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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 VI 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 development of 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. This report presents preliminary results from Cycle VI of the Germplasm Evaluation Program at the Roman L. Hruska U.S. Meat Animal Research Center (MARC) which focuses primarily on characterization of Continental European breeds with a history of dual purpose (milk and meat production) use and the Wagyu breed from Japan reputed to have unusual propensity to deposit marbling in Japanese beef production systems.

PROCEDURES

The Germplasm Evaluation (GPE) Program has been conducted in a series of cycles. Table 1 shows the mating plans for Cycles I through VI. In Cycle VI, as in previous cycles, the base cows included Angus (453) and Hereford (217) cows calving at 4 years of age or older, and in addition, 714 Composite MARC III (1/4 Angus, 1/4 Hereford, 1/4 Pinzgauer and 1/4 Red Poll) cows calving in the spring of 1997 and 1998 at 4 years of age or older were included in Cycle VI. The cows were mated by artificial insemination (AI) for 21 days each year to produce top-cross progeny by the following sire breeds:

Hereford and Angus. Semen from 22 polled and 10 horned Hereford bulls was used to artificially inseminate (AI) Angus and MARC III cows and from 30 Angus bulls was used in AI matings to Hereford and MARC III cows. Hereford-Angus reciprocal crosses have been used as a reference throughout the GPE Program to facilitate pooling of data and comparison of breeds used in different cycles. To create ties for pooled analyses, 11 of the Hereford bulls (born from 1982-1984) were used for the first time in Cycle IV, 9 Hereford bulls (born in 1989 or 1990) were used for the first time in Cycle V, and the remaining 11 Hereford bulls (born since 1994) were used for the first time in Cycle VI. Ten of the Angus bulls (born from 1982-1984) were used for the first time in Cycle IV, 9 Angus bulls (born in 1989 or 1990) were used for the first time in Cycle V, and the remaining 11 Angus bulls (born since 1994) were used for the first time in Cycle VI. At the time of purchase of semen, the Hereford and Angus bulls used were unproven by progeny test but considered to be excellent young herd sire prospects in the Angus and Hereford

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breeds.

Norwegian Red and Swedish Red and White. Semen from 14 Norwegian Red bulls imported from the Norwegian Cattle AI and Breeding Cooperative, Hamar, Norway and semen from 16 Swedish Red and White bulls imported from the Svensk Avel Ornsro, Skara, Sweden was used in AI matings to Angus, Hereford, and MARC III cows. For practical purposes, the Norwegian Red and the Swedish Red and White are the same breed, because of an open herd book policy of each registry to the other over a considerable length of time. Over the past 20 years, each breed has introduced germplasm from North American Holsteins. However, only bulls with non-Holstein influenced pedigrees were sampled for this experiment.

Friesian. Semen from 24 bulls obtained through cooperation of American Beef Friesian breeders was used in matings to Hereford, Angus, and MARC III cows. Fourteen of the bulls born from 1979 to 1990 were full-bloods originally imported to the U.S. from Ireland, England, Holland, and Germany. Ten bulls were upgrades or full blood sons of imported parents born in the U.S. from 1979 to 1990. Only bulls with non-Holstein influenced pedigrees were sampled for this experiment.

Wagyu. Semen from 19 bulls obtained through cooperation of the American Wagyu Association was used in matings to Hereford, Angus, and MARC III cows. Four bulls were full-bloods born in 1973 and 1974 and imported into the U.S. in the late 1970's. Eleven were full-bloods born in 1989-1994 and imported from Japan into the U.S. in the 1990's. Four of the bulls were upgraded pure-breds ($\geq$ 15/16 Wagyu) born in 1985-1989 in the U.S.

Management. Calves were produced in March through mid-April of 1997-1998. Male calves were castrated within 24 hours of birth.

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 255 days. For 21 days following weaning, a diet containing about 2.55 Mcal ME/kg and 14.25% crude protein was fed. Then a growing diet containing about 2.7 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 early March of each year. Representative samples of steers were slaughtered serially in 5 slaughter groups spaced about 14 days apart (spanning 56 days) in 1998, and 4 slaughter groups spaced about 14 - 21 days apart (spanning 56 days) in 1999. 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, longissimus area, estimated % kidney, pelvic and heart fat, and carcass weight) and 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, fat trim, and bone yields (percentage of carcass weight) was estimated using right side wholesale rib dissection prediction equations derived from steers produced previously in the GPE Program (Shackelford et al., 1995). Retail product, fat trim and bone weights were estimated by multiplying carcass weights times the respective yields. Warner-Bratzler shear force measures of tenderness and sensory panel evaluations of tenderness, flavor, and juiciness were determined on cooked rib steaks (after aging 14 days postmortem).

