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PRELIMINARY RESULTS FROM CYCLE VII OF THE CATTLE GERMPLASM EVALUATION PROGRAM AT THE ROMAN L. HRUSKA U.S. MEAT ANIMAL RESEARCH CENTER[1]

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INTRODUCTION

Breeds with differences in performance characteristics are an important genetic resource for improving efficiency of beef production. Diverse breeds are required to exploit heterosis and breed complementarity through crossbreeding and development of Composite populations to match genetic potential with different markets, feed resources and climates. Beef producers are under increasing pressure to reduce fat while maintaining or improving tenderness and palatability of products. No single breed excels in all traits of economic importance to beef production. This report presents preliminary results from Cycle VII of the Germplasm Evaluation Program (GPE) at the Roman L. Hruska U.S. Meat Animal Research Center (MARC) which focused on characterization of the seven *Bos taurus* breeds that register the largest number of animals in their respective herd books. Each breed, except Red Angus, had been characterized in earlier Cycles of the Germplasm Evaluation Program as shown in Table 1. The objective of Cycle VII was to evaluate relative changes in these breeds since they were evaluated with samples of sires born 25-30 years earlier and to provide a current evaluation of these prominent *Bos taurus* breeds.

PROCEDURES

The GPE Program has been conducted in seven Cycles. Table 1 shows the mating plan for each Cycle. In Cycle VII the base cows included Angus, Hereford, and Composite MARC III (1/4 Angus, 1/4 Hereford, 1/4 Pinzgauer, and 1/4 Red Poll). Matings were made to produce straightbreds and reciprocal crosses of Hereford and Angus to provide estimates of heterosis to permit adjustment of means of progeny of Hereford, Angus, and Red Angus sires to heterosis expected in F1 crosses to provide unbiased comparisons to F1 crosses by Continental European sire breeds. All females were four years old or older at calving. All sire breeds except Red Angus had been included in either Cycles I or II of the GPE Program (progeny born 1970-1974). In contrast to previous Cycles of the GPE Program, when only young unproven sires were sampled, about one-half of the sires sampled from each breed were among the top 50 in progeny registrations in their respective herd books and about one-half were young unproven sires of each

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breed.

___**Hereford and Angus.** Semen from 12 Polled Hereford and nine Horned Hereford sires and 22 Angus sires were used to produce F1 cross progeny. Hereford and Angus sires have been used in each Cycle of the GPE Program to facilitate pooling of data and comparison of breeds in different Cycles. To provide ties for analyses pooled across Cycles, six of the Hereford bulls and five of the Angus bulls had previously been used in Cycle VI of the Program. The Hereford breed registered 80,976 animals and the Angus breed registered 271,222 animals in 2001 (National Pedigreed Livestock Council Annual Report, 2001-2002).

___**Red Angus.** The Red Angus breed maintains a separate Herd Book from the Angus breed. The Red Angus was established as a separate breed in 1954. The gene for red coat color is recessive to the gene for black. Some Angus carry the gene for red coat color. The foundation for the Red Angus breed was based on red segregates from the Angus breed. The Red Angus breed continues to permit introduction of red segregates from the Angus breed. Performance recording has been required by the Red Angus breed since the Herd Book was established in 1954. The Red Angus breed registered 41,900 animals in 2001. Semen from 21 Red Angus sires was used to produce F1 cross progeny.

Charolais. The Charolais breed was developed in France as a beef breed. The breed was introduced into Mexico in the 1930's and samples were brought to the United States from Mexico in the late 1940's. With the development of a maximum security quarantine facility in Canada in the mid 1960's, large numbers of Charolais were brought to North America from France in the late 1960's and early 1970's. The Charolais breed registered 45,354 animals in 2001. Semen from 22 Charolais sires was used to produce F1 cross progeny.

Limousin. The Limousin breed was developed in France as a beef breed. The breed was introduced into North America via Canada in 1968. The Limousin breed registered 49,036 animals in 2001. Canadian registrations are included in this number. Semen from 20 Limousin sires was used to produce F1 cross progeny.

Simmental. The Simmental breed was developed in Switzerland as a dual purpose breed. Fleckvieh from Germany and Pie Rouge from France also contributed to Simmental in North America. The breed was introduced into North America via Canada in 1968. The Simmental breed registered 44,159 animals in 2001. Semen from 20 Simmental sires was used to produce F1 cross progeny.

Gelbvieh. The Gelbvieh breed was developed in the state of Bavaria in Germany as a dual purpose breed. The breed was introduced into North America in the early 1970's. The Gelbvieh breed registered 32,323 animals in 2001. Semen from 23 Gelbvieh sires was used to produce F1 cross progeny.

