Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 1 *Cattleman's Day (1993-2014)*

Article 697

1994

Breed effects and retained heterosis for growth, carcass, and meat traits in advanced generations of composite populations of beef cattle (1994)

K.E. Gregory

L.V. Cundiff

R.M. Koch

See next page for additional authors

Recommended Citation

Gregory, K.E.; Cundiff, L.V.; Koch, R.M.; Koohmaraie, M.; and Dikeman, Michael E. (1994) "Breed effects and retained heterosis for growth, carcass, and meat traits in advanced generations of composite populations of beef cattle (1994)," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 1. https://doi.org/10.4148/2378-5977.2100

Breed effects and retained heterosis for growth, carcass, and meat traits in advanced generations of composite populations of beef cattle (1994)

Authors
K.E. Gregory, L.V. Cundiff, R.M. Koch, M. Koohmaraie, and Michael E. Dikeman

BREED EFFECTS AND RETAINED HETEROSIS FOR GROWTH, CARCASS, AND MEAT TRAITS IN ADVANCED GENERATIONS OF COMPOSITE POPULATIONS OF BEEF CATTLE[1]

M. E. Dikeman K. E. Gregory[2], L. V. Cundiff[2], R. M. Koch[3], and M. Koohmaraie

Summary

Retained heterosis for growth, carcass, and meat traits was estimated in F_3 generation steer progeny in three composite populations finished on two levels of dietary energy density (2.82 MCal ME and 3.07 MCal ME, and 11.5 % CP) and serially slaughtered at four endpoints at intervals of 20 to 22 days. Breed effects were evaluated in the nine parental breeds of Red Poll (RP), Hereford (H), Angus (A), Limousin (L), Braunvieh (B), Pinzgauer (P), Gelbvieh (G), Simmental (S), and Charolais (C) that contributed to the three 'composite' populations. MARC-I was l/4 B, l/4 C, l/4 L, l/8 H, and l/8 A; MARC-II was l/4 G, l/4 S, l/4 H, and l/4 A; and MARC-III was l/4 RP, l/4 P, l/4 H, and l/4 A.

Breed effects were important for growth traits; carcass traits; and retail product, fat trim and bone percentages, and weights. Even though mean slaughter weight was 126.6 lb heavier for Simmental, Gelbvieh and Charolais breeds, they did not differ from Limousins in retail product weight because of their lower dressing percentages, higher fat trim percentages, and higher bone percentages. The effects of dietary energy density were important for most traits, and little interaction occurred between breed group and dietary energy density. The MARC-III composite had lighter final and carcass weights, a lower percentage of retail product, a higher percentage of fat trim, and a higher percentage of ribeye fat than the MARC-I composite, with the MARC-II composite being generally intermediate. Retained heterosis generally was significant for each composite population and for the mean of the three composite populations for weight of retail product, fat trim, and bone. For percentage of retail product and fat trim, MARC-II and MARC-III composites had a lower percentage of retail product and a higher percentage of fat trim than the mean of the contributing breeds. Composite populations or breeds provide an opportunity to use breed differences to achieve and maintain optimum additive genetic composition for carcass composition traits and to use heterosis to increase lean tissue growth rate and(or) to increase rate of fat deposition.

Introduction

Fluctuation in breed composition between generations in rotational crossbreed-

[1]This article was derived from a research paper accepted for publication in the Journal of Animal Science. These data are from the Germ Plasm Utilization project that was conducted under the leadership of Dr. Keith E. Gregory at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE. Michael E. Dikeman is a collaborator on the carcass retail product data collection.

[2]USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE.
[3]Professor Emeritus of Animal Science, University of Nebraska, Lincoln.

ing systems can result in considerable variation among both cows and calves in level of performance for major bioeconomic traits, unless breeds used in the rotation are similar in performance. Using breeds with similar performance characteristics restricts the use of breed differences to meet requirements for specific production and marketing situations. This report focuses on breed differences in growth, carcass, and meat traits and the potential of 'composite' breeds as alternatives to crossbreeds for using heterosis and genetic differences among breeds to achieve and maintain a more optimum additive genetic (breed) composition.

Experimental Procedures

Matings were made to establish three composite populations: MARC-I (l/4 Braunvieh, l/4 Charolais, l/4 Limousin, l/8 Hereford, and l/8 Angus); MARC-II (l/4 Gelbvieh, l/4 Simmental, l/4 Hereford, and l/4 Angus); and MARC-III (l/4 Red Poll, l/4 Pinzgauer, l/4 Hereford, and l/4 Angus). F_1 is defined as the first generation that reflects the final breed composition of a composite population; F_1, F_2, and F_3 generations were mated among themselves to produce, respectively, F_2, F_3, and F_4 generation progeny. Composite populations were formed from the same sires and dams represented in the nine contributing parental breeds (Table 1).

