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Germplasm Evaluation Program Progress Report No. 19

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Germplasm Evaluation Program

Progress Report No. 19

Roman L. Hruska U.S. Meat Animal Research Center
in Cooperation with University of Nebraska,
Institute of Agriculture and Natural Resources,
Agricultural Research Division

Preliminary Information Available Upon Request.

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

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INTRODUCTION

Breed differences in performance characteristics are an important genetic resource for improving efficiency of beef production. Diverse breeds are required to exploit heterosis and complementarity through crossbreeding and composite populations to match genetic potential with diverse 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 importance to beef production. Previous results have shown that *Bos indicus X Bos taurus* (e.g., Brahman, Sahiwal and Nellore sired F_1 cows out of Hereford and Angus dams) crosses were exceptionally productive and efficient cows, especially in a subtropical environment (e.g., Florida versus Nebraska). However, as the proportion *Bos indicus* increased, the advantages of *Bos indicus* crosses were tempered by older age at puberty and reduced meat tenderness. This report presents preliminary results from Cycle V of Germplasm Evaluation Program at the Roman L. Hruska U.S. Meat Animal Research Center (MARC) focusing primarily on characterization of some heavy muscled continental European breeds and some tropically adapted breeds compared to Hereford and Angus sired crosses for characteristics of importance in beef production.

PROCEDURES

The Germplasm Evaluation (GPE) Program has been conducted in five cycles. Table 1 shows the mating plan for each cycle. In Cycle V, as in previous cycles of the program, the base cows included Angus (about 500) and Hereford (about 350) cows calving at 4 years of age or older. In addition, about 550 composite MARC III (1/4 Angus, 1/4 Hereford, 1/4 Pinzgauer and 1/4 Red Poll) cows calving at 4 years of age or older were included in Cycle V. The cows were mated to produce topcrosses by the following sire breeds.

Hereford and Angus. Semen from 20 polled and 11 horned Hereford bulls and from 43 Angus bulls was used to produce F_1 cross progeny. Hereford-Angus reciprocal crosses have been used as a reference throughout the GPE Program to facilitate pooling of data and comparison of breeds in different cycles. Twenty of the Hereford bulls (born from 1982-1984) were used in Cycle IV and the remaining 11 bulls (born since 1988) were used for the first time in Cycle V. Twenty seven of the Angus bulls (born 1982-1984) were used in

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Cycle IV and the remaining 16 bulls (born since 1988) were used for the first time in Cycle V.

Tuli. The Tuli, a Sanga type of cattle (non-humped), was developed relatively recently in a research program initiated in the 1940's using foundation cattle considered to be the most productive type selected from indigenous Tswana cattle in Zimbabwe. Australian scientists at CSIRO, Tropical Agricultural Research Station, Rockhampton, Queensland, and a consortium of private breeders in Australia imported frozen Tuli embryos from Zimbabwe into Australia in 1990. Semen from nine Tuli bulls was imported from Australia for use in the experiment.

Boran. Borans are a pure Zebu breed (*Bos indicus*, humped) that evolved in southern Ethiopia and are believed to have been developed for milk and meat production under stressful tropical conditions. They were imported into Australia from East Africa (Zambia). Semen from eight Boran bulls was imported from Australia for use in the experiment.

Brahman. Semen from a current broad sample of 21 Brahman (Grey and Red) bulls (born from 1984-1989, mean birth year 1987) was used to produce F_1 progeny. Semen was used from 26 bulls (born from 1964 to 1975, mean birth year 1969) sampled earlier in the program to facilitate pooling of data over cycles and estimate genetic trends.

Belgian Blue. Muscle hyperplasia (double muscling) has been favored for at least 40 years by Belgian Blue breeders in Belgium. Semen from 25 bulls was used in the experiment.

Piedmontese. Piedmontese originate in the Piedmont region of northern Italy. Muscle hyperplasia has also been emphasized as a criterian of selection in this breed. Seventeen Piedmontese sires included in Cycle IV of the program were repeated to produce one calf crop (1992) in Cycle V.

Management. Calves were produced in mid-March through mid-May of 1992-1994. Each year a sample of about 80 male calves were left intact to evaluate growth and pubertal development of bulls. The remaining male calves were castrated within 24 hours of birth. Calves were creep fed whole oats from mid-July until weaning in early October.

