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Optimal use of beef breeds and crossing systems depends on total-industry net returns, not just value of carcasses. Level of feed requirements, milk production and other performance characteristics are important in determining industry value.

Summary

This study simulated total life-cycle expenses and income under value-based marketing to arrive at predicted net returns for crossbreeding systems. The simulation used a deterministic model of totally contained beef breeding systems and evaluated 14 breeds and their crosses from biological data collected at the U.S. Meat Animal Research Center in Nebraska. Comparing beef cattle crossbreeding systems under value-based marketing will aid us in understanding the interactions of the total system. Besides value of carcasses, feed requirements, level of milk production and other characteristics are important in determining net returns.

Introduction

For the evaluation of breeds and crosses, the beef cattle industry should not simply base decisions on carcass value. Rather, consideration needs to be given to total life-cycle expenses and income. For example, breeds or crosses that have the highest carcass value might also have the highest production costs due to poorer reproduction and/or higher maintenance feed costs. The system also should evaluate a full, totally contained, sustainable, crossing system (i.e., one that contains all necessary purebred and crossbred groups). The purpose of this study was to simulate biological and then economic outcomes under value-based marketing for several breeding systems. All systems were simulated for two marketing scenarios for fed calves: equal age at slaughter and equal backfat at slaughter.

Procedure

Fourteen breeds and their crosses were simulated using biological performance derived from several data reports from the Germ Plasm Utilization and the Germ Plasm Evaluation projects, conducted at the U.S. Meat Animal Research Center near Clay Center, Neb. The 14 breeds were: Hereford, Angus, Simmental, Limousin, Charolais, Brahman, Red Poll, Gelbvieh, Maine Anjou, Braunvieh, Chianina, Brangus, Pinzgauer and Tarentaise. In addition, reports from other literature also were incorporated to set levels of individual and maternal heterosis for the simulation and to predict heifer performance from steers.

Simulations were done using a deterministic model (i.e., all performance was based on averages within a breed or cross with no variation between animals) encompassing conception through slaughter. All systems were simulated using an equal resource base. The standard resource base was an equal use of summer pasture. For the 14 pure breeds, the number of AUM's per 1,000-cow herd was simulated. The average of these 14 purebred systems with 1000 breeding females became the standard base of AUM usage. After establishing the standard base, the total number of cows in each total system, including all purebred systems, was varied to equalize use of the standard pasture resource.

This work simulated purebred, two-breed rotation, three-breed rotation, rota-terminal, and four-breed composite systems, using the 14 breeds. The rotational and rota-terminal systems were totally contained beef breeding systems. Separate breeding groups were part of the total rotational systems and were assumed to produce purebred breeding animals (bulls) needed for the rest of the system. The rota-terminal system assumed a two-breed rotation to generate replacement females plus terminal crossing to a third breed of sire to produce only slaughter animals. Thus for a rota-terminal system, there would be three purebred groups (two to produce bulls for the two-breed rotation plus one to produce bulls for the terminal cross) in addition to the crossbred groups that made up the total system. The four-breed composite was assumed to be already created, thus only one breeding group was simulated.

The system simulated conception through slaughter. Calving was in the spring, weaning was at 205 days, and calves immediately entered the feedlot for feeding until slaughter. The average days fed for the biological data from the U.S. Meat Animal Research Center was 235 days with slaughter at 440 days. Output was initially generated for an equal number of days fed (235) and equal age at slaughter (440 days). These outcomes are called "Equal Age." Purebred groups varied widely in backfat and yield grade when slaughtered at an equal age. Thus, another management scenario was simulated where genetic groups of animals were fed different numbers of days and then slaughtered at the same backfat. Outcomes under this management are called "Equal Fat." Because this required further extrapolation from the biological data base and minimizing

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the amount of extrapolation is desired, the average backfat of purebred groups in the "Equal Age" scenario was used as the slaughter endpoint in the "Equal Fat" scenario. For steers, this was .24 in, and for heifers, the endpoint was .28 in.