The 1,661 steers included in this study were unselected male progeny of 21 Red Poll, 22 Hereford, 23 Angus, 24 Limousin, 26 Braunvieh, 27 Pinzgauer, 27 Gelbvieh, 19 Simmental, 25 Charolais, 39 MARC-I, 30 MARC-II, and 24 MARC-III sires. Calves were born in 1988, 1989, 1990, and 1991. Mean birth date was April 13. Because of drought in 1988, calves were weaned at an average age of 127 days vs. about 150 days for other years. Weaned calves were started on a diet of 2.65 MCal ME/kg of dry matter and 15.4 % crude protein, which was changed gradually to a backgrounding diet that was 2.69 MCal ME/kg of dry matter and 12.88% crude protein. At an average age of 203 days over the 4 years, animals of each breed group were weighed and randomly assigned to treatment, stratified by weight. Prior to assigning animals to treatment, seven to nine males in each breed group were identified as candidate replacement sires to represent a broad pedigree base. They were near the mean weights of their respective breed groups. All except candidate replacement sires were castrated. Two finishing diets were fed to each year-breed-group-subclass. Both were 11.5% crude protein. One diet had 2.82 MCal ME/kg of dry matter, and the other, 3.07.

Animals were slaughtered serially at four end points with 20 to 22 days between slaughter dates, beginning at about 13 l/2 mo of age. Final weights were taken without shrink. Carcass USDA yield and quality grade data were obtained, and one side of each carcass was fabricated into boneless retail cuts to .30 inch fat cover. Retail cuts then were trimmed free of surface fat and reweighed. Rib steaks from each carcass were cooked and sheared with a Warner-Bratzler shear device and evaluated by a trained sensory panel.

Results and Discussion

The earlier maturing breed groups (i.e., Angus, Hereford, Red Poll and MARC-III) had more fat than the later maturing breed groups (i.e., Charolais, Simmental, Braunvieh, Gelbvieh, Limousin, and MARC-I). Contrary to expectations, breed groups responded similarly to the two dietary energy densities. Further, few breed differences occurred in the 63-day span between slaughter groups 1 and 4 (data not shown).

Large differences were observed among breed groups in growth and slaughter traits (Table 1). For initial weight, Herefords were lightest. Gelbviehs, Pinzgauers, Simmentals and Braunviehs were heaviest and did not differ from each other. Charolais were heavier than Angus, Red Polls, and Limousins, which were intermediate in initial weight. For final weight, Herefords, Angus, Red Polls, and Limousins did not differ statistically. Simmentals, Charolais, Gelbviehs, and Braunviehs were heaviest and similar, whereas Pinzgauers differed only from Simmentals among the heavier breed groups. For ADG, Red Polls gained slowest but were not different from Angus, Limousins, and Pinzgauers, whereas Simmentals and Charolais gained faster than all breed groups. For carcass weight, Herefords, Red Polls and Angus did not differ. Simmentals, Charolais, Gelbviehs, and Braunviehs were heaviest and did not differ from each other. Pinzgauers and Limousins were intermediate. Limousins dressed significantly higher than all breed groups; Angus and Charolais were intermediate. Differences in dressing percentage among other breed groups were relatively small, even though some of them were significant.

Adjusted fat thickness at the 12th rib ranged from .14 inches in Gelbviehs to .46 inches in Angus (Table 2). Breeds ranked similarly in ribeye area (REA) as for carcass weight, except that Limousins had larger REA than all breed groups except Braunviehs and Gelbviehs. Differences among breed groups in estimated kidney, pelvic, heart fat (KPH) percentages generally were small, except that Red Polls had a significantly higher KPH percentage than all other breed groups. For marbling score, Limousins were lower than all breeds except Gelbviehs. Angus were higher than all breeds except Red Polls, Herefords, and Pinzgauers. Braunviehs, Simmentals, and Charolais were intermediate in marbling score and not significantly different from each other.

The MARC-III composite had lighter initial, final, and carcass weights; lower ADG; higher fat thickness; and higher marbling score than MARC-I. The MARC-II composite had a higher fat thickness and marbling score than MARC-I.

