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THE OPTIMUM COW - WHAT CRITERIA MUST SHE MEET?[1]

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INTRODUCTION

I would like to take poetic license and change the title of this presentation to Search for the Elusive Optimum Cow because she is indeed an elusive beast. I have searched for her for over 20 years. I have not yet found her, but I believe I am getting close. During this search, I have heard her defined in numerous ways: the high performance cow, the mini-care cow, the low-maintenance cow, and the biologically efficient cow, to mention a few. The latter definition served as the focal point of The Beef Cow Efficiency Forum , held in 1984 in Colorado State University and Michigan State University (Ritchie and Hawkins, 1984). The purpose of this conference was to review the research that had been conducted to date on beef production efficiency. The ultimate objective was to identify potential means for improving beef production efficiency, particularly in the cow-calf segment of the industry.

BIOLOGICAL EFFICIENCY

Efficiency can be expressed in two ways: (1) biological efficiency and (2) economic efficiency. Economic efficiency was covered only lightly in the 1984 Forum because up to that time research conducted on the subject was somewhat limited.

Dickerson (1984) estimated that an average of only 6% of the total life cycle dietary energy expended in beef production is used for protein deposition in market progeny. Pork and broiler chicken production are much more efficient at 14% and 21%, respectively, although it should be noted that a high percentage of the total life cycle diet used in beef production is composed of high-fiber forages which cannot be utilized by monogastric species such as swine, poultry, and humans. Nonetheless, it remains clear that beef production si a relatively inefficient process from the standpoint of total energy expenditure. This begs the question, Why is it inefficient?

Maintenance

One explanation for the energetic inefficiency of beef production is the high cost of maintenance. At the 1984 Forum, it was reported that 71% of the total dietary energy expenditure in beef production is used for maintenance and that 70% of the maintenance energy is required for the

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cow herd (Johnson, 1984). Therefore, a staggering 50% of the total energy expended in producing beef is used for maintenance of the cow. Research has indicated that the genetic variation for maintenance energy
requirement of beef cows is moderate to high, which suggests there may be opportunities to select for more biologically efficient cows (Anderson, 1980; Carstens *et al*., 1989; DiConstanzo *et al*., 1990). Unfortunately, there is currently no simple and inexpensive method for evaluating the maintenance requirements of individual cattle.

U.S. MARC workers (Farrell and Jenkins, 1984) reported that breedtypes differ in their maintenance requirement (Table 1). Not only did the heavier-milking breeds, Jersey and Simmental, exhibit greater maintenance needs during lactation but during the dry period as well. Texas researchers later reported similar results (Solis *et al*., 1988). In a review of the literature, Farrell and Jenkins (1985) made the following important statement: Research results indicate a positive relationship between maintenance requirements and genetic potential for measures of production (e.g., rate of growth, milk production, etc.). Available data also suggest, possibly as a consequence of increased maintenance requirements, that animals having genetic potential for high productivity may be at a disadvantage in a more restrictive environment. They went on to propose that the increased maintenance requirement of high producing animals can be largely accounted for by their increased mass of visceral organs, especially the gastrointestinal tract and liver, which have a very high rate of energy expenditure. Furthermore, the increased lean tissue mass in heavier-muscled animals may result in a higher energy expenditure because research has shown that more energy is required to maintain a given weight of body protein than a comparable weight of body fat (Pullar and Webster, 1977; Thompson *et al* 1983; DiConstanzo *et al*., 1990).

Table 1. Estimates of metabolizable energy (ME) required for maintenance of four biological types of nonpregnant, nonlactating cows»

Breed of cow	Maintenance requirement (kilocalories ME per kg metabolic body weight per day)
Angus x Hereford	130
Charolais x British	129
Jersey x British	145
Simmental x British	160

[a] Farrell and Jenkins, 1984. J. Anim. Sci. 58:234.

Based upon these studies, and those of other researchers, high maintenance cows tend to have the following characteristics: high milk production, high visceral organ weight, high body lean mass, low body fat mass, high output, **and** high input. Conversely, low maintenance cows tend to be: low in milk production, low in visceral organ weight, low in body lean mass, high in body fat mass, low output, **and** low input. All of this implies that there is a need for balance based upon the production environment and the market requirements for a given region and/or for a given farm or ranch.