Numbers of steers and heifers fed directly for slaughter varied for each system and were a function of the total size of the system as determined by the constant pasture resource base, the reproductive rate and the number of breeding bulls (purebred and composite systems and segments of rotational systems) and replacement heifers needed (purebred and composite systems plus rotational segments of rotational and rota-terminal systems). Feedlot income, cowherd income, feedlot costs and cowherd costs were totaled and total income minus total costs yielded predicted net returns of each system. Various input costs and output values were derived from 10-year averages for Nebraska.

Fifteen traits were used in the simulations. Many of these 15 traits incorporated differences in 2-year-old, 3-year-old, and mature dams to help evaluate the cow herd. For the crossbreeding systems to be evaluated, individual and maternal heterosis estimates were determined for each of the 15 traits. An age distribution for the cow herd was simulated, based on reproductive rate and culling of all non-pregnant females at weaning time to produce income. All cows were assumed culled for salvage at 8.5 years of age. Calf losses were simulated at various times of the production year, and cows not nursing a calf were culled to generate income.

Traits simulated can be subdivided into growth and body weights, energy requirements, milk production, reproduction and carcass characteristics. Tables 1 (calf and cow weights, milk production, reproduction and calving difficulty), 2 (feed energy requirements), 3 (carcass characteristics and value under Equal Age slaughter), and 4 (carcass characteristics and value under Equal Fat slaughter) contain purebred values for samples of the traits. Value per pound of carcass for slaughter steers and heifers was based on yield grade, marbling and breed type using regression equa-

Table 1. Purebred animal weights (1b), milk production (lb/205 days), reproductive performance and calving difficulty used in simulations.

Breed	Birth weight weight mature dam[a,b]	200-day weigiht mature dam[a,b]	Breeding female mature weight[a]	Milk production mature dam[a]	% weaned of exposed mature dam[a]	% calving difficulty 2-year-old dam[c]
Hereford	83	431	1151	2156	83.3	49
Angus	78	465	1155	2846	84.7	32
Simmental	92	540	1332	4105	82.4	45
Limousin	86	474	1273	3258	85.2	34
Charolais	95	522	1416	3137	85.2	42
Brahman	75	517	1352	4262	84.0	7
Red Poll	85	484	1168	3752	84.4	58
Gelbvieh	91	543	1330	4045	85.1	53
Maine Anjou	92	505	1407	3876	85.4	48
Braunvieh	94	542	1326	4475	85.2	51
Chianina	92	509	1415	3117	86.4	37
Brangus	84	468	1302	3543	83.3	41
Pinzgauer	96	525	1278	4061	84.2	53
Tarentaise	82	506	1279	3783	83.2	36

[a]Data simulated for 2-year-old, 3-year-old, and mature dams; data from only mature dams shown here.
[b]Average for steers and heifers.
[c]Data simulated for 2-year-old, 3-year-old, and mature dams; data from only 2-year-old dams shown here.

Table 2. Purebred energy requirements and milk production used in the simulations.

Breed	Maintenance energy[a] Kcal/kg$^{.75}$/day	Preweaning gain energy Mcal/lb	Feedlot gain energy[b] Mcal/lb	Feedlot gain energy[c] Mcal/lb
Hereford	108	2.27	5.56	5.39
Angus	109	2.38	5.59	5.39
Simmental	121	2.55	5.32	5.39
Limousin	118	2.38	5.33	5.39
Charolais	116	2.50	5.31	5.39
Brahman	109	2.54	5.40	5.39
Red Poll	117	2.41	5.44	5.39
Gelbvieh	116	2.57	5.31	5.39
Maine Anjou	110	2.46	5.39	5.39
Braunvieh	117	2.56	5.34	5.39
Chianina	125	2.47	5.38	5.39
Brangus	109	2.37	5.40	5.39
Pinzgauer	114	2.50	5.33	5.39
Tarentaise	113	2.49	5.40	5.39

[a]Non-lactating, gestating cow; all other cow and calf simulated maintenance costs derived from this base value.
[b]Data simulated for steers and heifers; steer data shown here for "Equal Age" slaughter scenario.
[c]Data simulated for steers and heifers; steer data shown here for "Equal Fat" slaughter scenario.