Following a postweaning adjustment period of about 30 days, steers were assigned to replicated pens within sire breed (Hereford and Angus sired steers were treated as a single sire breed) and fed separately by sire breed for an average of 233 days. The growing diet contained about 2.7 Mcal ME/kg dry matter and 12.9% crude protein and the finishing diet fed from about 700 lb to slaughter contained about 3.04 Mcal ME/kg dry matter and 10.9% crude protein. Representative samples of steers were slaughtered serially in 3 slaughter groups spaced 28 days apart in 1993, and 4 slaughter groups spaced about 21 days apart in 1994 and 1995. The steers were slaughtered in a commercial facility and hot carcass weights were obtained and used to estimate dressing percent (100 X carcass weight/final live weight). After a 24-hour chill, USDA yield grade (fat thickness, longissimus area, estimated % kidney pelvic and heart fat, carcass weight) and quality grade (marbling, maturity) data were obtained. The right side of the carcass was transferred to the meat laboratory at MARC and processed into closely trimmed (8 mm fat thickness) and totally trimmed (0 mm fat thickness) and boneless, retail product (steaks, roasts and lean trim with 20% chemical fat content in the lean trim), fat trim and bone. Retail product, fat trim, and bone from the right side was doubled to estimate retail product yield from the carcass. Warner-Bratzler shear force (after 7 and 14 days postmortem aging) and trained sensory panel ratings of tenderness, juiciness, and beef flavor intensity (after 7 days postmortem aging) were determined on cooked rib steaks.

After weaning and a 42 day adjustment period, heifers were assigned to two pens per sire breed (Hereford and Angus sired females were treated as a single sire breed). In each sire breed, one pen of about 30 heifers was fed a "moderate" energy level and the second pen of about 30 heifers received 80% (as fed) of the feed given to

the moderate group. The extra heifers (excess over 60 head per sire breed) were mixed together in two pens and fed the moderate energy level. Heifers were fed a 75% corn silage, 23% alfalfa haylage, and 2% protein mix (as fed) diet containing about 2.34 Mcal ME/kg dry matter and 11.6% crude protein until mid-March and then were fed a 59% corn silage, 39% alfalfa haylage, and 2% protein mix (as fed) diet containing about 2.24 Mcal ME/kg dry matter and 12.3% crude protein until they were moved to grass in early May. Females were checked visually twice daily for estrus beginning on February 1. Surgically altered teaser bulls, rotated weekly, were used to facilitate estrus observation. Weights were taken at 28 day intervals from weaning to the beginning of the breeding period. Heifers were moved to grass pasture in early May, at which time both treatments were combined and run together. Heifers were exposed to Red Poll bulls for a 63 day breeding season beginning in mid-May. Body weights were taken at the beginning and end of the breeding season. Heifers were weighed and pregnancy tested about 65 days after bulls were removed. The F_1 females are mated to Charolais and Belgian Blue F_1 (Belgian Blue X Angus or Belgian Blue X MARC II) bulls to produce progeny at 3 years of age through mature ages.

Bulls. Following weaning, each year about 80 bull calves were placed in two pens in a drylot, and fed a diet of corn silage, rolled corn and protein-mineral-vitamin supplement (2.69 Mcal ME/kg dry matter, 12.88% crude protein) for 9 months. At 28 day intervals, body weight, hip height, and scrotal circumference were measured. Electroejaculated semen collections were begun when bulls reached a scrotal circumference of 26 cm and continued at 28 day intervals until bulls reached puberty (first produced an ejaculate containing at least 500 x 10^6 sperm with $\geq$50% progressive motility).

Data Analyses. Preweaning data 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, 8-10, $11), year of birth, and sex of calf; interactions of sire breed-dam breed, sire breed-sex, and sire breed-birth year; and random effects of sire within breed of sire. Postweaning growth and carcass data on steers were analyzed by least squares procedures using a model that included fixed effects for sire breed, dam breed, age of dam (4-5, 6-7, 8-10, $11), year of birth, interactions of sire breed-dam breed, sire breed-year of birth, and random effects of sire within breed of sire, and covariates for age at weaning (mean = 184 d) and days fed postweaning (mean = 263 d).