After weaning, heifers were assigned at random to five pens in 1997, and four pens in 1998 containing 68-70 head per pen. Each sire breed - dam breed group was represented in proportion to their overall frequency in each pen. Heifers were fed a mixed diet of corn silage, sorghrum silage, and alfalfa silage containing about 2.4 Mcal ME/kg dry matter and 10.1% 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 56 day intervals from weaning to the beginning of the

breeding period. Heifers were moved to grass pasture in early May. Heifers were exposed to Composite MARC III (1/4 each Angus, Hereford, Red Poll, and Pinzgauer) bulls for a 63 day breeding season beginning in mid-May. Body weights were taken at the beginning and end of the breeding season. The heifers were pregnancy tested and weights and hip heights were recorded in late September.

Data Analyses. Preweaning data were analyzed by least squares mixed model procedures (Harvey, 1985) using a model that included a random effect for sires nested in sire breed (the appropriate error term for testing differences among sire breeds) and fixed effects for sire breed, dam breed, age of dam (4-5, 6-7, 8-9, ≥10), year of birth, and sex of calf; interactions of sire breed-dam breed, and other significant (P<.05) two factor interactions. Postweaning growth and carcass data on steers were analyzed by least squares mixed model procedures using a model that included a random effect for sires nested within sire breed and fixed effects for sire breed, dam breed, age of dam (4-5, 6-7, 8-9, ≥10), year of birth, interactions of sire breed-dam breed, sire breed-year of birth, and covariates for age at weaning (mean = 216 d) and days fed postweaning (mean = 255 d). Data on growth and puberty traits of heifers were analyzed by least squares mixed model procedures using a model that included a random effect for sires nested in sire breed (the appropriate error term for testing differences among sire breeds) and fixed effects for sire breed, dam breed, year of birth, age of dam, and two factor interactions for sire breed-dam breed, and cow age-dam breed, The average least significant difference (LSD .05) among sire breed contrasts is presented for each trait (Harvey, 1985). 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

Sire breed means averaged over Angus, Hereford, and MARC III dams are shown in Table 2 for preweaning traits. Sire breed means of steers for final weight and some carcass and meat characteristics, adjusted to 471 days of age, are shown in Tables 3, 4, and 5. Sire breed means for growth and puberty traits of heifers are shown in Table 6. Sire breed means for reproduction and maternal traits of F_1 females mated to produce their first calves by MARC III sires in 1999-2000 are shown in Table 7.

Preweaning Traits. Significant variation was found among sire breeds for gestation length, unassisted calvings, birth weight, and 200-d weight. Progeny of Wagyu sires had longer gestation lengths than those by Hereford sires, which were in turn significantly longer than those by any other sire breed. Progeny of Angus, Norwegian Red, Swedish Red and White, and Friesian sires did not differ in gestation length.

Progeny of Wagyu, Friesian, Norwegian Red, and Swedish Red and White sires did not differ in calving difficulty scores or percentage unassisted calvings. Hereford and Angus sired progeny experienced significantly fewer unassisted births than progeny of other sire breeds. Progeny of Wagyu sires were significantly lighter at birth than those of all other sire breeds. Progeny of Hereford sires were significantly heavier at birth than those of all other sire breeds. Birth weight did not differ significantly among progeny of Friesian, Angus, Swedish Red and White, and Norwegian Red sires. Survival of calves from birth to weaning did not differ significantly among sire breeds.

Progeny of Hereford and Angus sires were significantly heavier at weaning than those of Friesian and Wagyu sires. Wagyu sired progeny were significantly lighter at weaning than those of all other sire breeds. Progeny of Norwegian Red, Swedish Red and White, and Friesian sires did not differ significantly in 200-d weight and were intermediate between progeny of British (Angus and Hereford) and Wagyu sires.