Table 3. Purebred steer[a] carcass characteristics used in Equal Age (440 days) at slaughter simulations.

Breed	Yield grade	Marbling score	Carcass weight, lb	Value, $/lb
Hereford	3.32	421	675	1.05
Angus	3.46	441	697	1.04
Simmental	2.29	380	767	1.09
Limousin	1.89	343	728	1.10
Charolais	2.34	371	767	1.08
Brahman	2.91	351	743	1.05
Red Poll	3.11	430	694	1.06
Gelbvieh	2.09	353	750	1.09
Maine Anjou	2.49	368	747	1.08
Braunvieh	2.13	384	747	1.09
Chianina	2.24	317	732	1.09
Brangus	2.99	381	747	1.05
Pinzgauer	2.32	416	757	1.08
Tarentaise	2.91	393	728	1.07

[a]Heifer data were simulated from steer data.

Table 4. Purebred steer[a] carcass characteristics used in Equal Fat (.24 in) at slaughter simulations.

Breed	Days fed	Yield grade	Marbling score	Carcass weight,lb	Value, $/lb
Hereford	180	2.75	374	606	1.07
Angus	178	2.86	390	625	1.07
Simmental	301	2.75	431	860	1.07
Limousin	288	2.19	349	797	1.09
Charolais	314	2.91	431	877	1.06
Brahman	233	2.89	349	740	1.05
Red Poll	212	2.89	410	666	1.06
Gelbvieh	319	2.63	414	865	1.07
Maine Anjou	236	2.50	369	749	1.08
Braunvieh	274	2.38	414	800	1.08
Chianina	245	2.38	324	800	1.09
Brangus	229	2.94	376	739	1.05
Pinzgauer	286	2.68	459	797	1.07
Tarentaise	229	2.85	389	749	1.07

[a]Heifer data were simulated from steer data.

Table 5. Average net returns ($) under Equal Age at slaughter scenario for all crosses in a system and for selected crosses in each system.

System[a]	Average of all	Average of top 10[b]	Average of bottom 10[c]
Purebred	32,246	42,787	17,134
Two-breed rotation	41,450	51,175	28,975
Three-breed rotation	43,647	54,117	31,587
Rota-terminal	42,700	54,829	26,407
Composite	41,998	52,076	30,985

[a]All crossing systems are totally sustaining, thus including all necessary purebred groups. Rota-terminal has a two-breed rotation plus terminal cross. Composite has equal parts of four breeds. All systems have equal use of pasture resource derived from the average resource required for the fourteen 1000-cow purebred systems.
[b]Top 3 for purebreed.
[c]Bottom 3 for purebred.

tions developed in research work at Texas A&M (Griffin et al., 1989).

Results

Equal Age at Slaughter

Table 5 contains average net returns of the 14 purebreds, 91 possible (14!/[2! 12!]) two-breed rotations, 364 possible (14!/[3! 11!]) three-breed rotations, 1092 possible (14!/[2! 1! 11!]) rota-terminals, and 1001 possible (14!/[4! 10!]) composites under the Equal Age slaughter scenario. Because the systems were defined to have an arbitrary but equal pasture resource usage, net returns as presented are comparable on a relative basis. Overall, the three-breed rotation and rota-terminal were the most profitable systems under this scenario. These systems capitalize on appreciable amounts of heterosis. The four-breed composite also would have a high amount of heterosis, but it was constrained to have four breeds compared to the three-breed rotation and rota-terminal that contained three. Purebreeding was the least profitable system, losing out on the desirable benefits from heterosis.

Table 5 also contains averages for net returns of the top 10 and bottom 10 in each of the crossing systems plus averages for the top and bottom three purebreds for the Equal Age slaughter scenario. The average of all three-breed rotations was slightly higher than for all rota-terminals. But for the top 10 averages, the rota-terminal systems fared better than the three-breed rotations. Capitalizing on terminal crossing, especially with differential values of carcasses, was beneficial. Four-breed composite and three-breed rotation were the least risky systems because these were more profitable among the least profitable.