Data on growth and puberty traits of heifers were analyzed by least squares procedures using a model that included fixed effects for sire breed, dam breed, feeding level, year of birth, and two factor interactions for sire breed-feeding level, sire breed-dam breed, sire breed-year of birth feeding level-dam breed, feed level-year, and dam breed-year. The average least significant difference (LSD .05) among sire breed contrasts is presented for each trait. Differences as large or larger than LSD .05 are expected to result from chance only 5 times out of 100 in experiments of the same magnitude.

PRELIMINARY RESULTS

Breed group means averaged over Angus, Hereford, and MARC III dams are shown in Table 2 for preweaning traits. Breed group means for final weight of steers and some carcass and meat characteristics, adjusted to 447 days of age, are shown in Tables 3, 4, and 5. Breed group means for growth and puberty traits of heifers are shown in Table 6. Breed group means for puberal development traits of F_1 males are shown in Table 7. Breed group means for reproduction and maternal traits of F_1 females born in 1992-1994 mated to produce their first calves by Red Poll sires in 1994-1996 are shown in Table 8. Preliminary data on reproduction and maternal traits of F_1 females born in 1992-1994 producing progeny at 3 years of age through mature ages by purebred Charolais versus Belgian Blue F_1 sires

are shown in Table 9. Data comparing F_1 Belgian Blue and Charolais as terminal sires are shown in Table 10 for preweaning traits and in Table 11 for postweaning growth and carcass traits of steers and heifers.

Preweaning Traits. Progeny of Boran, Brahman, and Tuli sires had longer gestation length than those of Hereford, Angus, and Belgian Blue sires. Gestation length was intermediate for progeny of Piedmontese sires compared to other breeds. Birth weights were significantly heavier for progeny of current Brahman sires (mean birth year, 1987) than for progeny of Brahman sires originally sampled and used in Cycle III of the GPE Program (mean birth year, 1969). Progeny of Boran sires were lighter in birth weight than progeny of Brahman sires but heavier than progeny of Angus and Tuli sires. Progeny of Piedmontese and Belgian Blue sires were similar in birth weight. Progeny of Hereford sires were heavier at birth than progeny of Angus sires, but neither breed differed significantly from progeny of Piedmontese or Belgian Blue sires. Progeny of Tuli sires had lighter birth weight than progeny by any other sire breed. In general, calving ease (unassisted calvings, %) was associated with birth weight of the progeny, except that progeny of Belgian Blue sires required relatively more assistance at calving than calves with comparable birth weights by other sire breeds. Progeny of current Brahman sires required significantly more assistance at calving than those of original Brahman sires and progeny of other sire breeds. Considering the relatively heavy birth weights of their progeny, it is somewhat surprising that even higher calving assistance rates were not required for progeny of original and current Brahman sires. Perhaps their shape or conformation offsets some of the effects of excessive birth weight. However, all dams were $4-yr-old, therefore little calving assistance is expected.

Survival of calves from birth to weaning was significantly lower in progeny of Brahman sires than in progeny of any other sire breed. Most of the mortality in Brahman sired calves occurred within 72 hr after birth. Survival of calves did not differ significantly among the other sire breeds.

Sire breed groups differed significantly in 200 day weaning weight. Weaning weight tended to be greater in progeny of current Brahman sires born from 1984-1989 than in progeny of original sires born from 1964-1975, but the difference was not significant. Progeny of both Brahman sire groups ranked higher in weaning weight than other sire breeds and were significantly heavier than progeny by Piedmontese, Boran, and Tuli sires. Belgian Blue, Angus, and Hereford sired progeny had similar weaning weights, and were significantly heavier than Piedmontese, Boran, and Tuli sired progeny at weaning.