Postweaning Growth and Carcass Traits of Steers. Effects of sire breed were significant for postweaning average daily gain, final weight, and carcass weight. Steers by Hereford and Angus sires did not differ but had significantly greater postweaning average daily gains and heavier final weights than steers by any other sire

breed. Progeny of Norwegian Red, Swedish Red and White, and Friesian sires were similar in postweaning average daily gain and final weight. Steers by Wagyu sires had lower average daily gains and lighter final weight than those by other sire breeds. Differences among sire breeds for carcass weight followed patterns similar to those for final weight. Progeny of Wagyu, Angus, and Hereford sires had about 0.8% higher dressing percentages ($P<.05$) than progeny of Norwegian Red and Swedish Red and White sires.

Analyses of variance revealed significant variation among sire breeds for marbling, percentage grading USDA Choice or higher, percentage grading USDA Select, and for fat thickness. Sire breed effects were not significant for rib-eye area. Progeny of Angus and Wagyu sires did not differ significantly in marbling score or in percentage of carcasses grading USDA Select, or USDA Choice or higher. Angus and Wagyu sired progeny had significantly higher marbling scores than Swedish Red and White sired progeny. Progeny of Norwegian Red and Swedish Red and White sires did not differ significantly from one another in marbling or percentage grading USDA Select, or USDA Choice or higher. Progeny of Hereford, Friesian, and Swedish Red and White sires did not differ in marbling score, or percentage grading USDA Select or USDA Choice or higher.

Carcasses from progeny of Angus sires had significantly greater fat thickness than progeny of Hereford sires, which in turn had significantly greater fat thickness than those of Wagyu sires. Progeny of Norwegian Red, Swedish Red and White, and Friesian sires had less fat thickness than progeny of Hereford and Angus sires. Angus and Hereford topcrosses had significantly higher yield grades than Norwegian Red, Swedish Red and White, Friesian, and Wagyu topcrosses. Wagyu and Norwegian Red sired progeny stood out for their relatively high levels of marbling but relatively low levels of fat thickness and low yield grades.

Differences among sire breeds for estimates of retail product, fat trim, and bone yield (percentage of carcass weight) and weights were significant. Progeny of Continental European breeds (Norwegian Red, Swedish Red and White, and Friesian) had significantly greater retail product yields and lower fat trim yields than progeny of British sire breeds (Hereford and Angus). Progeny of Wagyu sires did not differ from those by Continental European breeds in estimates of retail product or fat trim yield. Wagyu sired progeny had significantly lower fat trim than either Hereford and Angus sired progeny, and significantly higher retail product yields than Angus sired progeny. Carcasses from progeny of Norwegian Red, Friesian, Swedish Red and White, and Hereford sires had higher percentages of bone than carcasses from progeny of Wagyu and Angus sires.

Significant differences among breed group means for weight of retail product, fat trim, and bone at a constant age (471 d) reflect significant differences among breeds in growth rates of muscle, fat, and bone. Progeny of Hereford sires had higher lean tissue growth rates (retail product weight to a constant age) than progeny of any other sire breed. Retail product growth rates were similar and not significantly different for Angus, Norwegian Red, Swedish Red and White, and Friesian sired progeny. Wagyu sired progeny had lower weights of retail product at 471 days than progeny of any other sire breed. Fat accretion rates were similar for Wagyu, Friesian, Norwegian Red, and Swedish Red and White sired progeny, which were significantly lower than those for Hereford and Angus sired progeny. Bone weights at 471 days were significantly greater for Hereford sired progeny than for Friesian, Swedish Red and White, and Wagyu sired progeny and significantly less for Wagyu sired progeny than for any other sire breed.

Significant differences were found among sire breeds for shear force and sensory panel measures of tenderness. Sensory estimates for flavor and juiciness did not differ significantly among sire breeds. Shear force differences indicated that steaks from Wagyu and Angus sired progeny were significantly more tender than steaks from Hereford, Norwegian Red, Swedish Red and White, and Friesian sired progeny. Rankings for sensory estimates of tenderness were in close agreement with those for shear

force measures of tenderness. Sensory estimates for tenderness favored Wagyu topcrosses over all breeds except Angus and Norwegian Red. Norwegian Red, Angus, Swedish Red and White, Friesian, and Hereford topcrosses did not differ in sensory estimates of tenderness.