Table 6 contains the top 10 crosses for each crossbreeding system under the Equal Age slaughter scenario. Differences in net returns among the top 10 crosses within a system were not large, especially for those in the rota-terminal system. The top ten rota-terminals had five different breeds of terminal sire represented. Breeds that were included in many of the top crossing systems were: Charolais, Gelbvieh, Limousin,

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Table 6. Top ten crosses[a] in each system[b] on the basis of their net returns[c] ($) for Equal Age (440 days) at slaughter scenario.

Two-breed rotation		Three-breed rotation		Rota-terminal		Composite	
Cross	Net	Cross	Net	Cross[d]	Net	Cross	Net
CA*MA	52,876	LM*CA*MA	55,618	CA MA*TA	55,746	LM*CA*MA*TA	54,207
LM*MA	52,675	LM*MA*TA	55,330	LM MA*TA	55,580	LM*CA*GV*MA	52,959
MA*TA	52,406	CA*MA*TA	55,209	LM CA*MA	55,185	LM*GV*MA*TA	52,709
LM*CA	52,254	LM*CA*TA	55,087	GV MA*TA	55,107	CA*GV*MA*TA	52,637
CA*TA	52,063	LM*GV*MA	53,715	SM MA*TA	54,831	LM*CA*GV*TA	52,550
LM*TA	51,829	CA*GV*MA	53,515	GV CA*MA	54,701	SM*LM*CA*MA	51,274
GV*MA	49,821	LM*CA*GV	53,482	SM CA*MA	54,421	LM*CA*MA*PG	51,211
CA*GV	49,486	GV*MA*TA	53,141	BV MA*TA	54,315	LM*CA*MA*BV	51,206
LM*GV	49,468	LM*GV*TA	53,134	CA AN*MA	54,266	AN*LM*CA*MA	51,015
GV*TA	48,876	CA*GV*TA	52,938	CA GV*MA	54,135	SM*LM*MA*TA	50,989

[a]Breed codes: AN = Angus, BV = Braunvieh, CA = Charolais, GV = Gelbvieh, LM = Limousin, MA = Maine Anjou, PG = Pinzgauer, SM = Simmental, and TA = Tarentaise.
[b]All systems are totally sustaining, including necessary purebred groups.
[c]Net returns based on an equal use of pasture resources (average of 1000-cow purebred systems) and can be compared on a relative basis.
[d]Terminal sire breed and two-breed rotation dam breeds.

Maine Anjou and Tarentaise. On purebred carcass value, these five breeds averaged 1.6% higher value per pound than the other nine breeds.

Equal Fat at Slaughter

Table 7 contains the average net returns of the 14 purebreds, 91 two-breed rotations, 364 three-breed rotations, 1,092 rota-terminals, and 1,001 composites under the Equal Fat slaughter scenario. Overall, the three-breed rotation and composite were the most profitable systems under this scenario. These systems capitalize on appreciable amounts of heterosis, with substantial benefits coming through increased reproductive performance and increased rate of growth. Consistent with the Equal Age slaughter scenario, purebreeding was the least profitable system, losing out on the desirable benefits from heterosis.

Table 7 also contains the averages for net returns of the top 10 and bottom 10 in each of the crossing systems plus the averages for the top and bottom three purebreds for the Equal Fat slaughter scenario. The averages of all three-breed rotations and of all composites were slightly higher than for all rota-terminals. But for the top 10 averages, the rota-terminal systems fared better than the three-breed rotations and the composites. Being able to capitalize on terminal crossing, gaining the benefit of larger calf size relative to cow size in some systems, was beneficial. Four-breed composite and three-breed rotation were the least risky systems because these were more profitable among the least profitable.

Table 8 contains the top 10 crosses for each of the crossbreeding systems under the Equal Fat slaughter scenario. Differences in net returns among the top 10 crosses within a system were not as large in the composites as in the systems that used rotational crossing. The top 10 rota-terminals had six different breeds of terminal sire represented. Breeds that were included in many of the top crossing systems were: Angus, Charolais and Gelbvieh. On purebred carcass value, these three breeds averaged slightly less value per pound than the other 11 breeds. Thus value per pound of carcass had little or no influence on the value of breeds in crossing systems in the Equal Fat slaughter scenario.