Management. Calves were born in March through mid April of 1999 and 2000. Male calves were castrated within 24 hours of birth. Calves were weaned in mid October at an average age of 202 days. Following a postweaning adjustment period of about 30 days, steers were assigned to replicated pens within sire breed and fed separately by sire breed for an average of 243 days. For the first 26 days following weaning a diet containing about 2.55 Mcal ME/kg dry matter and 14.25% crude protein was fed. Next, a diet containing about 2.62 Mcal ME/kg dry matter and 12.74% crude protein was fed until early December. Then a growing diet containing about 2.73 Mcal ME/kg dry matter and 11.81% crude protein was fed until early February. The finishing diet fed from about 700 lb to slaughter contained about 3.05 Mcal ME/kg dry matter and 13.1% crude protein. Steers were implanted with Synovex S (200 mg progesterone and 20 mg estradiol benzoate) in mid December and again in mid March.

Representative samples of the steers born in 1999 were slaughtered serially in 5 slaughter groups spanning 43 days (May 15, June 11, June 12, June 25, June 27, 2000). Representative samples of steers born in 2000 were slaughtered serially in four groups spanning 53 days (May 7, May 21, June 11, and June 25, 2001). The steers were slaughtered in a commercial facility. Hot carcass weights were obtained and used to estimate dressing percent (100 x carcass weight/final live weight). After a 36-hour chill, USDA yield grade (fat thickness, ribeye area, estimated % kidney pelvic and heart fat, and carcass weight) and USDA quality grade (marbling, maturity) data were obtained. The wholesale rib was transferred to the meat laboratory at MARC and separated into lean, fat trim, and bone. Retail product (totally trimmed, .0 inch outside fat, and boneless steaks, roasts, and ground beef with 20% chemical fat content), fat trim, and bone from the right side was estimated using wholesale rib dissection prediction equations derived from steers produced previously in the GPE Program (Shackelford et al., 1995). After 14 days postmortem aging, Warner-Bratzler shear force and trained sensory panel ratings of tenderness, flavor, and juiciness were determined on cooked rib steaks.

After weaning, heifers were assigned to five pens each year containing about 70 head per pen. Each sire breed-dam breed was represented in each pen in proportion to their overall frequency. Heifers were fed a mixed diet of 70% corn silage and 30% alfalfa silage containing about 2.4 Mcal ME/kg dry matter and 10.1% crude protein until they were moved to grass pastures in early May. Females were checked visually twice daily for estrus beginning on January 2 in each year. Surgically altered teaser bulls, rotated weekly, were used to promote estrus behavior and aid in estrus detection. Weights were taken at 56 day intervals from weaning to the beginning of the breeding period. Heifers were exposed to Composite MARC III bulls for 63 days beginning on May 10 in 2000 and for 61 days beginning on May 21 in 2001. Body weights were recorded at the beginning and end of the breeding season. The heifers were pregnancy tested and weights and hip heights were recorded in late September each year. The females born in 1999 produced their first calves February 8 - April 24, 2001 and those born in 2000 produced their first calves February 13 - May 2, 2002. Calves produced by the females at 2 yr of age were weaned at an average age of 202 days in 2001 (Sept. 25), and due to drought conditions at a younger average age of 168 days (August 29) in 2002.

Data Analyses. Preweaning data were analyzed by mixed model procedures (Harvey, 1985. The Ohio State University. Mimeo.) using a model that included a random effect for sires nested in breed of sire and fixed effects for sire breed, dam breed, age of dam (4-5, 6-7, 8-9, $\geq$10 yr), year of birth, and sex of calf; interaction effects for sire breed-dam breed, and, if significant, other two factor interactions; i.e., breed-sex, and sire breed-birth year. Postweaning growth and carcass data on steers were analyzed by mixed model procedures using a model that included fixed effects for sire breed, dam breed, age of dam (4-5, 6-7, 8-9, $\geq$10 yr), and interactions of sire breed-dam breed, other two factor interactions (if significant for specific traits), covariates for weaning age and days fed postweaning, and random effects of sire within breed of sire and progeny within sire.

For analysis of feed efficiency, regression of marbling score, fat thickness, fat trim percentage, and retail product weight on days on feed was used to estimate days required for each sire breed to reach a marbling (Small35, the overall mean, Small00 to Small99 levels of marbling qualify for the USDA quality grade of Low Choice), fat thickness (0.43 in, the overall mean), fat trim (24.8% fat trim, the overall mean), or weight of retail product (RP = 496 lb, the overall mean) endpoint. Quadratic regression of pen mean weights on days fed and of cumulative metabolizable energy (ME) on days fed were used to estimate pen mean gain, ME consumption, and efficiency (lb/Mcal ME) in time (0 to187 d) and weight (750 to 1300 lb) intervals or from the starting date (day 0) to a marbling (Small 35), fat thickness (0.43 in), fat trim (24.8% fat trim), or weight of retail product (RP = 496 lb) endpoint. Estimates of pen mean efficiencies (2 pens per sire breed per year) for each interval and endpoint were analyzed by analysis of variance considering sire breed (df = 6), year (df = 1), and residual (df = 20) sources of variation. Sire breed-birth year interaction was not included in analyses of feed efficiency traits because preliminary analyses indicated it was not a significant source of variation for any estimate of efficiency. The residual mean square was used as the error variance for estimates of least significant differences (LSD<.05) among estimates of sire breed means for feed efficiency.

