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Postweaning growth and carcass traits in crossbred cattle from Hereford, Angus, Brangus, Beefmaster, Bonsmara, and Romosinuano maternal grandsires[1,2]

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ABSTRACT: The objective of this study was to characterize breeds representing diverse biological types for postweaning growth and carcass composition traits in terminal crossbred cattle. Postweaning growth and carcass traits were analyzed on 464 steers and 439 heifers obtained by mating F_1 cows to Charolais and MARC III (1/4 Hereford, 1/4 Angus, 1/4 Pinzgauer, and 1/4 Red Poll) sires. The F_1 cows were obtained from mating Angus and MARC III dams to Hereford, Angus, Beefmaster, Brangus, Bonsmara, and Romosinuano sires. Traits evaluated were postweaning ADG, slaughter weight, HCW, dressing percentage, percentage of carcasses classified as USDA Choice, LM area, marbling score, USDA yield grade, fat thickness, retail product yield (percentage), and retail product weight. Maternal grandsire breed was significant ($P < 0.05$) for all traits. Animals with Angus grandsires grew faster and had the heaviest carcasses, with the greatest percentage of carcasses classified as USDA Choice and the greatest marbling scores when compared with other grandsire breeds. Animals with Romosinuano and Bonsmara inheritance grew slower, had the lightest weights at slaughter, the lightest carcass weights, the least percentage of carcasses classified as USDA Choice, and the least amount of marbling and fat thickness. Animals with inheritance from these 2 breeds had a more desirable yield grade with the greatest retail product yield. Maternal granddam breed was significant ($P < 0.05$) for marbling score, USDA yield grade, fat thickness, and retail product yield. Sex class was significant ($P < 0.05$) for all traits except for retail product yield. Steers grew faster, were heavier, had heavier carcasses, and were leaner than heifers. Heifers had a greater dressing percentage, a greater percentage of carcasses classified as USDA Choice, a greater LM area, and a decreased yield grade when compared with steers. Sire and grandsire breed effects can be optimized by selection and use of appropriate crossbreeding systems.

Key words: beef cattle, breed, carcass composition, growth

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INTRODUCTION

The Germplasm Evaluation (**GPE**) program at the US Meat Animal Research Center characterizes breeds representing several biological types of cattle. In this program, postweaning growth (Cundiff et al., 1981, 1984), carcass composition, and meat quality traits (Wheeler et al., 2001, 2004, 2005a) have been evaluated in F_1 animals. Casas and Cundiff (2003, 2006) evaluated postweaning growth and carcass composition in the terminal cross from Cycles V and VI of the GPE program.

The eighth cycle of this program (Cycle VIII), included 1 Sanga-influenced breed (Bonsmara), 1 breed of *Bos taurus* descent adapted to tropical and subtropical conditions (Romosinuano), and 2 breeds with *Bos taurus* and *Bos indicus* inheritance (Beefmaster and Brangus). Carcass composition and meat quality traits have been evaluated in the F_1 generation from this cycle (Wheeler et al., 2005b). Evaluation of postweaning growth and carcass composition traits is important in establishing the potential value of alternative germplasm resources in the beef industry; however, evaluation of postweaning growth and carcass traits in the terminal cross is needed. The objective of this study was to characterize breeds representing diverse biological types for postweaning growth and carcass composition traits in terminal crossbred cattle.

[1]Mention of trade name, proprietary product, or specified equipment does not constitute a guarantee or warranty by the USDA and does not imply approval to the exclusion of other products that may be suitable.

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Table 1. Number of offspring produced by crossbred dam and sire breed in each year

	Sire breed						
	Charolais			MARC III			
Dam breed[1]	2004	2005	2006	2004	2005	2006	Total
Hereford × Angus	20	33	34	17	0	0	104
Hereford × MARC III	21	38	32	17	0	0	108
Angus × MARC III	34	78	70	38	0	0	220
Brangus × Angus	2	10	12	8	0	0	32
Brangus × MARC III	22	27	25	6	0	0	80
Beefmaster × Angus	11	16	17	8	0	0	52
Beefmaster × MARC III	15	24	22	12	0	0	73
Bonsmara × Angus	7	21	20	13	0	0	61
Bonsmara × MARC III	6	17	18	8	0	0	49
Romosinuano × Angus	7	16	15	9	0	0	47
Romosinuano × MARC III	14	27	26	10	0	0	77
Total	159	307	291	146	0	0	903

[1]MARC III = 1/4 Hereford, 1/4 Angus, 1/4 Red Poll, and 1/4 Pinzgauer.