Choices among breeds to use in crossing systems should be based on their overall contribution to total system net returns. There were 78 different combinations of crossbred dams for each terminal sire in the rota-terminal systems. Table 9 lists average net returns for the top 10 breeds when used as terminal sires in the rota-terminal systems and the top 10 two-breed rotations used for dams in the rota-terminal systems under the Equal Fat slaughter scenario. As terminal sires, Simmental, Gelbvieh and Charolais ranked as the top breeds. Angus was included as part of the dam-breed rotation in all of the top 10 rota-terminal systems.

Table 7. Average net returns ($) under Equal Fat at slaughter scenario for all crosses in a system and for selected crosses in each system.

System[a]	Average of all	Average of top 10[b]	Average of bottom 10[c]
Purebred	36,077	45,662	20,703
Two-breed rotation	49,121	60,459	36,411
Three-breed rotation	55,404	69,711	38,622
Rota-terminal	51,771	70,757	32,992
Composite	53,971	68,757	38,783

[a]All crossing systems are totally sustaining, thus including all necessary purebred groups. Rota-terminal has a two-breed rotation plus terminal cross. Composite has equal parts of four breeds. All systems have equal use of pasture resource derived from the average resource required for the fourteen 1000-cow purebred systems.
[b]Top 3 for purebreed.
[c]Bottom 3 for purebred.

Discussion

As with any simulation, results depend on the assumed models and data as well as the marketing system. All systems that were simulated had a constant amount of summer pasture usage for the cow-calf herd. This resulted in varying numbers of cows for the different crossbred and purebred groups. For

Table 8. Top ten crosses[a] in each system[b] on the basis of their net returns[c] ($) for Equal Fat at slaughter scenario.

Two-breed rotation		Three-breed rotation		Rota-terminal		Composite	
Cross	Net	Cross	Net	Cross[d]	Net	Cross	Net
AN*CA	64,906	AN*CA*GV	74,250	SM AN*GV	73,559	AN*LM*CA*GV	70,671
AN*GV	63,872	HE*CA*GV	72,366	GV AN*CA	73,335	AN*SM*CA*GV	69,586
HE*CA	62,598	AN*LM*CA	70,352	CA AN*GV	73,236	AN*CA*GV*MA	69,540
HE*GV	61,613	AN*LM*GV	69,961	SM AN*CA	72,577	HE*LM*CA*GV	69,194
CA*MA	60,345	AN*SM*CA	69,291	BV AN*GV	69,891	AN*CA*GV*PG	68,747
CA*TA	59,589	AN*SM*GV	68,759	LM AN*GV	69,649	HE*CA*GV*MA	68,544
GV*MA	58,784	CA*GV*MA	68,596	BV AN*CA	69,354	AN*CA*GV*TA	68,526
GV*TA	57,897	HE*LM*CA	67,956	LM AN*CA	69,129	HE*SM*CA*GV	68,479
AN*LM	57,729	CA*GV*TA	67,855	PG AN*GV	68,446	AN*CA*GV*BV	68,144
AN*SM	57,261	AN*CA*PG	67,724	GV AN*MA	68,390	HE*AN*CA*GV	67,929

[a]Breed codes: AN = Angus, BV = Braunvieh, CA = Charolais, HE=Hereford, GV=Gelbvieh, LM = Limousin, MA = Maine Anjou, PG = Pinzgauer, SM = Simmental, and TA = Tarentaise.
[b]All systems are totally sustaining, including necessary purebred groups.
[c]Net returns based on an equal use of pasture resources (average of 1000-cow purebred systems) and can be compared on a relative basis.
[d]Terminal sire breed and two-breed rotation dam breeds.