Data on postweaning growth, puberty traits, and reproduction and maternal performance of heifers were analyzed by least squares mixed model procedures using a model that included a random effect for sires nested in breed and fixed effects for sire breed, dam breed, year of birth, age of dam, and sire breed-dam breed, and, if significant, other two factor interactions. The production of straightbred Hereford and Angus and their reciprocal crosses provided for estimates of heterosis which were used (if heterosis effects were significant, P<.05) in linear contrasts to adjust Hereford, Angus and Red Angus means for differences between them and the Continental European breeds in expected heterosis (resulting from some straightbred matings and matings of all sire breeds with Composite MARC III females which have a breed composition of 1/4 Hereford, 1/4 Angus, 1/4 Red Poll and 1/4 Pinzgauer). The average least significant difference (LSD<.05) among sire breed contrasts (using sire within breed mean square as the error term) was used to assess sire breed differences. Differences as large or larger than LSD<.05 are expected to result from chance in only 5 out of 100 experiments of the same magnitude as the present experiment.

PRELIMINARY RESULTS

Estimates of sire breed effects averaged over Hereford, Angus, and MARC III dams (and all other effects as well) are shown in Table 2 for preweaning traits. Breed of sire means for postweaning growth rate and final weight of steers and some carcass traits adjusted to 445 days of age are provided in Table 3. Breed of sire means for estimates of carcass composition, and for meat tenderness and sensory traits are provided in Tables 4 and 5. Joint distributions for USDA quality grade and yield grade are shown in Table 6 for progeny of British sire breeds and Table 7 for progeny of Continental European sire breeds. Breed of sire means for feed efficiency of F1 cross steers in alternative intervals are summarized in Table 8. Data for postweaning growth and puberty traits of heifers are shown in Table 9. Breed group means for reproduction and maternal performance of females mated to produce their first calves by MARC III sires are shown in Table 10. The differences shown in the tables for breed of sire, estimate one-half of the genetic differences between breeds because progeny were produced by the same dam breed groups.

Preweaning traits. Breed of sire was significant (P<.05) for all preweaning traits summarized in Table 2, except for survival of calves from birth to weaning. Progeny of Angus and Red Angus sires had shorter gestation lengths than Hereford and the four Continental European breeds. Among the Continental European breeds, progeny of Limousin sires had the longest gestation lengths. Among British breeds, Angus and Red Angus sired calves had lower birth weights, lower calving difficulty scores, and more unassisted births than Hereford sired calves. Birth weight, calving difficulty score, and percentage of unassisted births generally did not differ between calves sired by the Hereford and the Continental European breeds. Charolais topcrosses had the heaviest birth weights, highest calving difficulty scores, and lowest percentages of unassisted calvings of all breed of sire groups. Differences among calves sired by the British breeds were small for 200-day weight. Limousin topcrosses were lighter at weaning than all other breed groups while Gelbvieh topcrosses were similar to those for the British breeds. Simmental topcrosses were significantly heavier at weaning than all breed groups followed by Charolais topcrosses which were significantly heavier than Limousin, Hereford, and Red Angus topcrosses. Angus and Red Angus topcrosses were similar for all traits evaluated.

The differences between British and Continental European breeds are less for unassisted calvings, calving difficulty scores, and 200 day weaning weights than when they were evaluated in the early 1970's (Cycles I and II) of the GPE Program. The results indicate that British breeds have emphasized selection for growth rate relatively more than Continental European breeds while Continental European breeds have emphasized improvement in calving ease relatively more than British breeds.

Postweaning growth and carcass traits of steers. Breed of sire was a significant source of variation for all traits summarized in Table 3.