Measures of Biological Efficiency

The measures of beef cow biological efficiency up to weaning time that have been commonly used in research studies include the following: (1) lb calf weaned per cow exposed; (2) lb calf weaned per cow exposed per lb cow weight; (3) lb calf weaned per cow exposed per unit of feed energy consumed. In studies that have involved retained ownership up to slaughter time, measures of efficiency have included: (1) lb slaughter progeny weight per unit of feed energy consumed by cow and slaughter progeny; (2) lb carcass weight per unit of feed energy consumed by cow and slaughter progeny; (3) lb edible beef per unit of feed energy consumed by cow and slaughter progeny. In some retained ownership trials, reproductive rate was included in the efficiency equation, whereas in others it was not.

Summary of Beef Cow Efficiency Forum

1. Measures of mature cow size (weight, height, etc.) are not correlated with biological efficiency.
2. Acceptable market weight range should be a major consideration when decisions are made regarding breed size and mating systems.
3. Large differences in reproductive rate have a profound impact on cow efficiency and tend to over-ride all other factors including calf weight, feed consumption, etc.
4. Under a liberal feed supply and a relatively stress-free environment, there are no consistent differences between biological types in efficiency, but there is a tendency for larger, heavier-milking types to be more efficient than small to moderate types.
5. Under a restricted feed supply and/or a stressful environment, biological types having moderate size and moderate milk tend to be better adapted and excel larger, heavier-milking types in efficiency.

The latter two conclusions were confirmed in an extensive 5-year study by Jenkins and Farrell (1994) in which they compared biological efficiencies of nine pure breeds of mature cows fed year-round on one of four different levels of dry matter. The cows were mated to have purebred calves. Biological efficiency was expressed as grams (g) of calf weaned per kilogram (g) of dry matter intake per cow exposed. Table 2 shows that if dry matter intake increased from 3,500 to 7,000 kg per cow per year, there was a dramatic change in the efficiency of the breeds. For example, at 3,500 kg, Red Poll and Angus were the most efficient breeds, but at 7,000 kg, they ranked considerably lower. Conversely, Simmental, Charolais, Gelbvieh, Braunvieh, and Limousin improved markedly when their intake went from 3,500 to 7,000 kg. Morris *et al.* (1993) reported a similar genotype by environment interaction for 11 breeds differing in genetic potential for production in three geographical locations. Although not shown here, Jenkins and Farrell (1994) calculated the dry matter intake required to maximize efficiency for each of their nine breeds. When this was done, there was a wide range in intake (3,790 to 8,009 kg) but a relatively narrow range in efficiency (35.1 to 47.1 g) among breeds.

Table 2. Predicted biological efficiency at varying dry matter intakes for nine breeds of cattle[a].		
	Dry matter intake, kg/cow/year	
Breed	3,500	7,000
	g calf weaned/kg DM/cow exposed	
Angus	39	17
Braunvieh	33	42
Charolais	27	45
Gelbvieh	29	36
Hereford	30	13
Limousin	33	42
Pinzgauer	38	44
Red Poll	47	24
Simmental	26	42

[a] Adapted from Jenkins and Farrell, 1994. J. Anim. Sci. 72:2787.

ECONOMIC EFFICIENCY

Since the 1984 Beef Cow Efficiency Forum, a number of research teams have included measures of economic efficiency in the design of their experiments.

Merlyn Nielsen and his colleagues at the University Nebraska conducted a classic study on economic efficiency of three biological types of cows that differed in milk production but were similar in body size (Van Oijen *et al*., 1993). Low milk cows were Hereford x Angus crosses, medium cows were Red Poll x Angus crosses, and high cows were Milking Shorthorn x Angus crosses. All three groups were fed in a manner that allowed them to express their milk production potential. Results are summarized in Table 3.

Table 3. Economic efficiency of beef production from three milk groups[a].			
		Sale time	
Cow milk group	205-d milk prod., lb[b]	Weaning	Slaughter
		$ output/$100 input	
Low	2833	90.3	99.5
Medium	3599	89.2	96.5
High	4143	88.1	95.3

[a] VanOijen *et al.*, 1993. J. Anim. Sci. 71:44.
[b] Cow 4 years and older.