Differences among breed groups in retail product, fat trim, and bone percentages when retail product was trimmed to .3 in. fat and then to 0 in. fat are presented in Table 3. The mean differences between .3 in. and 0 in. fat trim were 4.9% for retail product, 3.6% for fat trim, and 1.2% for bone. Differences in retail product percentage between the two trim levels tended to be less in breeds with less fat (i.e., Limousins, 4.2 %) than in breeds with more fat (Herefords, 5.9%), likely because breeds like Limousin had less than .3 in. fat cover on some cuts, so less fat was removed by trimming to 0 in. Limousins had the highest retail product percentage and lowest fat trim percentage (except for Gelbviehs) and were similar to Angus and Herefords in bone percentage. Herefords, Angus, and Red Polls were similar in retail product, fat trim, and bone percentages. The range in fat trim percentage was 12.1% among breeds at 0 in fat trim, whereas the range in bone percentage was only 2.4 %. The MARC-I composites had a higher percentage of retail product and a lower percentage of fat trim than MARC-II and MARC-III composites.

Differences among parental breeds in retail product and fat trim weights when retail product was trimmed to both .3 in. and 0 in. fat are presented in Table 4. Retail product weights reflect differences among parental breeds in lean tissue growth rate. The similarity of Limousin, Simmental, Charolais, and Gelbvieh in retail product weight at 0 in. fat trim is of interest. Even though the mean slaughter weight for the Simmental, Gelbvieh, and Charolais breeds was 126.6 lb greater than that for the Limousin breed, their lower dressing percent, lower retail product percent, and higher bone percent resulted in no difference among these four breeds in retail product weight. The Herefords had the lowest retail product weight of all breed groups, followed by Angus and Red Polls, which did not differ from each other.

Longissimus steaks from Angus and Pinzgauers had lower Warner-Bratzler shear force values (more tender) than those from all other breed groups except Red Polls (Table 5). Steaks from Gelbviehs and Limousins had higher shear force values than those from all breed groups except Simmental. The three composite breed groups were not different in shear force values. Limousins and Gelbviehs had a lower percentage of fat in the longissimus muscle than other breed groups, whereas Angus, Red Polls, and Herefords had a higher percentage of fat in the longissimus muscle than most other breed groups. MARC-I composites had a lower percentage of fat in the longissimus muscle than MARC-II and MARC-III composites.

Sensory panel scores for tenderness, juiciness and flavor are presented in Table 5. Longissimus steaks from Angus and Pinzgauers were more tender than those from all breed groups. Steaks from Gelbviehs were scored less tender than those from all breed groups except Limousins and Simmentals. Ranking of breed groups for greater sensory panel tenderness agreed very closely with the ranking of breed groups for lower shear force values. Differences among breed groups for sensory panel juiciness were smaller than those for tenderness. Steaks from Angus were scored juicier than those from most breed groups; steaks from Red Polls and Herefords were scored juicier than those from some breed groups. Differences among breed groups for sensory panel flavor were too small to be of practical importance. Longissimus muscle percentage of fat was poorly related to flavor.

Although not presented in tabular form, the high energy diet resulted in heavier final and carcass weights, higher ADG, higher dressing percentage, thicker fat, larger ribeye areas, higher KPH percentages, and higher marbling scores. It also resulted in a lower percentage of retail product, higher percentage of fat trim, and lower percentage of bone. However, weight of retail product was higher for cattle on the high energy diet. The high energy diet also resulted in more fat in the longissimus muscle and lower shear force values.

Estimates of retained heterosis for growth traits and for cooler-measured carcass traits are presented in Table 6. For traits related to growth and size, retained heterosis generally was significant for each composite population and for the mean of the three composites. Retained heterosis was not observed for dressing percentage or adjusted fat thickness. Significant retained heterosis was observed for marbling score for the MARC-II composite but not for MARC-I or MARC-III composites or for the mean of the three composites.

Estimates of retained heterosis for retail product, fat trim, and bone percentages at 0 in. fat trim are presented in Table 7. For composite MARC-I, retained heterosis was not significant for retail product or fat trim but was significant for bone. For composite MARC-II, retained heterosis was significant for retail product (less), fat trim (greater), and bone (less) percentages. For composite MARC-III, retained heterosis was significant for retail product (less) and fat trim (greater). For the mean of the three composites, retained heterosis was significant for retail product (less), fat trim (greater), and bone (less) percentages.

Estimates of retained heterosis for shear force of the longissimus muscle and percentage of fat are presented in Table 7. For composite MARC-II, retained heterosis was significant (greater) for fat percentage in the longissimus muscle. Significantly greater shear force was required for composite MARC-III than for the mean of the contributing purebreds. This anomaly is interpreted to result from chance, because there is no biological basis for this observation.