MATERIALS AND METHODS

Experimental procedures were approved and performed in accordance with US Meat Animal Research Center Animal Care Guidelines and the Guide for Care and Use of Agricultural Animals in Research and Teaching (FASS, 1999).

Animals

Animals for this study were produced by F_1 cows from Cycle VIII of the GPE program. The F_1 cows were produced by Angus and MARC III (1/4 Hereford, 1/4 Angus, 1/4 Pinzgauer, and 1/4 Red Poll) mature dams, mated by AI to Hereford, Angus, Brangus, Beefmaster, Bonsmara, and Romosinuano sires. No purebred Angus matings were made. Mature cows obtained from these crosses were mated to Charolais sires during 3 consecutive years (2003, 2004, and 2005) and to MARC III sires in 2003. Matings were made by natural service in multiple-sire herds. Cows were run in 2 separate breeding pastures each year. Sires were randomly allocated to pastures (8 sires per pasture). Individual sires of progeny were unidentified. Therefore, this mating scheme assumes that the progeny per sire and the genetic merit of the sires were similar.

Offspring were born during the spring of 2004 (n = 305), 2005 (n = 307), and 2006 (n = 291). Table 1 shows the number of animals born by breed group and year. Male calves were castrated within 24 h of birth. Calves were creep-fed whole oats from early July or early August until weaning in early September. Calves were weaned in mid-September at an average age of 163 ± 18 d. After an adjustment period of approximately 30 d, steers and heifers were randomly assigned to pens and fed for 286 ± 28 d. Steers were assigned to pens with only steers, and heifers were assigned to pens with only heifers. The growing diet fed from weaning until calves weighed approximately 320 kg included corn silage, corn, and urea-based liquid supplement containing approximately 2.7 Mcal of ME/kg of DM and 12.5% CP. The finishing diet fed from approximately 320 kg to slaughter contained approximately 3.05 Mcal of ME/kg of DM and 13.1% CP. Animals were slaughtered during the summers of 2005, 2006, and 2007 in a commercial beef processing plant. In 2005, steers and heifers were slaughtered on June 1 and June 8. In 2006, steers were slaughtered on June 17 and heifers on June 22. In 2007, steers were slaughtered on June 25 and heifers on August 7.

Traits

Traits analyzed for growth included postweaning ADG (kg/d) and slaughter weight (kg). Carcass traits analyzed were HCW, dressing percentage, percentage of carcasses graded as USDA Choice, LM area, marbling score, USDA yield grade, fat thickness (cm), retail product yield (percentage), and retail product weight (kg). Marbling score was evaluated on a cross section of the LM at the 12th- to 13th-rib interface as follows: Practically Devoid = 200 to 299; Traces = 300 to 399; Slight = 400 to 499; Small = 500 to 599; Modest = 600 to 699; Moderate = 700 to 799; Slightly Abundant = 800 to 899; Moderately Abundant = 900 to 999; and Abundant = 1,000 to 1,099 (USDA, 1997). Retail product percentage was estimated using the prediction equations that included carcass yield grade traits (LM area, fat thickness, and estimated KPH) and marbling score (Shackelford et al., 1995). Table 2 shows the number of observations for each trait and the mean and SD for the analyzed traits.

Statistical Analysis

Data were analyzed with the MIXED model procedure (SAS Inst. Inc., Cary, NC). The model included the fixed effects of maternal grandsire breed (Hereford, Angus, Beefmaster, Brangus, Bonsmara, and Romosinuano), maternal granddam breed (Angus and MARC

Table 2. Number of observations, mean, and SD for the traits studied

Trait	Number of animals	Mean	SD	Minimum	Maximum
Postweaning ADG, kg/d	903	1.30	0.18	0.82	1.91
Slaughter weight, kg	903	577	62	428	791
HCW, kg	903	352	38	254	485
Dressing percentage, %	903	61.0	1.7	50.7	67.4
USDA Choice, %	903	61.6	48.7	0.0	1.0
LM area, cm^2	765	83.4	8.2	63.2	122.6
Marbling score[1]	765	509	74	210	770
USDA yield grade	903	2.03	1.08	0.00	4.00
Fat thickness, cm	765	1.15	0.42	0.25	2.74
Retail product yield, %	765	64.2	3.6	52.5	75.4
Retail product weight, kg	765	228	28	161	335

[1]Marbling score: 400 = $slight^{00}$; 500 = $small^{00}$.