Postweaning Growth and Carcass Traits of Steers. Steer progeny of Hereford, Angus, and Belgian Blue sires were heavier at slaughter (447 days of age) than those of Brahman, Piedmontese, Boran, or Tuli sires ($P<.05$). Mean marbling score was greater in progeny of Angus, Tuli and Hereford sires than in progeny of, Brahman, Piedmontese, and Belgian Blue sires ($P<.05$). Marbling score for Boran crosses was intermediate to that of Brahman ($P<.05$) and Hereford. Progeny of Angus, Tuli, and Hereford sires graded USDA Choice with a higher frequency than those of Piedmontese, Brahman or Belgian Blue sires ($P<.05$). Shear force and sensory panel estimates of tenderness of longissimus (rib eye) steaks were significantly more favorable for progeny of Belgian Blue, Piedmontese, Angus, Hereford, and Tuli sires than for progeny of Boran or Brahman sires (Table 5). Sensory panel estimates for juiciness were lower for progeny of Brahman sires than for progeny of other sire breeds.

Mean weight of retail product was greater for progeny of Belgian Blue sires than Piedmontese sires ($P<.05$) which was greater than that of Hereford and Angus sires. Weight of retail product was greater for progeny of Brahman sires, than that of Tuli and Boran sires ($P<.05$). Although live weights of Piedmontese were significantly lighter than those of Angus or

Hereford sires, weight of retail product was greater because of their higher dressing percentage and greater percentage of retail product. Mean percentage fat trim was less in progeny of Belgian Blue and Piedmontese sires than in progeny of Brahman sires which was less than that in progeny of Angus, Hereford, Boran, or Tuli sires ($P<.05$). Breed group means for percentage retail product were inversely related to those for percentage fat trim. Percentage bone for Tuli and Boran progeny was less than that Angus, Hereford, and Brahman progeny, which was in turn significantly less than that in Belgian Blue progeny.

Heifers. Mean 365 day weights of heifers were heavier for progeny of Hereford and Angus sires than progeny of all other sire breeds ($P<.05$). At 365 d, heifer progeny of Belgian Blue and Brahman sires were heavier than those of Piedmontese sires or progeny of Brahman, Boran or Tuli sires ($P<.05$). Weight and height at 18 months and pregnancy rate of heifers were significantly greater in females by current Brahman sires than females by original Brahman sires. Progeny of original and current Brahman sires did not differ significantly in 365 day weight. Brahman F_1 crosses were significantly heavier and taller than Boran and Tuli F_1 crosses. In all breed groups except Brahman, a high percentage of the females expressed estrus, prior to mid-June when estrus observations were discontinued. Mean age at puberty was relatively young for heifer progeny of Piedmontese, Belgian Blue, Angus, and Hereford sires, rankings were significantly older for progeny of Brahman sires than any other breed, and intermediate for progeny of Boran and Tuli sires. Breed group means for pregnancy rate of heifers tended to correspond to rankings for age at puberty except for Boran crosses which had the highest pregnancy rate of all crosses.

Bulls. Results for scrotal circumference and age at puberty (i.e., age when bulls produced 500 million sperm per ejaculate with $\geq$50 progressive motility) are summarized in Table 7. Scrotal circumference at 8 months of age was smallest in Brahman and Boran and largest in Hereford-Angus, Tuli, and Belgian Blue sired crosses. Hereford-Angus and Belgian Blue bulls reached puberty earliest, Tuli tended to be intermediate, and Boran and Brahman sired bulls were the oldest at puberty. All bulls reached puberty at 30 to 32.5 cm scrotal circumference. Brahman and Boran sired bulls were heavier at puberty than Boran, Hereford-Angus, Tuli, or Belgian Blue sired bulls.

Maternal Traits. Breed group means for reproduction and maternal performance of F_1 females are shown in Table 8 for two-year-olds. Reproduction rates of Boran, Tuli, Hereford, Angus, Piedmontese and Belgian Blue were similar and greater than that of Brahman sired F_1 females. Brahman F_1 females excelled in calving ease and weaning weight per calf. Weaning weight per cow exposed was greater for Boran F_1 females than for Tuli or Brahman sired F_1 females and intermediate for Piedmontese, Hereford, Angus, and Belgian Blue females.

Data for reproduction and maternal performance of females three years of age and older raising progeny sired by Charolais and Belgian Blue F_1 sires are shown in Table 9. Birth weights were significantly lighter for progeny of Brahman, Boran and Tuli F_1 females than for Hereford, Angus, Piedmontese, and Belgian Blue F_1 females. Brahman females required significantly less assistance at calving than Piedmontese or Belgian Blue F_1 females. Survival of progeny was significantly lower for females sired by Belgian Blue than for those sired by Hereford sires. At these more mature ages (3-7 years), production expressed in terms of 200-day weaning weight per calf was significantly greater for F_1 females by Brahman sires than for F_1 females by any other sire breeds. Brahman sired F_1 females produced significantly more weaning weight per cow exposed than Tuli or Belgian Blue F_1 females. Differences among Hereford, Angus, Boran, Tuli, Piedmontese and Belgian Blue sired F_1 females were not significantly different for 200-

day weaning weight per cow exposed to breeding.