Measure of economic efficiency was the ratio of value of output per $100 of total input costs. If calves were sold at weaning time, the spread between milk groups was relatively narrow, but favored the low and medium groups over the high group. If progeny were sold as finished cattle, rank of the groups remained the same, but the spread among them was greater than at weaning time. It should be noted that the low cows were actually relatively good milkers by industry standards. Average production of mature cows over a 205-day lactation was nearly 14 lb per day. In general, a level of 12 lb milk per day could be considered adequate to raise a thrifty calf having an acceptable weaning weight (Notter, 1984).

Table 4 demonstrates the effect of cow culling age on efficiency (Kress *et al.*, 1988). The measure of economic efficiency was $ cost per 100 lb of slaughter progeny weight. This study illustrates that longevity (stayability) has economic value. Cost of production declined as cows stayed in the herd for a greater number of years. Several breed associations are now including EPDs for stayability in their cattle evaluation program and other associations are considering it.

Table 4. Effect of cow culling age on beef herd efficiency[a].

	Measure of efficiency	
Maximum cow culling age, years	Biological (lb TDN/lb slaughter wt)	Economic ($ cost/cwt slaughter wt)
7	10.09	74.83
9	9.78	72.12
11	9.55	69.39
13	9.30	68.03
15	9.10	67.57

[a] Kress *et al.*, 1988. J. Anim. Sci. 66(Suppl. 1):175.

Data in Table 5 are adapted from an Agriculture Canada study which placed an economic value on the contribution of various traits to net income per cow. Conception rate, calving rate, and calf mortality ranked ahead of other traits in their effect on net income. These results are in agreement with data in Table 6, which summarizes results form two studies, one in the U.S. (Melton, 1994) and another in Australia (Barwick and Nicol, 1993). In both cases, the relative value of reproductive traits was approximately 50% of the total. Table 6 likewise illustrates the importance of reproduction on economic value (Lust, 1989). In this study, adjusting total cost per lb of retail yield for weaning percentage resulted in a significant re-ranking of the selected Hereford group from first to fourth. This group had undergone single-trait selection for yearling weight for a period of 20 years, which eventually resulted in extremely high birth weights, increased calf losses, and a lower weaning rate. MacNeil *et al*. (1994) and MacNeil and Newman (1994) reported that relative economic value of traits varies according to mating system as well as breedtypes or strains used in the mating system. Their research showed that maternal strains improve profitability through increased female fertility and calf survival, reduced cow size, and easier fleshing. In achieving maximum profitability, these strains sacrifice potential for growth and carcass cutability. Improvement in profitability in terminal sire strains results from increased male fertility, calf survival, genetic potential for growth, and carcass cutability.

Table 5. Contribution to various beef cattle traits to net farm income[a].

Trait (1% increase)	Contribution to net farm income $/cow
Conception rate	6.34
Winter feed	-1.28
Calving rate	3.59
Birth weight	0.46
Difficult calvings	-1.80
Post-natal calf death loss	-3.59
Weaning weight	3.30
Price of steer calves	3.30

[a] Adapted from Agriculture Canada data.

Table 6. Relative value of beef industry traits (weighted for economic value).

Industry phase	USA Melton (1994)	Australia Barwick and Nicol (1993)[a]
Reproduction	47	50
Growth	23	27
Product	30	23[b]
	100	100

[a] Courtesy of Gibb (1995).
[b] Marbling not included as a value-determining trait.

Table 7. Effect of 20 years of selection and crossbreeding, total cost/retail yield».

		Total cost/lb retail yield	
		Unadjusted for reproduction rate	Adjusted for reproduction rate
Breeding group	% calves weaned	— Dollars/lb and rank —	
Unselected Hereford	86	1.42 (4)	1.56 (3)
Selected Hereford	74	1.35 (1)	1.65 (4)
Her x Ang x Sh	89	1.38 (2T)	1.49 (2)
Sim x Geib X Hol	91	1.38 (2T)	1.47 (1)

[a] Adapted from Lust, 1989. M.S. Thesis, Michigan State University, East Lansing, MI.