Hereford, Angus, Red Angus, Simmental, and Charolais topcrosses were similar for postweaning average daily gain. The postweaning average daily gains of Limousin and Gelbvieh topcrosses were similar to each other, and were significantly less than those of Angus, Red Angus, and Simmental topcrosses. Angus and Simmental were similar for slaughter weight adjusted to 445 days, and were significantly heavier than Hereford, Gelbvieh and Limousin. Charolais, Red Angus, Hereford and Gelbvieh did not differ significantly for slaughter weight. Limousin had the smallest slaughter weight and were significantly lighter than Red Angus, Charolais, Simmental and Angus. The similarity between the average of British breeds and the average of the Continental European breeds in postweaning average daily gain and slaughter weight adjusted to 445 days is of interest. The magnitudes of differences in these traits between British and Continental European breeds are considerably less than when they were evaluated in Cycles I and II of the GPE Program. These results show that the British breeds have emphasized increased growth rate relatively more than Continental European breeds during the 25-30 year period between Cycles I and II and Cycle VII of the GPE Program.

Because of similarity of dressing percentages among all breed of sire groups, except Limousin which was significantly higher than all other breed of sire groups except Charolais, differences for carcass weights adjusted to 445 days agree with differences for slaughter weights.

Sire breed effects were significant for marbling score and percentage of carcasses grading USDA Choice or higher. Marbling score, measured on a continuous scale, is a more accurate predictor of breed differences than percentage USDA Choice or higher, for which carcasses are grouped into only two categories. Thus, percentage USDA Choice or higher was estimated by linear regression of percentage choice on marbling score (Table 3). Angus and Red Angus were similar in marbling, and differed significantly from all other sire breeds. Simmental, Hereford, Charolais, Gelbvieh, and Limousin sire breeds did not differ significantly for marbling score.

Continental European breed topcrosses had significantly less fat at the 12^{th} rib and significantly larger ribeye areas than the British breed topcrosses. Thus, yield grades were significantly more favorable (lower) for Continental European breed topcrosses than for British breed topcrosses. Among British breeds, Herefords had significantly less fat thickness than Angus. However, Angus had significantly greater ribeye area than Hereford and Red Angus. Limousin had larger ribeye areas than Gelbvieh and all British breeds. Angus and Red Angus topcrosses were similar for all traits evaluated except ribeye area.

Carcass composition and meat tenderness. Breed of sire was a significant source of variation for percentages and weights of retail product, fat trim and bone summarized in Table 4. Hereford topcrosses had significantly greater percentages of retail product and lower percentages of fat trim than Angus and Red Angus topcrosses. Continental European breed topcrosses were similar to each other in estimated percentages of retail product, fat trim, and bone. The Continental European breed topcrosses averaged 3.7% more retail product, 3.9 % less fat trim, and .4% more bone than the British breed topcrosses.

Differences in weights of retail product, fat trim, and bone at a constant age (445 d) reflect differences in growth rates of muscle, fat, and bone tissues. Lean tissue growth rates were significantly greater for Simmental, Charolais, and Gelbvieh topcrosses (which did not differ significantly from each other) than for Hereford, Angus, and Red Angus topcrosses (which did not differ significantly from each other). Limousin topcrosses were intermediate in ranking for retail product weight at a constant age and did not differ significantly from Gelbvieh or Angus.

Even though Angus differed significantly from Hereford in carcass weight (Table 3), Angus, Hereford, and Red Angus topcrosses did not differ for weight of retail product at 445 days of age. The extra carcass weight of Angus compared to Hereford sired progeny was due to their extra fat trim, as weight of bone was similar among all British breeds. Angus and Red Angus were similar to each other for yields and weights of retail product, fat trim and bone.

Even though the British breed topcrosses have experienced considerable change in growth rate relative to the Continental European breed topcrosses since they were evaluated in Cycles I and II of the GPE Program, differences in carcass composition between British and Continental European breed topcrosses at the same age are not different from what they were when sampled and characterized 25-30 years ago. Although British breeds have experienced major increases in growth rate and frame size (Table 9) these changes have not been accompanied by changes in carcass composition on an age constant basis.

Analysis of variance indicated significant variation among sire breeds in Warner Bratzler Shear and sensory estimates of tenderness and juiciness but not in flavor of rib steaks (Table 5). Gelbvieh topcrosses had steaks that were higher for shear force than those from all British sire breeds and lower for sensory panel tenderness ratings than Angus, Red Angus, and Limousin. Angus and Red Angus had more juicy rib steaks than Gelbvieh and Charolais.