Table 1. Least Square Means for Growth and Slaughter Traits

Breed Group	N	Initial Weight (lb)	Final Weight (lb)	ADG (lb/d)	Carcass Weight (lb)	Dressing Percent (%)
Red Poll	114	551	1158	2.58	695	60.0
Hereford	146	478	1118	2.72	675	60.3
Angus	118	514	1136	2.64	697	61.3
Limousin	142	531	1144	2.61	728	63.4
Braunvieh	139	602	1250	2.78	748	59.7
Pinzgauer	118	609	1228	2.65	730	59.5
Gelbvieh	150	611	1250	2.73	750	59.9
Simmental	127	604	1281	2.90	767	59.8
Charolais	126	587	1263	2.90	767	60.7
D.05[a]		24	42	.11	27	.8
MARC-I F_3	178	584	1241	2.81	761	61.2
MARC-II F_3	148	604	1263	2.81	765	60.5
MARC-III$_3$	155	560	1197	2.70	725	60.6
D.05[b]		24	43	.13	28	.8

[a]D.05 is the approximate difference between means of parental breeds required for significance.
[b]D.05 is the approximate difference between means of all breed groups required for significance.

Table 2. Least Square Means for Cooler-Measured Carcass Traits

Breed Group	Adj. Fat (inches)	REA (inches^2)	Est. KPH (%)	Marbling Score[a]
Red Poll	.30	10.8	3.3	5.3
Hereford	.44	10.5	2.4	5.2
Angus	.46	10.6	2.6	5.4
Limousin	.17	13.4	2 . 5	4.4
Braunvieh	.18	13.2	2.8	4.8
Pinzgauer	.17	12.3	2.7	5.2
Gelbvieh	.14	13.0	2.7	4.5
Simmental	.16	12.6	2.5	4.8
Charolais	.15	12.5	2.8	4.7
D.05[b]	.05	.54	.3	.3
MARC-I F_3	.23	12.9	2.9	4.8
MARC-II F_3	.32	12.1	2.9	5.1
MARC-III F_3	.36	11.5	3.1	5.3
D.05[C]	.06	.56	.3	.3

[a]4.00-4.90 = slight; 5.00-5.90 = small.
[b]D.05 is the approximate difference between means of parental breeds required for significance.
[c]D.05 is the approximate difference between means of all breed groups required for significance.

Table 3. Least Square Means for Carcass Composition (Percentages)

	Retail Product[a]		Fat Trim		Bone	
Breed Group	.30 inch[b] %	0 inch[c] %	.30 inch[b] (%)	0 inch[c] (%)	.30 inch[b] (%)	0 inch[c] (%)
Red Poll	67.8	62.6	18.6	22.4	13.6	14.9
Hereford	66.0	60.1	20.8	25.5	13.2	14.4
Angus	67.1	61.5	20.0	24.4	12.9	14.1
Limousin	76.5	72.3	10.4	13.4	13.1	14.3
Braunvieh	71.9	67.3	12.9	16.1	15.1	16.5
Pinzgauer	71.5	66.8	13.7	17.0	14.8	16.1
Gelbvieh	74.2	70.0	11.3	14.2	14.5	15.8
Simmental	72.8	68.4	12.4	15.5	14.8	16.1
Charolais	73.2	68.7	11.9	15.0	14.9	16.2
D.05[d]	1.3	1.5	1.5	1.6	.4	.4
MARC I F_3	71.9	67.2	14.4	17.9	13.7	14.9
MARC II F_3	68.3	63.1	18.3	22.3	13.4	14.7
MARC III F_3	67.2	61.9	19.2	23.3	13.5	14.8
D.05[e]	1.4	1.5	1.5	1.7	.4	.4

[a]Retail product includes steaks and roasts plus lean trim adjusted to 20% fat based on chemical analysis of lean trim.
[b]Subcutaneous and accessible intermuscular fat trimmed to .3 inches.
[c]All subcutaneous and accessible intermuscular fat removed.
[d]D.05 is the approximate difference between means of parental breeds required for significance.
[e]D.05 is the approximate difference between means of all breed groups required for significance.