Biological types of cows may change rank in profit when raised in different environments (Table 8). In this study (Smith, 1987a,b), three breedtypes were maintained in each of two environments: Brandon, Manitoba, a fertile mixed farming region where feed resources are relatively abundant, and Manyberries, Alberta, a more stressful environment where feed resources are more restrictive. The Brandon environment allowed a relatively heavy-milking biological type, the _-Simmental, to emerge as the most profitable cow group. But in the more stressful Manyberries environment, a moderate-milking biological type, the _-Charolais, surpassed the Simmental cross as the most profitable group.

Table 8. Net income per cow relative to Hereford x Angus crosses[a].

Breed of cow	Location: Manitoba	Location: Alberta
	Net income/cow relative to A x H, $	
Angus x Hereford	0	0
Charolais x British	+16	+19
Simmental x British'	+28	+9

[a] Adapted from Smith *et al*., 1987. Agric. Canada Tech. Bull. Nos. 121071 and 121072.

Jim Wilton s research group at the University of Guelph (Armstrong *et al*., 1990) evaluated annual net returns (income minus variable costs) for four mating systems and two resource constraints, feed supply (198 tons dry matter/year) or herd size (100 cows). Results are shown in Table 9. When feed supply was the resource constraint, the range in average annual net return was only $778 ($9,292 vs. $8,514). When herd size was constrained, there was a change in rank and the spread in net return between larger and smaller breedtypes became wider.

Table 9. Annual net returns for 5 mating systems and 2 resource constraints[a].

Mating system	Feed supply constraint (198 T. DM)	Herd size constraint (100 cows)
	Annual net returns and rank	
Purebred Herefords	$8,846 (3)	$14,351 (4)
Small rotational cross (Ang x Gelb x Pinz x Tar)	$9,192 (2)	$17,970 (3)
Large rotational cross (Char x M-A x Sim)	$9,292 (1)	$20,371 (1)
Large rotational cross cows Mated to Angus sires	$8,514 (4)	$18,285 (2)

[a] Armstrong *et al*., 1990. J. Anim. Sci. 68:1857.

In a simulation study, North Carolina State University scientists (Lamb and Tess, 1989) estimated total gross income generated by various mating systems in a small 30-cow, one-bull herd over a 21-year time period (Table 10). Crossbreds or composites exceeded purebreds by 9 to 14%. Three-breed rotations were 4% higher in gross income than 2-breed rotations. A four-breed composite produced only slightly less income than the 3-breed rotations. Interestingly, there was little difference between natural service and A.I. systems. But this is understandable because, in many instances, natural service bulls are direct sons of heavily-used A.I. sires.

Table 10. Total gross income from various mating systems over a 21-year period in a one-bull 30-cow herd[a].

Mating system	Total gross income, $ (PB = 100)
Purebred	100[c]
2-breed rotation (natural service)[b]	109[d]
3-breed rotation (natural service)[b]	113[d,e]
2-breed rotation (A.I.)	110[d,e]
3-breed rotation (A.I.)	114[e]
4-breed composite	112[d,e]

[a] Lamb and Tess, 1989. J. Animal Sci. 67:28.
[b] Natural service; sire-breed changed every 4 years.
[c,d,e] Means within column differ ($P < .05$).

In a subsequent simulation study, Tess *et al*. (1993a,b) compared the economic efficiency of three mating systems (purebred, 2-breed rotation, and 3-breed rotation) using five different breeds (Angus, Charolais, Hereford, Limousin, and Simmental) for a 100-cow herd in the southeastern U.S. As shown in Table 11, rotational crossbreeding reduced the cost of producing a pound of steer calf equivalent weight at weaning time by 15% ($0.87 vs. $1.02/lb). The average cost of the ten 2-breed rotations was identical to that of the ten 3-breed rotations. Using these data, together with assumptions based on data from composite populations at U.S. MARC (Gregory *et al*., 1992), this author estimated the cost of producing a weaned steer calf in 2- and 3-breed composite systems at $0.91/lb. However, this value may be a slight over-estimate because it was assumed in my calculations that total annual cost in composite systems would be identical to that in the comparable rotational systems. In reality, annual costs may be slightly lower in composite systems than costs in rotational systems using the same breeds.