USDA Quality grades and yield grades for British and Continental European breed topcrosses. Joint distributions for USDA quality grades and yield grades are presented separately for British and Continental European breed topcrosses in Tables 6 and 7. These are raw means, not adjusted by least squares procedures for disproportionate numbers among breed groups or for slaughter age. However, subclass numbers were not greatly disproportional as evidenced by the close agreement between least squares means for percentage grading USDA Choice or higher (Table 3) and raw means (Tables 6 and 7) for British and Continental European breed topcrosses. British breed topcross steer carcasses graded 86.1% USDA Choice or higher, but only 33.8% were Yield Grade 1 and 2 while 22.9% were Yield Grade 4. Continental European breed topcrosses had carcasses that graded 57.6% USDA Choice or higher, but 69.8% were Yield Grade 1 and 2 and only 3.3% were Yield Grade 4. Only one carcass graded USDA Standard in the experiment. The British breed topcrosses were largely pure British breed in ancestry with Hereford, Angus and MARC III dams; MARC III is 1/4 Hereford, 1/4 Angus, 1/4 Red Poll and 1/4 Pinzgauer in breed composition. The Continental European breed topcrosses had the same dams, thus they were largely one-half Continental European and one-half British breed composition. For most marketing "grids", crossbred steers with a 50:50 ratio of Continental European to British breed inheritance are likely to produce a more optimum balance between carcass quality grade and yield grade than crossbred or straightbred steers that represent either 100% British breed, or 100% Continental European breeding. It is important to note that all steers were slaughtered serially over 56 day time span, to provide for evaluation of alternative age, weight and composition end points in final analyses and reports from the experiment. Thus, some steers were slaughtered earlier or later than optimum in each breed group. If fatness and weight were optimized for each individual, more favorable "grid" distributions could be achieved for each breed group; however, results to date from this and previous experiments indicate that optimum outcomes for retail product percentage, marbling and carcass weight are more easily achieved in cattle with 50:50 ratios of Continental European to British inheritance than in cattle with higher or lower ratios of Continental European to British inheritance.

Postweaning feed efficiency of steers. Efficiency of post weaning live weight gain (lb/Mcal ME) was evaluated in time (0 to187 d) and weight (750 to 1300 lb) constant intervals or from the starting date (day 0) to a marbling (Small35), fat thickness (0.43 in), fat trim (24.8%), or weight of retail product (496 lb) endpoint (Table 8). Effects of sire breed were not significant for efficiency in time or weight constant intervals. Steers with British breed sires (B = Angus, Hereford, or Red Angus) were more efficient (P<.01) than those with Continental European breed (C= Simmental, Gelbvieh, Limousin, and Charolais) sires to marbling (B = .1321, C = .1206, lb/MCal), fat thickness (B = .1306, C =.1202), and fat trim (B = .1313, C = .1205, lb, Mcal) endpoints. However to the retail product endpoint (496 lb), steers with Continental European breed sires (.1285) were more efficient (P<.01) than those with British breed sires (.1210). Within British breeds, Hereford, Angus, and Red Angus did not differ in efficiency in any interval except that Herefords were more efficient than Red Angus to the retail product end point (P<.05). Within Continental European breeds, Simmental, Gelbvieh, Limousin, and Charolais did not differ significantly in efficiency to any of the end points, with the exception that Simmental were significantly more efficient than Charolais to the marbling, fat thickness, and fat trim endpoints (P<.05). Breed rankings for efficiency of live weight gain differed depending on the endpoint, and were inversely correlated with the number of days of maintenance required to reach the endpoint. To fatness endpoints, steers with British breed sires were more efficient because they reached the endpoint in fewer days. However, steers with Continental European breed sires were more efficient than those with British breed sires to the retail product endpoint because they required fewer days to produce 496 lb of retail product. Results for feed efficiency to fatness endpoints are consistent with those in Cycles I and II (1970-1975) of the GPE Program. However, in Cycles I and II, steers with Continental European breed sires were significantly more efficient than those with British breed sires in time or weight constant intervals because they had significantly faster average daily gains. Now in Cycle VII, when these breeds do not differ significantly in growth rate, sire breed differences in feed efficiency were not significant in either time or weight constant intervals.

Postweaning growth and puberty traits of heifers. Effects of sire breed were significant for all traits summarized in Table 9, except pregnancy rate. Results for heifers, as in steers (Table 3), indicate that differences between British and Continental European sire breeds are not as great today as they were 25-30 years ago when in Cycles I and II of the GPE Program, weights of heifers by Continental European sire breeds were heavier than those by British sire breeds. Contrary to the earlier results reported in the 1970's, at 400 days heifers with Angus and Red Angus sires ranked a close 1st and 2nd among the seven sire breeds and were significantly heavier than heifers with Gelbvieh and Limousin sires which ranked 6th and 7th. By 18 months of age, only the 1st and 7th ranking sire breeds, Simmental and Gelbvieh, differed significantly for body weight.

Significant sire breed differences were found for height and frame scores of heifers at 550 days of age. Simmental, Limousin, Charolais, and Gelbvieh sired heifers were significantly taller than Angus and Red Angus sired heifers. Gelbvieh and Hereford sired heifers were intermediate in height and frame score.