Charolais Versus F_1 Belgian Blue Sires. Preweaning traits are presented in Table 10 for progeny of Charolais versus F_1 Belgian Blue sires mated to the F_1 females calving at 3-6 years of age. Percentage unassisted calves did not differ significantly for Charolais and F_1 Belgian Blue sired progeny, even though birth weights were significantly heavier for Charolais than Belgian Blue sired progeny. Calf survival and 200 day weaning weights were significantly greater for progeny of Charolais than for progeny of F_1 Belgian Blue sires.

Data on postweaning growth and carcass characteristics of heifers born in 1997 and steers born in 1996 by Charolais and F_1 Belgian Blue sires are summarized in Table 11. Heifer progeny by Charolais sires had significantly faster postweaning gains and heavier final weights than heifer progeny by F_1 Belgian Blue sires. However, steer progeny by Charolais and F_1 Belgian Blue sires did not differ significantly in postweaning growth rate. Progeny of Charolais and F_1 Belgian Blue sires did not differ significantly for most carcass traits. The data for carcass and meat traits are preliminary. Additional carcass data are being obtained on steer and heifer progeny by Charolais and F_1 Belgian Blue sires.

DISCUSSION

Preliminary results indicate that Belgian Blue and Piedmontese are excellent candidates as terminal sire breeds provided producers are compensated for carcass and meat value. They produced 5 to 9% higher percentage retail product than other sire breeds with meat palatability similar to Angus and Hereford sire breeds. However, less than 33% graded USDA Choice. Thus, special marketing programs for lean-tender beef are needed to realize their potential. Additional data are needed to characterize reproduction and calving traits of backcross and F_2 (e.g., Piedmontese-Angus X Piedmontese-Angus) progeny to assess their potential for use in rotational crossing systems or composite populations. Preliminary results indicate that Tuli cattle, which have evolved in the tropics, produce crossbred progeny with carcass and meat characteristics more similar to progeny sired by British *Bos taurus* breeds (i.e., Hereford and Angus) than to progeny sired by *Bos indicus* breeds (i.e., Brahman or Boran). Tuli crosses had relatively low average daily gains. Tuli and Boran crosses were significantly younger at puberty and had higher reproduction rates as 2-year-olds than Brahman crosses. However, at 3 years of age or older, reproduction rate did not differ among Brahman, Boran and Tuli sired females. At all ages, maternal weaning weight was greater for Brahman than Boran sired F_1 cross females which were in turn greater than Tuli sired F_1 cross females. Tuli cattle may be useful to replace a portion of *Bos indicus* breeding and maintain tropical adaptation traits without the detrimental effect on meat tenderness, provided they are crossed with other breeds that optimize size and growth rate. Cooperative research efforts are in progress to evaluate reproduction and maternal performance of F_1 cows by Tuli, Boran and Brahman sires at research stations located in subtropical regions of the U.S. (i.e., Florida, Georgia, Texas, Louisiana and Oklahoma).

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)
F_1 crosses from Hereford or Angus dams (Phase 2)[a]				
Hereford	Hereford	Hereford	Hereford	Hereford
Angus	Angus	Angus	Angus	Angus
Jersey	Red Poll	Brahman	Longhorn	Tuli
S. Devon	Braunvieh	Sahiwal	Salers	Boran
Limousin	Gelbvieh	Pinzgauer	Galloway	Belgian Blue
Simmental	Maine Anjou	Tarentaise	Nellore	Brahman
Charolais	Chianina		Shorthorn	Piedmontese
			Piedmontese	
			Charolais	
			Gelbvieh	
			Pinzgauer	
3-way crosses out of F1 dams (Phase 3)				
Hereford	Hereford			
Angus	Angus			
Brahman	Brangus			
Devon	Santa Gertrudis			
Holstein				

[a]In Cycle V, composite MARC III (1/4 Angus, 1/4 Hereford, 1/4 Pinzgauer and 1/4 Red Poll) cows are also included.

