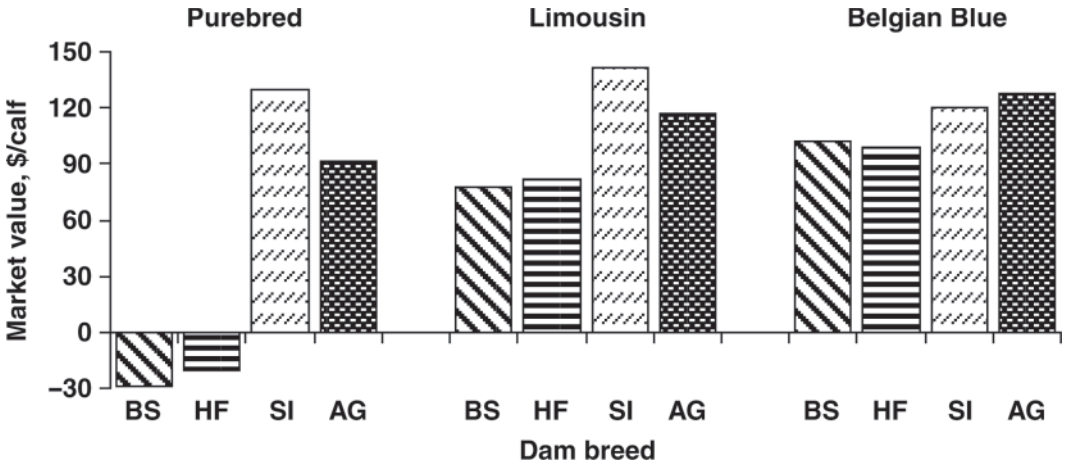

Figure 6. Average differences between the market value ($/calf) of male and female calves of different breeds and breed crosses (BS = Brown Swiss; HF = Holstein-Friesian; SI = Simmental; AG = Alpine Grey). Within each breed and breed cross, the market value of male calves differs significantly ($P < 0.001$) from zero.

economic revenue from selling crossbred calves. In the more specialized dairy herds, the use of crossbreeding has been decreasing because of fertility and longevity problems. However, this practice is expected to become more popular in the next years because there is an increasing interest in the use of sexed semen among dairy producers. This perspective would lead to more dairy cows available for mating with beef bulls.

LITERATURE CITED

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