The percentage of heifers expressing their first pubertal estrus by May 7 in 2000 and 2001, when estrus observations were discontinued and heifers were moved from the dry-lot to grass pastures, was significantly less for Hereford and Limousin sired heifers than for Gelbvieh, Simmental, and Angus sired heifers. No other contrasts among sire breeds were significantly different for percentage expressing puberty. Sire breed differences were significant for weight and age at puberty (actual and adjusted for deviations from 100% expression of puberty by May 7). Limousin topcrosses expressed their first estrus at a significantly older age than those by other sire breeds and at a significantly heavier weight than Angus, Red Angus, and Gelbvieh. Gelbvieh topcrosses were the youngest in age and the lightest in body weight at first estrus. Gelbvieh topcrosses differed significantly from Herefords and Limousin in age at puberty, and had significantly lighter body weight at puberty than Angus, Simmental, and Charolais topcrosses. Charolais, Simmental, Angus, Red Angus, and Hereford topcrosses did not differ significantly in weight at puberty. Hereford sired heifers were significantly older at puberty than Charolais, Angus, Simmental and Red Angus sired heifers. Heifers sired by breeds that have had a history of selection for milk production (e.g., Simmental and Gelbvieh) reached puberty earlier than those sired by breeds that have not been selected for milk production (all other breeds). Breed of sire means were not significantly different for pregnancy rate.

Reproduction and maternal performance. Data reported for reproduction and maternal performance are especially preliminary, representing only the first of six or seven calf crops planned to be produced by the F1 females. Breed of sire of the F1 dams calving at 2 years of age was not a significant source of variation for any of the traits summarized in Table 10, except for 200-day weaning weight per calf weaned. Weaning weights of progeny raised by F1 females with Gelbvieh (rank 1st) and Simmental (2nd) sires were significantly heavier than those with Charolais (3rd), Limousin (4th) , and Angus (5th) sired dams. Weaning weights of progeny raised by F1 females with Hereford sires (7th) were significantly lighter that those by any other sire breed, except Red Angus (6th). Contrasts between British and Continental European breeds are less than half as great for direct and maternal weaning weight today as they were 25 to 30 years ago.

TABLE 1. SIRE BREEDS USED IN GERMPLASM EVALUATION PROGRAM AT MARC

Cycle I (1970-72)	Cycle II (1973-74)	Cycle III (1975-76)	Cycle IV (1986-90)	Cycle V (1992-94)	Cycle VI (1997-98)	Cycle VII (1999-2000)
			F_1 crosses (Hereford or Angus dams)[a]			
Hereford	Hereford	Hereford	Hereford	Hereford	Hereford	Hereford
Angus	Angus	Angus	Angus	Angus	Angus	Angus
Jersey	Red Poll	Brahman	Longhorn	Tuli	Wagyu	Red Angus
S. Devon	Braunvieh	Sahiwal	Salers	Boran	Norwegian Red	Limousin
Limousin	Gelbvieh	Pinzgauer	Galloway	Belgian Blue	Swedish Red&White	Charolais
Simmental	Maine Anjou	Tarentaise	Nellore	Brahman	Friesian	Simmental
Charolais	Chianina		Shorthorn	Piedmontese		Gelbvieh
			Piedmontese			
			Charolais			
			Gelbvieh			
			Pinzgauer			
3-way crosses out of F_1 dams						
Hereford	Hereford					
Angus	Angus					
Brahman	Brangus					
Devon	Santa Gertrudis					
Holstein						

[a] Composite MARC III cows (1/4 each Angus, Hereford, Red Poll and Pinzgauer) were also included in Cycles V, VI, and VII.

TABLE 2. LEAST SQUARES MEANS FOR BREED OF SIRE FOR PREWEANING TRAITS OF CALVES PRODUCED IN CYCLE VII OF THE GPE PROGRAM (1999 AND 2000 CALF CROPS)

Sire breed of calf	No. calves born	Gestation length days	Calvings unassisted %	Calv. diff. score	Birth wt. lb	Surv. to wn. %	200-d wn. wt. lb
Hereford	190	284.3	95.6	1.24	90.4	96.2	523.9[a]
Angus	189	281.6	99.6	1.01	84.0	96.7	533.2[a]
Red Angus	206	282.1	99.1	1.06	84.5	96.7	526.3[a]
Simmental	201	285.2	97.7	1.10	92.2	96.7	553.3
Gelbvieh	209	284.4	97.8	1.10	88.7	97.1	534.0
Limousin	200	286.2	97.6	1.13	89.5	96.9	518.7
Charolais	199	283.0	92.8	1.40	93.7	97.1	540.0
LSD<.05		1.5	3.6	.21	3.3	4.0	14.0

[a] Estimates for Hereford, Angus and Red Angus sires were adjusted to the level of heterosis expected in F1 crosses (10.0 lbs. was added for weaning weight) to provide for unbiased comparisons to F1 crosses by Continental European sire breeds.