III), sex class (steers and heifers), and contemporary group. A contemporary group was defined as a group of calves fed in the same pen and slaughtered on the same day. There were 6 contemporary groups (2 in 2004, 2 in 2005, and 2 in 2006) with an average of 150 calves per group. The model also included 2-way interactions of maternal grandsire breed by sex and maternal granddam breed by sex. The random effects of maternal grandsire within maternal grandsire breed, and dam within maternal grand sire were included in the model. The grandsire breed × granddam breed interaction was nonestimable because no matings of Angus sires with Angus cows were made. To account for this effect, the proportion of expected maternal heterosis was included. Age at weaning was included in the model as a covariate for all traits. The Kenward-Rogers option of the MIXED procedure of SAS was used to ascertain degrees of freedom. Least squares means and probability values for differences were estimated for significant effects. Probability values were corrected for multiple testing. A Bonferroni adjustment was applied to the probability values using a factor of 11, which is the number of traits analyzed.

RESULTS

Levels of significance, least squares means, and SE of the means are reported in Tables 3, 4, and 5 for the effects of maternal grandsire breed, maternal granddam breed, and sex. Contemporary group was significant for all traits except for marbling score. No interactions were significant for any of the analyzed traits.

Maternal Grandsire Breed

Grandsire breed effect was significant for all traits ($P < 0.05$). Animals with Brangus, Angus, and Hereford maternal grandsires grew faster than animals with Beefmaster, Bonsmara, and Romosinuano maternal grandsires. At slaughter, animals with Hereford, Brangus, Angus, and Beefmaster maternal grandsires were heavier when compared with animals with Bonsmara, and Romosinuano maternal grandsires. Animals with Brangus maternal grandsires had the heaviest carcass, and animals with Bonsmara and Romosinuano inheritance had the lightest carcasses. Animals with Angus maternal grandsires had carcasses as heavy as Brangus and similar to Hereford and Beefmaster. Animals with Brangus inheritance had greater dressing percentages than all other animals except those with Bonsmara inheritance. Animals with Angus and Hereford maternal grandsires had the greatest percentage of carcasses classified as USDA Choice. Animals with Brangus inheritance had greater LM area than all animals except those with Bonsmara inheritance. Animals with Hereford and Beefmaster maternal grandsires had smaller LM area than all animals, except those with Romosinuano inheritance. Animals with Angus maternal grandsires had the greatest marbling score, whereas animals with Romosinuano and Bonsmara inheritance had less marbling scores than animals with Hereford inheritance. Animals with Romosinuano and Bonsmara inheritance had the least numerical yield grades (greatest yields). Animals with Angus maternal grandsires had greater numerical yield grades than Brangus. Animals with Romosinuano and Bonsmara inheritance were leaner when compared with the other maternal grandsire breeds. Animals with Angus maternal grandsires had greater fat thickness than Hereford. Animals with Romosinuano inheritance had greater retail product yield than all other animals except Bonsmara, and animals with Angus maternal grandsires had the least retail product yield. Animals with Brangus inheritance had the largest retail product weight when compared with the other maternal grandsire breeds. In general, animals with Romosinuano and Bonsmara inheritance grew slower, had the lightest weight at slaughter, the lightest carcass weight, the fewest carcasses classified as USDA Choice, the least amount of intra- and extramuscular fat, the least yield grades, and the greatest retail product yield.

Maternal Granddam Breed

Maternal granddam breed was significant ($P < 0.05$) for marbling score, USDA yield grade, fat thickness, and retail product yield. Animals with MARC III maternal granddams had less marbling score and were leaner

Table 3. Levels of significance, least squares means, and SEM for factors affecting postweaning ADG (PWADG), slaughter weight (SLWT), and HCW