TABLE 2. BREED GROUP MEANS FOR PREWEANING TRAITS OF CALVES PRODUCED IN CYCLE V OF THE GPE PROGRAM
(Three Calf Crops, 1992-1994)

Sire breed of calf	No. calves Born	No. calves Weaned	Gestation length days	Calvings unassisted %	Birth weight lb	Calf surv. %	200-d weight lb
Hereford	334	322	285.7	96.7	94.3	94.7	532
Angus	313	305	283.7	98.0	90.3	99.0	528
Average	647	627	284.7	97.3	92.3	96.9	530
Brahman							
(Original)[a]	155	145	292.0	93.0	99.5	91.2	537
(Current)[b]	281	260	293.1	88.4	104.6	88.6	545
Average	436	405	292.6	90.7	102.1	89.9	541
Boran	456	439	292.4	95.5	95.6	96.3	508
Tuli	491	472	291.0	97.1	85.8	96.3	496
Piedmontese	144	143	289.6	94.7	92.5	98.7	509
Belgian Blue	469	450	284.7	92.8	92.6	95.8	526
LSD .05			1.8	4.2	3.4	3.7	15

[a]Progeny of sires born 1964-1975.
[b]Progeny of sires born 1984-1989.

TABLE 3. BREED GROUP MEANS IN FINAL WEIGHT AND CARCASS TRAITS OF STEERS (ADJUSTED TO AVERAGE AGE AT SLAUGHTER OF 447 DAYS)

Sire breed of steer	No.	ADG	Final wt. lb	Carc. wt. lb	Dress. pct. %	Marb-ling score sc	U.S.D.A Choice %	Fat thick-ness in	Rib eye area sq in
Hereford	115	2.96	1270	767	60.4	520	70.3	.46	11.47
Angus	126	2.99	1278	774	60.5	556	84.6	.49	11.76
Average	241	2.98	1274	771	60.4	538	77.4	.47	11.62
Brahman									
(Original)	43	2.47	1174	718	61.2	485	29.4	.38	11.31
(Current)	76	2.60	1199	742	61.9	466	30.4	.41	11.31
Average	119	2.54	1186	730	61.6	476	29.9	.40	11.31
Boran	151	2.39	1116	684	61.3	504	47.2	.44	11.50
Tuli	162	2.44	1110	681	61.3	525	63.8	.40	11.44
Piedmontese	35	2.61	1178	733	62.3	472	31.8	.23	13.15
Belgian Blue	144	2.80	1248	779	62.2	464	23.8	.26	13.34
LSD .05		.14	48	31	.9	30	22.2	.09	.58

TABLE 4. BREED GROUP MEANS IN MEAT TENDERNESS AND PALATABILITY CHARACTERISTICS OF RIB STEAKS FROM STEERS (ADJUSTED TO AVERAGE AGE AT SLAUGHTER OF 447 DAYS)

Sire breed of steer	No.	WB Shear, lb		Sensory panel (7 days aging)[a]		
		7 days aging	14 days aging	Tender-ness sc	Flavor sc	Juici-ness sc
Hereford	106	12.6	10.6	5.13	4.94	5.19
Angus	101	11.3	8.9	5.38	4.89	5.36
Average	207	11.9	9.7	5.25	4.92	5.28
Brahman						
(Original)	43	17.1	13.4	3.77	4.85	4.77
(Current)	76	15.0	12.9	4.22	4.81	4.79
Average	119	16.1	13.2	4.00	4.83	4.78
Boran	138	14.5	11.3	4.48	4.77	5.04
Tuli	158	12.6	10.1	5.00	4.86	5.17
Piedmontese	35	11.9	10.1	5.04	4.84	5.02
Belgian Blue	143	13.0	10.7	4.93	4.85	5.02
LSD.05		1.7	1.3	.47	.15	.20

[a]Scored 1 = extremely tough, bland, or dry through 8 = extremely tender, intense or juicy.