Table 11.Economic efficiency of various mating systems (cow-calf production)[a].	
Mating system	Production cost/lb steer calf equivalent wt sold, $/lb
Purebreds (average of 5)[b]	1.02
2-breed rotations (average of 10)	0.87
3-breed rotations (average of 10)	0.87
2-breed composite[c]	0.91
3-breed composite[c]	0.91

[a] Tess *et al*., 1993a. Montana Agric. Expt. Sta. Publ. Vol. 10, Issue 1.
[b] Purebreds: Angus, Charolais, Hereford, Limousin, Simmental.
[c] Estimated from data by Tess *et al*., 1993a and Gregory *et al*., 1992).

Table 12 shows that if calves in these systems were fed to Low Choice finish, the rotational systems had a 13% advantage ($0.91 vs. $1.04) in dollar input cost per dollar carcass value over the average of the purebreds. An examination of results of specific breed crosses revealed the following:

1. When calves were sold at weaning time:
   A. Among 2-breed rotations, British x British crosses were most economically efficient, followed by British x Continental crosses.
   B. Among 3-breed rotations, those using 2 British breeds and 1 Continental were most Efficient, followed by those using 2 Continental and 1 British.
2. When calves were fed to Low Choice finish and priced on carcass value and **no penalties** for light or heavy weight carcasses:
   A. Among 2-breed rotations, those using either 1 or 2 Continental breeds were more economically efficient than British x British crosses.
   B. Among 3-breed rotations, it made little difference whether 1, 2, or 3 Continental breeds were used in the cross.
3. When calves were fed Low Choice finish and priced on carcass value, **including** discounts for light and heavy weight carcasses as is the normal practice in most U.S. market channels:
   A. Among 2-breed rotations, British x British crosses were most economically efficient, followed by British x Continental crosses.
   B. Among 3-breed rotations, it made little difference whether 2 British or 2 Continental breeds were used in the cross.
4. When calves were fed to Low Choice finish and priced on the basis of lean product weight, crosses using Charolais and/or Simmental were more economically efficient than other 2- or 3-breed combinations.

Table 12. Economic efficiency of integrated beef production (fed to Low Choice finish)[a].

Mating system	$ input cost/$ carcass value, $/$[b]
Purebreds (average of 5)[c]	$1.04
2-breed rotations (average of 10)	$0.91
3-breed rotations (average of 10)	$0.91

[a] Tess *et al*., 1993a. Montana Agric. Expt. Sta. Publ. Vol. 10, Issue 1.
[b] Heavy and light carcasses were discounted.
[c] Purebreds: Angus, Charolais, Hereford, Limousin, Simmental.

Montana workers (Davis *et al*., 1994) reported the results of a well-designed simulation experiment which was based upon data from a 10-year study involving five biological types of cows at the Havre Research Center in north central Montana, a region that is typical of a northern range semi-arid environment. In an earlier paper, Kress *et al*. (1990) reported that biological efficiency (calf weaning wt/cow exposed/unit cow wt) of these five cow types tended to favor _-Simmental cows over the other breedtypes. They were closely followed by _-Simmental, _-Simmental, straightbred Hereford, and Angus x Hereford.

As shown in Table 13, when there were no resource constraints, economic efficiency, expressed as annual net profit per cow exposed, was highest for the two F_1 groups, Angus x Hereford and Simmental x Hereford, followed by the _- and _-Simmental groups, respectively. When ranch size was set at 2,700 AUM (animal unit months) of range forage (Table 14), it was necessary to adjust herd size in accordance with biological type. Nevertheless, rank of the cow breed groups in annual net profit to the ranch did not change from their rank in Table 13. This study could be summarized as follows:

A. Calf weight weaned per cow exposed was closely related to net profit.
B. Interestingly, feed energy consumed per lb of total weight sold (weaned calves + cull cows) was not closely related to profit.
C. Minimizing feed input per unit of output did not necessarily enhance net profit. This led the authors to propose that recommendations based on measures of energy conversion may be questionable.
D. F_1 dams (A x H and S x H) yielded consistently higher profits than either straightbred Herefords or _-Simmentals, with _-Simmentals being intermediate.
E. Maternal heterosis effects on increasing profit were **large** and highly significant.
F. Percentage increase in dollar output from maternal heterosis was only half negated by increased feed costs (25 vs. 12%).