	Trait		
Factor	PWADG, kg/d	SLWT, kg	HCW, kg
Maternal grandsire breed			
Significance	<0.001	<0.001	<0.001
Least squares means			
Hereford	1.32[a]	583[a]	354[b]
Angus	1.33[a]	591[a]	361[ab]
Brangus	1.33[a]	594[a]	366[a]
Beefmaster	1.28[b]	580[a]	352[b]
Bonsmara	1.24[c]	556[b]	339[c]
Romosinuano	1.25[c]	544[b]	331[c]
SEM	0.01	5	3
Maternal granddam breed			
Significance	0.8	0.19	0.27
Least squares means			
Angus	1.30	577	352
MARC III[1]	1.28	572	349
SEM	0.01	3	2
Sex			
Significance	<0.001	<0.001	<0.001
Least squares means			
Male	1.38[a]	604[a]	365[a]
Female	1.21[b]	545[b]	336[b]
SEM	0.01	3	2

[a–c]Within column and factor, means without a common superscript differ ($P < 0.05$).
[1]MARC III = 1/4 Hereford, 1/4 Angus, 1/4 Red Poll, and 1/4 Pinzgauer.

Table 4. Levels of significance, least squares means, and SEM for factors affecting dressing percentage (dress), percentage of carcasses classified as Choice, LM area, and marbling score (MAR)

	Trait			
Factor	Dress, %	Choice, %	LM area, cm^2	MAR[1]
Maternal grandsire breed				
Significance	0.035	0.002	0.032	<0.001
Least squares means				
Hereford	60.8[b]	69.6[a]	81.6[c]	521[b]
Angus	61.1[b]	77.8[a]	84.0[b]	551[a]
Brangus	61.7[a]	56.8[b]	87.0[a]	500[bc]
Beefmaster	60.8[b]	54.1[b]	83.0[c]	503[bc]
Bonsmara	61.2[ab]	52.3[b]	84.2[ab]	488[c]
Romosinuano	60.8[b]	56.3[b]	83.7[bc]	496[c]
SEM	0.2	4	1	8
Maternal granddam breed				
Significance	0.88	0.18	0.67	0.027
Least squares means				
Angus	61.0	65.6	83.7	520[a]
MARC III[2]	61.1	56.7	84.1	500[b]
SEM	0.1	2	0.5	5
Sex				
Significance	<0.001	0.019	<0.001	0.005
Least squares means				
Male	60.3[a]	53.1[a]	81.9[a]	496[a]
Female	61.8[b]	69.2[b]	85.9[b]	524[b]
SEM	0.6	3	0.6	5

[a–c]Within column and factor, means without a common superscript differ ($P < 0.05$).
[1]Marbling score: 400 = slight[00]; 500 = small[00].
[2]MARC III = 1/4 Hereford, 1/4 Angus, 1/4 Red Poll, and 1/4 Pinzgauer.

Table 5. Levels of significance, least squares means, and SEM for factors affecting USDA yield grade (YG), fat thickness (fat), retail product yield (RPYD), and retail product weight (RPWT)

	Trait			
Factor	YG	Fat, cm	RPYD, %	RPWT, kg
Maternal grandsire breed				
Significance	<0.001	<0.001	<0.001	0.014
Least squares means				
Hereford	2.12[ab]	1.20[b]	63.5[c]	224[b]
Angus	2.22[a]	1.34[a]	62.2[d]	226[b]
Brangus	2.02[b]	1.23[ab]	64.2[bc]	235[a]
Beefmaster	2.11[ab]	1.22[ab]	63.9[c]	225[b]
Bonsmara	1.79[c]	1.04[c]	65.4[ab]	223[bc]
Romosinuano	1.72[c]	0.95[c]	65.7[a]	217[c]
SEM	0.6	0.04	0.4	2
Maternal granddam breed				
Significance	0.004	0.033	0.002	0.61
Least squares means				
Angus	2.09[a]	1.22[a]	63.6[a]	225
MARC III[1]	1.91[b]	1.11[b]	64.7[b]	226
SEM	0.04	0.02	0.2	1
Sex				
Significance	<0.001	0.08	0.17	<0.001
Least squares means				
Male	2.15[a]	1.11	64.6	236[a]
Female	1.84[b]	1.22	63.7	215[b]
SEM	0.04	0.03	0.2	2

[a–d]Within column and factor, means without a common superscript differ ($P < 0.05$).
[1]MARC III = 1/4 Hereford, 1/4 Angus, 1/4 Red Poll, and 1/4 Pinzgauer.

than animals with Angus maternal granddams. Given that animals with MARC III maternal granddams were leaner, they produced carcasses with decreased yield grades (greater yield) and greater retail product yield.