Table 4. Least Square Means for Carcass Composition (Weights)

	Retail Product		Fat Trim	
Breed Group	.30 inch[b] (lb)	0 inch[c]	.30 inch[b] (lb)	0 inch[c]
Red Poll	446.5	412.6	124.4	149.7
Hereford	424.0	385.9	136.5	166.3
Angus	443.6	427.8	134.9	164.5
Limousin	528.8	499.4	73.4	93.9
Braunvieh	511.9	478.5	94.2	117.3
Pinzgauer	496.1	463.5	96.1	119.1
Gelbvieh	529.4	498.8	82.9	103.9
Simmental	527.7	495.0	93.1	115.5
Charglais	532.1	499.0	88.0	110.9
D.05[d]	18.1	17.6	12.6	14.1
MARC I F_3	521.3	486.4	105.6	131.0
MARC II F_3	497.4	459.1	134.9	164.1
MARC III F_3	464.4	427.1	135.6	164.1
D.05[e]	18.7	18.3	13.0	14.6

[a]Retail product includes steaks and roasts plus lean trim adjusted to 20% fat based on chemical analysis of lean trim.
[b]Subcutaneous and accessible intermuscular fat trimmed to .3 inch.
[c]All subcutaneous and accessible intermuscular fat removed.
[d]D.05 is the approximate difference between means of parental breeds required for significance.
[e]D.05 is the approximate difference between means of all breed groups required for significance.

Table 5. Least Square Means for Percentage of Fat, Shear Force Values and Sensory Panel Traits for the Longissimus (Ribeye) Muscle

			Sensory Panel		
Breed Group	% Fat	Shear Force, lb[a]	Tenderness[b]	Juiciness[b]	Flavor[b]
Red Poll	4.6	10.4	5.2	5.3	5.0
Hereford	4.5	11.2	5.1	5.3	4.8
Angus	4.8	9.9	5.6	5.4	4.9
Limousin	2.8	12.3	4.9	5.0	4.8
Braunvieh	3.7	11.2	5.1	5.1	4.9
Pinzgauer	4.2	9.9	5.4	5.2	5.0
Gelbvieh	3.2	12.8	4.6	5.0	4.8
Simmental	3.7	12.1	4.8	5.1	4.8
Charolais	3.4	11.5	5.0	5.1	4.9
D.05[c]	.5	.9	.3	.2	.l
MARC II	3.6	11.0	5.2	5.1	4.9
MARC II	4.3	11.2	5.0	5.2	4.9
MARC III	4.6	11.2	5.1	5.2	4.9
D.05[d]	.5	.9	.3	.2	.l

[a]Shear force required to cut through a .5 inch diameter core.
[b]Score of 8 = extremely tender, juicy and flavorful; 5 = slightly tender, juicy and flavorful; 1 = extremely tough, dry, and bland.
[c]D.05 is the approximate difference between means of parental breeds required for significance.
[d]D.05 is the approximate difference between means of all breed groups required for significance.

Table 6. Effects of Retained Heterosis on Growth and Slaughter Traits

Item	Initial Weight (lb)	Final Weight (lb)	ADG (lb/d)	Carcass Weight (lb)	Dressing Percent (%)	Adj Fat (inch)	REA ($inch^2$)	Marbling Score
Heterosis:								
MARC I[a] minus purebreds	30.2**	45.9**	.70*	29.5**	.08	-.008	.54**	-.03
MARC II[a] minus purebreds	51.2**	67.7**	.060†	42.3**	.13	.012	.43**	.15**
MARC III[a] minus purebreds	22.9**	37.0**	.055†	26.2**	.29	.012	.48**	.04
Mean heterosis:								
All composites minus purebreds	34.84**	50.27**	.062**	32.6**	.17	.004	.48**	.05

[a]F_3 generation progeny.
†P<.10.
*P.05.
**P<01.

Table 7. Effects of Retained Heterosis on Carcass Composition and Warner-Bratzler Shear Value

Item	Retail Product[a] 0 Inch[c] %	Fat Trim 0 Inch[c] %	Bone 0 Inch[C] %	Retail Product 0 Inch[b] lb	Shear Force[b] lb	Longissimus Muscle Fat %
Heterosis:						
MARC I[d] minus purebreds	-.11	.49	-.38**	18.1**	-.33	-.08
MARC II[a] minus purebreds	-1.90**	2.35**	-.45**	12.6**	-.26	.28*
MARC III[a] minus purebreds	-.89*	1.00*	-.10	10.35*	.93**	.06
Mean heterosis:						
All composites minus purebreds	-.97**	1.28**	-.31**	13.7**	.01	.09

[a]Retail product includes steaks and roasts plus lean trim adjusted to 20% fat based on chemical analysis of lean trim.
[b]All subcutaneous and accessible intermuscular fat removed.
[c]Shear force required to shear through a .5 inch diameter core.
*P<.05.
**P< .01.