G. Maternal breed effects were **much smaller** than maternal heterosis effects and generally were not significant.

H. Substituting Simmental dams for Hereford dams increased annual cost per cow exposed and reduced longevity, but was offset by greater output, resulting in no significant difference in profit.

Because of the beef industry s stated need for a dramatic improvement in uniformity and consistency, one is occasionally lulled into thinking about abandoning crossbreeding and returning to straightbreeding. However, the compelling evidence in this study favoring the use of the crossbred cow as a means of harvesting the significant economic benefits of maternal heterosis quickly dispels that notion.

Table 13. Economic performance of five biological types of cows (no resource constraints)[a].

Dam breed group	Total cost per cow exposed, $/year	Net profit per cow experiment, $/year
Angus x Hereford	412[d]	55[b]
Hereford x Hereford	475[b]	-23[e]
_ Simmental, _ Hereford	425[c,d]	34[c,d]
_ Simmental, _ Hereford	437[c]	46[c,d]
_ Simmental, _ Hereford	482[b]	19[d]

[a] Davis *et al*., 1994. J. Animal Sci. 72:2591.
[b,c,d,e] Means within columns differ (P < .05).

Table 14. Economic performance of five biological types of cows (fixed forage resource base)[a,b].

Dam breed group	Herd size, cows exposed/year	Net profit, $/year
Angus x Hereford	340[e]	13,935[c]
Hereford x Hereford	381[c]	-8,947[f]
_ Simmental, _ Hereford	357[d]	7,853[d]
_ Simmental, _ Hereford	330[f]	10,407[c,d]
_ Simmental, _ Hereford	334[e,f]	2,068[e]

[a] Davis *et al*., 1994. J. Animal Sci. 72:2591.
[b] Ranch size set at 2,700 AUM of range forage.
[c,d,e,f] Means within columns differ (P < .05).

Results of another study conducted by the Montana research team are summarized in Table 15 (Davis *et al*., 1995; Hirsch *et al*., 1995; Kress *et al*., 1995). Three breedtypes of cows, similar in body size, are maintained at the Havre Research Center: (1) straightbred Herefords; (2) Hereford x Tarentaise; (3) straightbred Tarentaise. As shown in Table 15, the F_1 and straightbred Tarentaise groups were heavier milking and produced more lbs of weaned calf than the straightbred Hereford group. Interestingly, the three groups did not differ in fecal output. Because fecal output is related to dietary intake, this finding implies that the three groups were similar in forage intake and that the F_1 and straightbred Tarentaise groups were more biologically efficient than the straightbred Hereford group. Although not shown here, the straightbred Tarentaise cows carried less body condition, which accounted for their lower body weight. In spite of their lower body condition, fertility of the straightbred Tarentaise group was comparable to that of the other groups. An analysis of genetic components showed that breed effects were significant for maternal milk and maternal weaning weight. Heterosis effects were significant for individual and maternal milk and for individual and maternal weaning weight.

Table 15. Productivity of three biological types of cows».

	Cow breed group		
Item	Her x Her	Her x Tar	Tar x Tar
Pregnancy rate, %	79	82	79
Milk prod. At 130 d, lb/d	16.3[b]	20.3[c]	22.0[c]
Cow wt at 130 d, lb	1164[b]	1155[b]	1087[c]
Calf wean wt, lb	487[b]	532[c]	527[c]
Wean wt/cow expt. Lb	326[b]	381[c]	354[d]
Fecal output, g/d	3220	3239	3182

[a] Davis *et al.*, Hirsch *et al.*, Kress *et al.*, 1995. Proc. Western Sect. ASAS.
[b,c,d] Means within rows differ (P<.05).