Postweaning growth and puberty traits of heifers. Significant differences were found among sire breeds for 400-d weight, 550-d weight, and hip heights (adjusted to 563 days of age). Angus topcross heifers had significantly heavier weight than all other breeds at 400 days and were significantly heavier than all other sire breeds except Hereford at 550 days. Hereford topcrosses ranked second in weights at 400 and 550 days, and were significantly heavier than Friesian and Wagyu topcrosses at both ages. Heifers by Norwegian Red, Swedish Red and White, and Friesian sires did not differ significantly from each other in 400-d or 550-d weights. Heifers by Wagyu sires were significantly lighter than those by any other sire breed. Hip height was significantly greater in heifers with Hereford sires than in those by any other sire breed.

Effects of sire breed were significant for percentage of heifers exhibiting pubertal estrus by early May (puberty expressed, %) and for age at puberty, but not for pregnancy rate. Percentages of heifers expressing estrus by early May were significantly less for Hereford and Wagyu topcrosses than for all other sire breeds. Angus, Swedish Red and White, and Norwegian Red and Friesian sired heifers did not differ in percentage expressing estrus. Consistent with previous results in the GPE Program, females by sire breeds that have had a history of selection for milk production under dual purpose, dairy-beef production systems (i.e.; Norwegian Red, Swedish Red and White, and Friesian) expressed puberty at significantly younger ages than those by sire breeds that have not been selected directly for milk production (i.e.; Angus, Hereford, and Wagyu). Although, significant differences existed among sire breeds for age at puberty, sire breed means for pregnancy rates were not significantly different and were not associated with sire breed means for age at puberty, as they have been in previous cycles of the program when breeds expressing larger differences in age at puberty were evaluated.

Reproduction and Maternal traits. Breed group means for reproduction and maternal performance of F_1 females are shown in Table 7 for two-year-olds. Sire breed effects were not significant for calf crop born or weaned, percentage unassisted births, calving difficulty score, survival from birth to weaning, or weaning weight per cow exposed to breeding. Significant differences among sire breeds of the F1 females were found for progeny birth and 200-d weaning weights. Progeny of Wagyu sired females were significantly lighter at birth than progeny of females by all other sire breeds. Birth weights did not differ significantly among progeny of Hereford, Angus, Norwegian Red and Swedish Red and White, or Friesian sired females. Females by Scandinavian (Norwegian Red and Swedish Red and White) sires weaned significantly heavier calves than those sired by all other sire breeds except Friesian. Progeny weaning weight of Friesian sired females did not differ significantly from those of Angus sired females but were significantly heavier than progeny of Hereford and Wagyu sired females. Progeny of Wagyu sired females were significantly lighter than those of females sired by any other sire breed.

SUMMARY

Hereford and Angus sired progeny had heavier birth weights and required more assistance at calving than Friesian, Scandinavian, or Wagyu sired progeny.

Hereford and Angus sired progeny were heavier at weaning and slaughter than progeny of Friesian or Scandinavian sire breeds, which were in turn heavier than Wagyu sired progeny.

Retail product yields (percentage of carcass weight) were significantly higher for progeny sired by Friesian and Scandinavian breeds than those sired by British breeds. However, because of offsetting effects in growth rate, progeny of Angus sires did not differ significantly from those of Friesian and Scandinavian sires in weight of retail product at 471 days of age. Retail product

growth rate was significantly greater for progeny of Hereford sires than for any other breed of sire, and significantly less for progeny of Wagyu sires than for any other breed.

Angus and Wagyu sired progeny had significantly higher levels of marbling and more favorable Warner-Bratzler shear measure of tenderness than progeny by other sire breeds. However, Angus sired progeny did not differ from other breeds in sensory panel estimates of tenderness. Wagyu and Norwegian Red topcrosses expressed relatively high levels of marbling considering their relatively low subcutaneous fat thickness.

Heifers by sire breeds that have had a history of selection for milk production under dual purpose dairy-beef production systems (i.e.; Norwegian Red, Swedish Red and White, and Friesian) expressed puberty at significantly younger ages than those by sire breeds that have not been selected directly for milk production (i.e., Angus, Hereford, and Wagyu). However, differences among sire breeds of F_1 females were not significant for pregnancy rates at 18 months or for calf crop percentages born and weaned at two years of age.

Differences among sire breeds of F1 females were not significant for calving difficulty at 2 years of age.

Weaning weights were heaviest for progeny of Scandinavian sired F_1 females, followed in order by progeny of females with Friesian, Angus, Hereford, and Wagyu sires.