TABLE 5. BREED GROUP MEANS IN RETAIL PRODUCT YIELDS OF STEERS (447 DAYS)

Sire breed of steer	No.	.3 in trim Retail prod. %	.3 in trim Retail prod. lb	.0 inch trim Retail prod. %	.0 inch trim Retail prod. lb	.0 inch trim Fat trim %	.0 inch trim Fat trim lb	.0 inch trim Bone %	.0 inch trim Bone lb
Hereford	106	67.6	491	61.9	449	23.6	174	14.5	105
Angus	101	67.9	495	62.2	454	23.5	173	14.3	104
Average	207	67.7	493	62.0	451	23.6	173	14.4	105
Brahman									
(Original)	43	69.7	476	64.1	438	21.7	148	14.3	97
(Current)	76	69.5	489	63.8	449	21.7	155	14.5	102
Average	119	69.6	482	63.9	444	21.7	152	14.4	100
Boran	138	68.4	438	62.6	400	23.9	156	13.5	86
Tuli	158	69.0	440	63.4	405	22.7	146	13.8	88
Piedmontese	35	75.3	514	71.0	484	14.8	105	14.2	97
Belgian Blue	143	74.0	542	69.3	508	15.9	118	14.8	109
LSD .05		1.5	19	1.7	18	2.0	18	.5	5

TABLE 6. BREED GROUP MEANS FOR GROWTH AND PUBERTY TRAITS OF HEIFERS

Sire breed of female	No.	365-d wt. lb.	18 month wt. lb.	18 month ht. cm	Puberty expressed %	Puberty weight lb	Age at puberty Act. d	Age at puberty Adj. d	Preg. rate %
Hereford	152	779	909	128.3	98.0	768	353	355	92.7
Angus	130	765	891	127.3	97.5	753	349	351	91.6
Average	282	772	900	127.8	97.7	761	351	353	92.2
Brahman	212	724	877	132.0	79.1	754	411	426	84.2
Diff. (curr. - orig.)[a]		7	22**	2.9**	6.0	-2	-6	-6	15.0*
Boran	206	667	797	125.8	93.2	683	389	396	96.8
Tuli	244	665	786	125.5	93.5	660	365	371	90.2
Piedmontese	75	670	788	125.5	96.0	654	344	348	90.2
Belgian Blue	237	737	855	126.6	98.5	721	346	348	85.0
LSD .05		12	12	1.6	7.4	12	13	13	11.0

[a]Difference between progeny of current and original Brahman sires estimated in separate analyses of data for heifers on the moderate and low feeding levels.

*P < .05.

**P < .01.

TABLE 7. BREED GROUP MEANS FOR GROWTH AND PUBERTAL DEVELOPMENT OF F_1 MALES

Sire breed of bull	No. of bulls	Scrotal circumference 8 mo cm	12 mo cm	16 mo cm	At puberty[a] Age d	Weight kg	Scrot. circ. cm
Hereford and Angus Average	58	27.7	34.0	36.7	319.5	414.9	31.8
Brahman	47	23.3	30.9	35.9	399.0	473.1	32.5
Boran	43	24.3	31.6	35.8	378.4	430.8	31.9
Tuli	44	26.5	30.7	34.2	360.9	395.6	30.5
Belgian Blue	44	26.2	32.7	36.3	325.2	408.1	31.0
LSD .05		1.0	1.0	.9	19	24	.7

[a]First ejaculate containing ≥ 500 x 10^6 sperm with ≥ 50% progressive motility.

TABLE 8. BREED GROUP MEANS FOR REPRODUCTION AND MATERNAL TRAITS OF F_1 FEMALES MATED TO PRODUCE THEIR FIRST CALVES BY RED POLL SIRES AT TWO YEARS OF AGE (1994-1996 Calf Crops)

Sire breed of female	Number cows exposed	calves born	Calf crop born %	weaned %	Unassisted calvings %	Birth weight lb	Survival to weaning %	200-day wt per calf lb	per cow exp.
Hereford	146	127	86.4	73.8	74.1	79.1	86.3	419	300
Angus	132	114	84.7	74.4	79.0	77.2	87.3	437	313
Average	278	241	85.6	74.1	76.6	78.2	86.8	428	307
Brahman									
(Original)	69	50	69.5	54.3	88.3	73.9	78.4	456	238
(Current)	135	113	83.6	69.6	87.4	76.4	84.0	476	319
Average	204	163	76.6	62.0	87.8	75.2	81.2	466	279
Boran	197	177	90.3	83.3	74.9	73.3	92.4	444	357
Tuli	235	205	86.1	74.6	76.2	74.7	87.0	413	296
Piedmontese	74	65	89.4	75.3	58.9	79.8	85.3	441	321
Belgian Blue	230	190	82.2	71.0	73.4	79.9	86.4	436	300
LSD.05			12.7	13.9	12.9	3.4	10.1	18	62