TABLE 3. LEAST SQUARES MEANS FOR BREED OF SIRE FOR POSTWEANING GROWTH AND CARCASS TRAITS OF F1 STEERS (445 DAYS)

Sire breed	N	Post Wn. A.D.G. lb	Slaughter wt. lb[a]	Carcass wt, lb[a]	Dress. %	Marb. sc	U.S.D.A. Choice %	Yield grade	Fat thick. in	Ribeye area sq in
Hereford	97	3.23	1322	803	60.5	526	65.4	3.19	.50	12.32
Angus	98	3.32	1365	836	61.1	584	87.6	3.44	.58	12.85
Red Angus	93	3.26	1333	811	60.7	590	89.9	3.44	.53	12.14
Simmental	92	3.26	1362	829	60.8	527	65.7	2.72	.37	13.57
Gelbvieh	90	3.12	1312	800	61.0	506	57.7	2.60	.35	13.41
Limousin	84	3.12	1285	795	61.8	504	56.9	2.43	.37	13.94
Charolais	95	3.21	1348	826	61.3	517	61.9	2.54	.34	13.74
LSD<.05		.13	40	24	.6	28	10.7	.31	.08	.52

[a] Estimates for Hereford, Angus, and Red Angus sires were adjusted to the level of heterosis expected in F1 crosses (estimate of 22.5 lbs. was added for slaughter weight, and 15.7 lbs. was added for carcass weight) to provide for unbiased comparisons to F1 crosses by Continental European sire breeds. Effects of heterosis were not significant for dressing percentage, marbling score, yield grade, fat thickness and rib eye area and no adjustment was made for heterosis effects for these traits.

[b] Percentage USDA Choice or higher was estimated by linear regression [USDA Choice, % = -136.529 + .38382 (Marb.)] using coefficients derived from the present experiment. Thus, chance fluctuations that result from analyzing percentage USDA Choice as a binomial trait (0 or 1) were reduced.

TABLE 4. LEAST SQUARES MEANS FOR BREED OF SIRE FOR ESTIMATED RETAIL PRODUCT, FAT TRIM, AND BONE YIELDS AND WEIGHTS OF F1 STEERS IN CYCLE VII OF THE GPE PROGRAM [a] (445 DAYS)

Sire		Retail product		Fat trim		Bone	
breed	N	%	lb	%	lb	%	lb
Hereford	86	60.7	480	26.0	213	14.3	113
Angus	83	59.2	488	27.7	235	13.7	113
Red Angus	81	59.1	474	27.6	226	13.8	111
Simmental	80	63.0	522	23.6	197	14.3	119
Gelbvieh	81	63.8	509	22.7	182	14.6	116
Limousin	73	63.7	504	23.5	188	14.1	111
Charolais	85	63.5	523	22.9	190	14.5	119
LSD<.05		1.3	16	1.6	16	.4	4

[a] Estimates from wholesale rib dissection prediction equations (Shackelford et al., 1995. J. Anim. Sci. 73:406).

TABLE 5. LEAST SQUARES MEANS FOR BREED OF SIRE FOR WARNER-BRATZLER SHEAR FORCE AND SENSORY CHARACTERISTICS OF RIB STEAKS AGED FOR 14 DAYS (ADJUSTED TO THE AVERAGE AGE AT SLAUGHTER, 445 DAYS)

		WB Shear	Sensory panel [b]		
Sire		force[a]	Tenderness	Flavor	Juiciness
breed	N	lb	score	score	score
Hereford	86	9.1	5.63	4.91	5.32
Angus	83	8.9	5.77	4.93	5.39
Red Angus	82	9.2	5.69	4.94	5.38
Simmental	80	9.5	5.63	4.85	5.28
Gelbvieh	81	10.0	5.32	4.83	5.21
Limousin	73	9.5	5.65	4.88	5.27
Charolais	85	9.6	5.47	4.87	5.21
LSD<.05		0.7	.32	.12	.12

[a] Lower shear values reflect greater tenderness.
[b] Sensory scores: 1 = extremely tough, bland, or dry through 8 = extremely tender, intense, or juicy.