TABLE 1. SIRE BREEDS USED IN THE GERMPLASM EVALUATION PROGRAM

Cycle I 70-72	Cycle II 73-74	Cycle III 75-76	Cycle IV 86-90	Cycle V 92-94	Cycle VI 97-98
		F1 crosses (Hereford or Angus dams)[a]			
Hereford	Hereford	Hereford	Hereford	Hereford	Hereford
Angus	Angus	Angus	Angus	Angus	Angus
Jersey	Red Poll	Brahman	Longhorn	Tuli	Wagyu
S. Devon	Braunvieh	Sahiwal	Salers	Boran	Norwegian Red
Limousin	Gelbvieh	Pinzgauer	Galloway	Belgian Blue	Swedish Red&White
Simmental	Maine Anjou	Tarentaise	Nellore	Brahman	Friesian
Charolais	Chianina		Shorthorn	Piedmontese	
			Piedmontese		
3-way crosses (F1 dams)			Charolais		
Hereford	Hereford		Gelbvieh		
Angus	Angus				
Brahman	Brangus				
Devon	Santa Gert.				
Holstein					

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

TABLE 2. SIRE BREED MEANS FOR PREWEANING TRAITS OF CALVES PRODUCED IN CYCLE VI OF THE GPE PROGRAM (1997 AND 1998 CALF CROPS)

Sire breed of calf	No. calves born	Gestation length days	Calving difficulty[a] score	Calvings unassisted[b] %	Birth weight lb	Calf survival %	200-d weight lb
Hereford	227	284.1	1.21	96.7	92.4	89.0	509.4
Angus	212	282.3	1.18	96.8	86.3	93.8	505.1
Average	439	283.2	1.19	96.7	89.3	91.4	507.3
Norweg. Red	150	282.6	1.05	99.6	84.9	92.2	498.6
Swed. Red & White	173	281.8	1.11	99.1	85.2	93.9	496.9
Average	323	282.2	1.08	99.4	85.0	93.0	497.7
Friesian	320	281.4	1.04	99.2	86.8	92.9	487.4
Wagyu	302	286.9	1.04	99.3	80.3	95.0	458.6
LSD.05		0.8	0.15	2.4	1.8	5.2	9.6

[a]Calving difficulty scores: 1 = No difficulty, 2 = little difficulty by hand, 3 = little difficulty with a calf jack, 4 = slight difficulty with a calf jack, 5 = moderate difficulty with a calf jack, 6 = major difficulty with a calf jack, 7 = caeserean birth, 8 = abnormal presentation.

[b]Unassisted births included calving difficulty scores of 1, and 2 = 0; scores 3, 4, 5, 6, 7 and 8 = 1.

TABLE 3. SIRE BREED MEANS FOR FINAL WEIGHT AND CARCASS TRAITS OF STEERS (ADJUSTED TO AVERAGE AGE AT SLAUGHTER, 471 DAYS)

Sire breed of steer	No.	Avg. daily gain, lb/d	Final wt., lb	Carcass wt., lb	Dress. Pct., %	Marb. score	USDA Select %	USDA Choice %	Yield grade score	Fat thickness in.	Ribeye area sq. in.
Hereford	89	3.12	1354	832	61.4	506	40	58	3.2	.45	12.80
Angus	88	3.13	1344	825	61.4	578	12	88	3.5	.53	12.58
Average	177	3.12	1349	828	61.4	542	26	73	3.3	.49	12.69
Norweg. Red	62	2.96	1299	788	60.6	542	29	71	2.8	.31	12.44
Sw. Red& White	75	2.89	1281	777	60.6	517	41	59	2.8	.31	12.29
Average	137	2.93	1290	782	60.6	530	35	65	2.8	.31	12.36
Friesian	134	2.89	1269	774	61.0	514	48	52	2.8	.34	12.45
Wagyu	128	2.69	1196	736	61.5	562	15	85	2.7	.36	12.55
LSD.05		0.10	33	20	0.5	26	15	15	.2	0.05	0.38

TABLE 4. SIRE BREED MEANS FOR ESTIMATED RETAIL PRODUCT, FAT TRIM, AND BONE YIELDS AND WEIGHTS (ADJUSTED TO AVERAGE AGE AT SLAUGHTER, 471 DAYS)