Table 9. **Top ten terminal-sire breeds and top ten dam-breed rotations for net returns ($) averaged across rota-terminal systems[a] for Equal Fat at slaughter scenario.**

Terminal Sire	Net Returns	Dam Rotation	Net Returns
Simmental	57,085	Angus*Gelbvieh	66,052
Gelbvieh	56,429	Angus*Charolais	66,041
Charolais	55,364	Hereford*Gelbvieh	61,917
Braunvieh	54,270	Hereford*Charolais	61,141
Limousin	53,673	Charolais*Maine Anjou	60,707
Pinzgauer	53,064	Angus*Maine Anjou	60,474
Chianina	51,613	Gelbvieh*Maine Anjou	60,353
Maine Anjou	51,362	Angus*Pinzgauer	59,664
Tarentaise	51,352	Angus*Simmental	59,587
Brangus	49,985	Angus*Limousin	59,571

[a]All systems are totally self sustaining, including necessary purebred groups.

example, the number of breeding females including replacement heifers, set to average 1,000 total breeding females, ranged in the purebreeding systems from 915 for Chianina to 1,216 for Hereford. Likewise, numbers of animals sold for income (cull females from the reproducing herd and fed steers and heifers) ranged widely too.

Several slaughter/marketing endpoints are possible. The "easiest" endpoint to simulate was the Equal Age at slaughter (440 days). Because the biological data on feedlot performance and carcass characteristics were available on a constant-time basis, simulation was relatively straightforward. The Equal Age scenario also is the easiest to follow for a producer trying to make comparisons using real, not simulated, cattle: It is very easy to designate a fixed number of days on feed and age at slaughter and then follow that. But, the range in carcass fatness at the Equal Age endpoint was large in the systems simulated under that scenario (e.g., purebred steers ranged in yield grade from 1.89 to 3.46, Table 3). Thus, the Equal Age scenario is probably not a realistic scenario for comparing possible performance of different systems.

The Equal Fat (.24 in for steers and .28 in for heifers) is more realistic and provides a much better basis for comparison. Producers can, through use of ultrasound or visual appraisal and experience, identify animals that are at the desired endpoint with reasonable accuracy. The differences between breeds and crossing systems in carcass value per pound are diminished when carcasses have the same outside fat. A possible weakness of the simulations under this Equal Fat scenario is linear adjustments, unique for each breed, were used to derive the carcass characteristics in Table 4 from those in Table 3. Because there were wide differences in backfat when slaughtered at 440 days of age, large differences then had to be simulated in days on feed to attain the target Equal Fat endpoints. Note in Table 4, that the different breeds of steers varied from 178 days on feed (slaughter at 383 days old) to 319 days of feed (slaughter at 524 days old).

Variation in value of slaughter animals from the feedlot was important in both scenarios but in different ways. The correlation between the average net returns for terminal sire breeds in rota-terminal systems and the value per steer was .94 in the Equal Age scenario and .96 in the Equal Fat scenario. But the correlation between the average net returns of terminal sire breeds in rota-terminal systems and the price per pound of carcass was .85 in the Equal Age scenario and only .31 in the Equal Fat scenario. Thus under an Equal Fat scenario, price per pound of carcass had very limited influence on net returns for the system.

Yet another marketing scenario could be examined, but it would require even further extrapolation and assumption. Assigning slaughter endpoints for breeds and crosses based on maximizing net returns would appear to be the most useful for ultimate decision-making in our industry. This would require assessing net returns for each cross in each system for variable days on feed, and then maximizing to set the endpoint. In the absence of this other scenario, net returns under the Equal Fat endpoint is our most useful scenario for making industry breeding decisions.

Breeds with high maintenance energy requirements generally did not surface as top maternal-use breeds. Cow size was not an important determiner of net returns for maternal use. Likewise, breeds with higher milk production levels did not rank well for maternal use. Breeds with the heavier slaughter weights at the target backfat ranked as the top terminal-sire breeds.

A marketing system that assigns "value" to individual carcasses and relays this information back to producers will affect choices of crossing systems plus influence selection and management decisions. By comparing beef cattle crossbreeding systems assuming value-based marketing we can better understand the interactions of the total system.

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