TABLE 9. BREED GROUP MEANS FOR REPRODUCTION AND MATERNAL TRAITS OF F_1 FEMALES MATED TO PUREBRED CHAROLAIS AND F_1 BELGIAN BLUE SIRES TO PRODUCE THEIR SECOND AND SUBSEQUENT CALVES (Preliminary Data, 1995-1999 Calf Crop)

Sire breed of female	Number: cows exposed	Number: calves born	Calf crop: born %	Calf crop: weaned %	Unassisted calvings %	Birth weight lb	Survival to weaning %	200-day wt, lb: per calf	200-day wt, lb: per cow exp.
Hereford	470	439	93.8	88.7	95.2	93.0	94.1	474	422
Angus	376	354	93.6	86.3	96.4	90.5	91.8	493	426
Average	846	793	93.7	87.5	95.8	91.8	92.9	483	424
Brahman									
(Original)	193	181	93.3	85.9	99.6	80.2	92.1	511	440
(Current)	428	394	92.3	82.7	98.0	83.9	89.4	521	430
Average	621	575	92.8	84.3	98.8	82.1	90.8	516	435
Boran	655	604	93.1	86.2	96.9	81.6	92.7	488	421
Tuli	722	650	90.1	84.1	96.8	84.4	93.3	471	397
Piedmontese	124	114	91.8	85.3	95.0	89.4	93.2	476	404
Belgian Blue	784	703	89.2	79.0	92.7	94.2	88.0	502	398
LSD.05			4.6	6.7	3.8	3.2	5.8	14	36

TABLE 10. BREED GROUP MEANS FOR PREWEANING TRAITS OF CALVES BY CHAROLAIS AND F_1 BELGIAN BLUE SIRES

Sire of calf	Calves born	Unassisted calvings %	Birth weight lb	Survival to weaning %	200-day wt lb
Charolais	1904	97.1	88.4	93.3	501.2
Belgian Blue F_1	1535	95.6	85.9	90.3	482.3
Difference		1.5	2.5**	3.0**	18.8**

*P < .05.
**P < .01.

TABLE 11. BREED GROUP MEANS IN POSTWEANING GROWTH AND CARCASS TRAITS FOR FEMALE AND MALE PROGENY OF CHAROLAIS VERSUS BELGIAN BLUE SIRES

	Heifers		Steers	
	Sire breed		Sire breed	
Trait	Charolais	Belgian Blue F1	Charolais	Belgian Blue F1
Number	218	240	100	88
Postwean. ADG, lb/d	2.192	2.115*	2.653	2.612
Final wt., lb	1082	1037*	1180	1151
Carcass wt, lb	685	667*	747	736
Dressing pct., %	63.3	64.3	63.3	63.9
Marbling	4.88	4.76	4.96	5.07
% USDA Choice	33.1	31.9	46.5	49.3
% Select	59.7	57.1	53.2	43.2
% Standard	7.2	10.9	0.3	7.5*
Fat thickness, in.	.259	.257	.237	.288*
Rib eye area, sq. in.	13.82	14.11	13.29	13.60
Kidney pelvic & heart fat	2.60	2.49	2.63	2.54
Yield grade	1.84	1.66*	2.21	2.17
Est. retail prod., %	67.4	68.0	67.2	66.5
Est. fat trim, %	17.5	16.9	17.6	18.5
Est. bone, %	15.3	15.4	15.4	15.2
Est. ret. prod., lb.	461.5	453.5	501.5	488.5
Est. fat trim, lb	120.8	113.2	132.0	137.7
Est. bone, lb	104.9	102.5	115.1	111.8

*Difference between progeny of Charolais and Belgian Blue F_1 sires is significant ($P < .05$).