Sire breed		Retail product		Fat trim		Bone	
of steer	No.	%	lb	%	lb	%	lb
Hereford	86	61.5	514	24.9	210	14.5	120.7
Angus	88	60.1	494	26.4	218	14.0	115.1
Average	174	60.8	504	25.7	214	14.2	117.9
Norweg. Red	62	62.8	494	22.5	178	15.0	118.0
Swed.Red&White	74	62.8	487	23.1	181	14.7	114.0
Average	136	62.8	491	22.8	179	14.9	116.0
Friesian	132	62.8	485	22.9	178	14.9	115.1
Wagyu	125	62.5	460	23.5	174	14.4	106.1
LSD.05		1.1	14	1.2	12	0.5	3.7

TABLE 5. SIRE BREED MEANS FOR MEAT TENDERNESS AND SENSORY CHARACTERISTICS OF RIB STEAKS AGED FOR 14 DAYS (ADJUSTED TO AVERAGE AGE AT SLAUGHTER, 471 DAYS)

			Sensory panel[c]		
Sire breed of steer	No.[a]	WB Shear[b] lb	Tenderness score	Flavor score	Juiciness score
Hereford	86/60	8.38	6.25	4.70	5.29
Angus	88/64	7.87	6.48	4.73	5.29
Average	174/124	8.13	6.36	4.71	5.29
Norweg. Red	62/56	8.35	6.49	4.71	5.34
Sw. Red&White	74/59	8.69	6.32	4.70	5.32
Average	136/115	8.52	6.40	4.71	5.33
Friesian	132/113	8.70	6.25	4.68	5.24
Wagyu	125/107	7.82	6.60	4.76	5.39
LSD.05		.48	.26	.11	.12

[a]Number for shear force (shown left of slash) were greater than numbers for sensory evaluation (shown right of slash).
[b]Lower shear values reflect greater tenderness.
[c]Score 1 = extremely tough, bland, or dry through 8 = extremely tender, intense, or juicy.

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

Sire breed of female	No.	400-d wt lb	550-d wt lb	18- mo. ht cm	Puberty expressed %	Age at puberty[a] Act. d	Adj. d	Preg. rate %
Hereford	98	776	909	128.6	78	354	366	86
Angus	99	808	922	127.3	89	352	359	76
Average	197	792	916	128.0	83	353	362	81
Norweg. Red	61	765	892	127.1	94	340	344	87
Sw. Red&White	69	761	892	128.0	93	341	346	77
Average	130	763	892	127.6	94	340	345	82
Friesian	148	750	875	126.2	94	341	345	84
Wagyu	131	684	798	123.9	80	342	353	86
LSD.05		23	22	1.2	11	9	10	12

[a]Actual age at puberty for heifers expressing estrus (ranging from 78 to 94%) and adjusted age at puberty, adjusted to remove bias due to differences in percentage expressing 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 7. SIRE BREED MEANS FOR REPRODUCTION AND MATERNAL TRAITS OF F1 FEMALES MATED TO PRODUCE THEIR FIRST CALVES BY MARC III BULLS AT 2 YEARS OF AGE (1999-2000 CALF CROPS)

Sire		Calf crop		Calving	Unassisted	Birth	Survival	200-day weight	
breed		born	weaned	diff.[a]	births	wt.	to weaning	per calf	per cow
of female	No.	%	%	score	%[b]	lb.	%	lb	exp., lb
Hereford	97	83.7	76.4	1.85	81.4	78.7	91.1	455	348
Angus	99	71.6	65.0	1.60	83.7	77.0	90.7	482	317
Average	196	77.7	70.7	1.73	82.6	77.9	90.9	468	333
Norwg. Red	59	84.4	81.2	2.15	71.5	77.5	96.2	509	418
Sw. Red&White	66	67.5	65.5	1.55	85.2	76.4	97.3	511	337
Average	125	76.0	73.4	1.85	78.4	77.0	96.8	510	377
Friesian	148	80.5	72.5	1.60	82.1	78.3	89.8	493	356
Wagyu	129	80.5	74.6	1.82	78.3	71.7	93.2	432	325
LSD.05		13.2	13.3	0.55	13.5	3.1	8.2	18	63

[a]Calving difficulty scores: 1 = No difficulty, 2 = little difficulty by hand, 3 = little difficulty with a calf jack, 4 = slight difficulty with a calf jack, 5 = moderate difficulty with a calf jack, 6 = major difficulty with a calf jack, 7 = caeserean birth, 8 = abnormal presentation.

[b]Unassisted births included calving difficulty scores of 1, and 2 = 0; scores 3, 4, 5, 6, 7 and 8 = 1.