Sex

Sex class was significant ($P < 0.02$) for all traits except for fat thickness and retail product yield. Steers grew faster, were heavier, had heavier carcasses, and had greater retail product weight than heifers. Heifers had a greater dressing percentage, a greater percentage of carcasses classified as USDA Choice, a greater LM area, a greater marbling score, and a decreased yield grade when compared with steers.

DISCUSSION

The objective of the GPE, Cycle VIII, was to evaluate tropically adapted *Bos taurus*, Sanga-influenced, and *Bos indicus*-influenced *Bos taurus* breeds, under temperate conditions. The use of *Bos indicus* cattle for meat production under tropical and subtropical conditions has been well established (Franke, 1997). Animals derived from the cross of *Bos taurus* × *Bos indicus* cattle have been evaluated under temperate conditions, where cows have adequate production performance (Cundiff, 1986). However, it also has been observed that these crossbred animals have less than desired performance for carcass composition and meat quality traits (Crouse et al., 1989; Wheeler et al., 2001).

Marbling is an economically important trait in meat production. Wheeler et al. (2005b), evaluating the parental generation of animals included in the present study, indicated that animals derived from Hereford and Angus crosses had greater marbling scores when compared with animals with Beefmaster, Brangus, Romosinuano, and Bonsmara inheritance. Animals with Angus inheritance tend to have a greater marbling score when compared with other breeds (Marshall, 1994). Bidner et al. (2002) found no difference in marbling score when comparing Angus, Brangus, and Beefmaster. Marbling score has seldom been evaluated in animals with Bonsmara and Romosinuano inheritance. Wheeler et al. (2005b) evaluated Hereford and Angus as a single breed (British breed). The increased marbling score in the British breed from the study of Wheeler et al. (2005b) is likely due to the Angus inheritance. In the present study, animals with Angus maternal grandsire had the greatest marbling score.

Differences for postweaning ADG have been previously reported. Beaver et al. (1989) reported Angus and Brangus were similar in postweaning growth. Crockett et al. (1979) found that Beefmaster steers grew faster than Brangus steers under tropical conditions. Muchenje et al. (2008) established that under South African conditions, Angus steers grew faster than Bonsmara steers. Chase et al. (1997) indicate that during winter growth, Hereford and Angus heifers grew faster than Romosinuano heifers. Growth comparison among the maternal grandsire breeds has been done under tropical

or subtropical conditions (Crockett et al., 1979; Chase et al., 1997; Muchenje et al., 2008). The present study comprises all breeds in a single study.

Body weight of the animal at slaughter has been previously evaluated. Beaver et al. (1989) indicated that Brangus steers were heavier at slaughter when compared with Angus steers. Steers from Brangus dams were heavier at slaughter when compared with steers from Hereford and Angus cows (Crockett et al., 1979). However, Crockett et al. (1979) also found that steers from Beefmaster sires were heavier than offspring from Brangus sires in their final BW. Muchenje et al. (2008) compared slaughter weight between Bonsmara and Angus steers. Bonsmara steers had similar slaughter weight than Angus steers. Differences between the study by Muchenje et al. (2008) and the present study could be due to climate conditions. Bonsmara is a Sanga-influenced breed adapted to the tropical conditions of South Africa, whereas Angus is not.

Hot carcass weight is an important factor in determining yield grade. Bidner et al. (2002) reported that Brangus steers had heavier carcasses than Angus steers. Marshall (1994) pooled carcass information across studies to present a review of scientific literature on breed characterization. Marshall (1994) reported in this review that Hereford and Angus had heavier carcass weights when compared with Brangus. Wheeler et al. (2005b) indicate that Brangus steers had similar HCW when compared with Hereford and Angus crossbred animals. Bidner et al. (2002) also compared carcass weight between Brangus and Beefmaster steers. Beefmaster steers had similar carcass weights when compared with Brangus steers. Wheeler et al. (2005b) also found similar carcass weights between Brangus and Beefmaster steers.

Yield grade is an accurate predictor of carcass composition (Abraham et al., 1980). The current study and the study by Wheeler et al. (2005b) agree in that animals with Romosinuano and Bonsmara inheritance produce carcasses with the least yield grade. Bidner et al. (2002) indicate that Beefmaster and Brangus have similar yield grade. Results from the current study also show that animals with Beefmaster and Brangus inheritance have similar yield grade.