TABLE 6. USDA QUALITY GRADE X YIELD GRADE DISTRIBUTIONS (%) FOR STEERS WITH HEREFORD, ANGUS AND RED ANGUS SIRES (N = 288)

USDA Quality grade	USDA Yield grade, %				Total
	1	2	3	4	
Low Prime	0.0	0.0	1.7	.4	2.1
High Choice	0.0	.7	2.1	1.7	4.5
Av. Choice	0.0	1.7	7.3	2.8	11.8
Low Choice	2.8	18.4	29.5	17.0	67.7
Select	1.7	8.3	2.8	1.0	13.9
Standard	0.0	0.0	0.0	0.0	0.0
Total	4.5	29.2	43.4	22.9	100.0

TABLE 7 USDA QUALITY GRADE X YIELD GRADE DISTRIBUTIONS (%) FOR STEERS WITH SIMMENTAL, GELBVIEH, LIMOUSIN, AND CHAROLAIS SIRES (N =361)

USDA Quality grade	USDA Yield grade, %				Total
	1	2	3	4	
Low Prime	0.0	0.0	0.0	.3	.3
High Choice	0.0	0.0	.3	0.0	.3
Av. Choice	0.3	1.9	3.1	.3	5.5
Low Choice	8.3	27.2	14.4	1.7	51.5
Select	13.6	18.3	9.1	1.1	42.1
Standard	0.3	0.0	0.0	0.0	.3
Total	22.4	47.4	26.9	3.3	100.0

TABLE 8. BREED OF SIRE MEANS FOR ESTIMATES OF FEED EFFICIENCY (LIVE WEIGHT GAIN PER UNIT METABOLIZABLE ENERGY CONSUMED, lb/Mcal) FOR ALTERNATIVE INTERVALS AND ENDPOINTS

Sire breed	Time 187 days	Weight 750-1300 lb	Marbling Small35	Fat thickness .43 in	Fat trim 24.8%	Retail product 456 lb
Hereford	.1306	.1275	.1289	.1334	.1331	.1256
Angus	.1248	.1236	.1344	.1312	.1319	.1214
Red Angus	.1227	.1202	.1329	.1273	.1291	.1159
Simmental	.1265	.1271	.1250	.1226	.1233	.1330
Gelbvieh	.1221	.1201	.1182	.1185	.1182	.1246
Limousin	.1281	.1230	.1223	.1243	.1248	.1300
Charolais	.1202	.1202	.1170	.1151	.1158	.1264
LSD < .05	.0081	.0094	.0076	.0075	.0074	.0095

TABLE 9. SIRE BREED LEAST SQUARES MEANS FOR GROWTH AND PUBERTY TRAITS OF HEIFERS

Sire breed of female	N	400-d wt.[a] lb	18 month wt.[a] lb	18 month ht. cm	Frame score[b] sc	Puberty expressed %	Puberty wt. lb	Age at puberty[c] Act. d	Age at puberty[c] Adj. d	Preg. rate %
Hereford	81	841	950	128.4	5.5	79.2	733	342	357	94
Angus	85	869	936	127.2	5.3	97.2	750	340	343	88
Red Angus	106	868	953	126.9	5.2	97.4	744	339	342	91
Simmental	103	849	961	130.2	5.9	91.6	757	335	342	90
Gelbvieh	111	807	922	128.8	5.6	91.5	711	322	329	83
Limousin	109	824	933	129.9	5.8	80.3	785	363	377	87
Charolais	103	828	950	129.5	5.8	88.5	758	349	358	91
LSD<.05		31	32	1.6	.3	9.9	35	15	16	13

[a] Estimates for Hereford, Angus, and Red Angus were adjusted to the level of heterosis expected in 3-way F1 crosses (estimates of 32.2 lb was added for 400-d weight, and 20.7 lb was added for 550-d weight) to provide for unbiased comparisons to 3-way F1 crosses by Continental European sire breeds.

[b] Frame scores were calculated from height using the equation recommended in Guidelines for Uniform Beef Improvement, Beef Improvement Federation (BIF, 2002).

[c] Actual age at puberty and adjusted age at puberty, adjusted to remove bias due to differences in percentage expressing first estrus when observation of estrus was discontinued in early May by adding i(s) where i is the expected negative deviation from the true mean in standard deviation (s) units.

TABLE 10. SIRE BREED LEAST SQUARES MEANS FOR REPRODUCTION AND MATERNAL TRAITS OF F1 FEMALES MATED TO PRODUCE THEIR FIRST CALVES AT 2 YEARS OF AGE (2001 AND 2002 CALF CROPS)

Sire breed of female	No	Calf crop born %	Calf crop wn. %	Calving diff. score	Unassist births %	Birth wt. lb	Surv. to wn. %	200-d wt. per calf lb	200-d wt. per cow exp. lb
Hereford	80	92	70	1.9	74	81.5	78	413	292
Angus	84	83	76	2.0	72	79.8	93	424	325
Red Angus	104	86	76	2.2	68	78.2	88	415	317
Simmental	98	86	69	1.5	86	79.6	82	442	309
Gelbvieh	109	79	68	2.2	64	83.6	86	447	307
Limousin	109	85	73	2.0	68	80.3	85	429	313
Charolais	97	87	73	2.1	69	81.6	83	430	315
LSD<.05		14	15	.6	19	4.4	14	20	68