Differences in fat thickness have been identified in comparisons between *Bos taurus*- and *Bos indicus*-influenced breeds (Crockett et al., 1979; Marshall, 1994; Bidner et al., 2002; Wheeler et al., 2005b). Conflicting reports on fat thickness exist in the literature. Bidner et al. (2002) found that animals derived from Angus sires were fatter than Brangus and Beefmaster. Crockett et al. (1979) also indicated a difference in fat thickness between animals produced from Angus and Brangus dams, where offspring from Brangus cows were leaner than offspring from Angus cows. However, Marshall (1994) indicated that fat thicknesses for animals with Angus, Hereford, Brangus, and Beefmaster influence were similar. Wheeler et al. (2005b) indicated that animals from Hereford and Angus have similar fat thickness as Beefmaster, but different than Brangus. In the current study, animals obtained from Angus, Brangus, and Beefmaster maternal grandsires had similar fat thickness. Muchenje et al. (2008) evaluated fat content by chemical analysis and found that meat at the longissimus thoracis et lumborum muscle from Bonsmara contained more fat than cuts from Angus animals. Differences in fat thickness among breeds from different studies could be explained by differences in environment, including feeding regimens, or could be due to limited sampling of breeds.

Differences between Angus and MARC III for fatness traits have been previously reported by Casas and Cundiff (2003), when comparing performance of these breeds as maternal granddams within Cycle V of GPE. Casas and Cundiff (2006) reported similar tendencies when evaluating Angus and MARC III maternal granddams in the Cycle VI of GPE, but none of the effects were significant. Casas and Cundiff (2006) reported a tendency ($P = 0.06$) for retail product yield, where animals with MARC III maternal granddams had a greater retail product yield compared with animals with Angus maternal granddams.

Romosinuano is a beef breed developed under tropical conditions in Colombia (Rouse, 1977). This breed has been evaluated for growth and reproduction traits under tropical and subtropical conditions (Elzo et al., 1998; Casas and Tewolde, 2001; Sarmiento and Garcia, 2007). Carcass traits have seldom been evaluated in Romosinuano. Wheeler et al. (2005b) evaluated the carcass traits in the parental generation of the animals in the present study. In the present study and in the study by Wheeler et al. (2005b), animals with Romosinuano inheritance had similar LM area to Hereford and Angus, but slower growth and smaller BW at slaughter.

Bonsmara is an African Sanga-influenced breed developed under tropical conditions. Carcass composition and meat quality traits have been evaluated in this breed and in crossbred cattle derived from this breed (Wheeler et al., 2005b; Muchenje et al., 2008). Muchenje et al. (2008) compared meat quality traits from Bonsmara and Angus. Muchenje et al. (2008) found that Bonsmara had similar fat content to Angus. Results from Muchenje et al. (2008) were based on fat percentage obtained from chemical composition analysis from a steak cut from the 10th rib. Wheeler et al. (2005b) found that F_1 steers with Bonsmara inheritance were leaner when compared with Hereford and Angus. Wheeler et al. (2005b) indicated that LM area from animals with Bonsmara inheritance was similar to animals from Romosinuano and Brangus sires. Results from the present study are similar to those from Wheeler et al. (2005b). Animals with Bonsmara inheritance grew slower, were lighter, and had lighter carcasses than animals from Hereford, Angus, or Brangus maternal grandsires.

The breed differences estimated in this project reflect the breed effects at the time the bulls were sampled. This study represents a broad sampling of the germplasm of each breed in the years 2001 to 2002. It is

important to note that breed differences are not a constant and are subject to change, primarily due to selection and, to a lesser extent, genetic drift. The Angus, Hereford, Beefmaster, and Brangus breeds all produce carcass EPD in their yearly genetic evaluations that provide effective tools for genetic change in the traits evaluated in this project.

Grandsire breed effects can be optimized by selection and use of appropriate crossbreeding systems. The current beef production system in the United States is designed for the production of high quality meat. The Romosinuano and Bonsmara breeds are alternatives to *Bos indicus*-influenced germplasm that could be incorporated in breeding programs in subtropical regions. However, crossbreeding programs including Romosinuano or Bonsmara germplasm may have to incorporate breeds of larger size to compensate for their smaller size. Brangus and Beefmaster are intermediate in marbling score and fatness, and competitive in weight of retail product. They contribute considerably to beef production in subtropical regions of the United States.

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