This paper would not be complete without recognizing the significant increase in efficiency that can be achieved by taking advantage of the maternal heterosis of the *Bos indicus x Bos taurus* crossbred female in the southern regions of the U.S. As shown in Table 16 (Peacock *et al.*, 1981), this is especially evident in Brahman x British crosses, which exceeded British x Continental crosses by 22% in biological efficiency; Brahman x Continental crosses were intermediate. Even in a northern environment (south-central Nebraska), Green *et al.* (1991) reported an advantage in biological efficiency of over 4% for *Bos indicus x Bos taurus* F_1 females compared to *Bos taurus x Bos taurus* F_1 females. Although biological efficiency is well-documented in the literature, there is little research on economic efficiency of the *Bos indicus* crossbred female. Nevertheless, data adapted from Marshall *et al.* (1982) indicated that second-generation two-breed rotational Brahman x European crosses returned an average of 26% more income above feed costs than the average of the parent breeds (Brahman/Angus, Brahman/Charolais, and Brahman/Hereford).

Table 16. Production efficiency of different breedtypes of cows[a].

Breedtype of cow	Production efficiency[b] (Brit x Cont = 100)
Brahman x British	122
Brahman x Continental	108
British x Continental	100

[a] Adapted from Peacock *et al.*, 1981. J. Anim. Sci. 52:1007.
[b] Prod. eff. = weaning wt + cow weight) x weaning rate.

Because previous research has demonstrated that beef toughness tends to increase as percentage of *Bos indicus* breeding increases, there is discrimination in the marketplace against fed cattle containing certain levels of *Bos indicus* genetics. However, there was consensus among industry leaders attending the National Beef Tenderness Conference (Lambert, 1994) that acceptable palatability could be generally anticipated from genotypes with no more than _ to d *Box indicus* breeding. For example, a carcass produced by mating a half-blood Brahman female to a *Bos taurus* breed of bull would be expected to provide acceptable tenderness. Discarding the maternal advantages in the southern U.S. of the *Bos indicus* crossbred female to achieve a small improvement in palatability does not appear to be warranted. Introduction of the Senepol and more recently the Tuli, both of which are believed to have not descended from *Bos indicus*, offer another heat-tolerant alternative for the southern U.S.

After reviewing the large body of literature (only some of which is presented here) in the preparation of this paper, it became clear that the crossbred cow offers so much maternal heterosis that she becomes a necessary ingredient for maximizing profit in a commercial cow-calf herd. The challenge then becomes the choice of breeds that go into the makeup of the crossbred cow. We now have enough data characterizing breeds (e.g., the Germ Plasm Evaluation program at U.S. MARC, as well as other research studies to do a reasonably accurate job of matching cow genotype to the production environment. The BIF Systems Committee has already performed an important task of developing guidelines for optimal levels for a number of traits in varying production environments (BIF, 1990). Following are four (by no means all) examples of matching breedtypes to different production environments:

1. Restricted feed resources, arid climate: British x British
2. Medium feed resources, semiarid climate: British x Smaller Continental
3. Abundant feed resources, adequate precipitation: British x Larger Continental
4. Sub-tropical environment: British x *Bos indicus*

When one imposes market requirements into the description of the optimum crossbred cow, the task becomes more complex, especially for rotational crossbreeding systems. Market requirements are more easily handled in terminal sire crossbreeding systems. Well-devised composite systems can also make the inclusion of market specifications an easier task.

As a final note regarding economic efficiency, a paper by Melton and Colette (1993) presents an interesting analysis of various criteria for evaluating beef production efficiency. They content that output:input ratios, which have often been used as indicators of economic efficiency, may lead to erroneous conclusions regarding the true commercial applicability of the breedtypes evaluated. Their reasoning is twofold: (1) most studies evaluate breedtypes within an unrealistically narrow range of input use values; and (2) output:input ratios fail to reflect consistently the long-term economic objectives of commercial cow-calf producers. They suggest that a preferred criterion for evaluating economic efficiency would be net present value computed under alternative scenarios regarding prices and production conditions. Net present value is defined as the sum of future net returns over multiple cattle generations discounted back to the present time. The discount rate accounts for risk and the time preference of money. For most agricultural investments, the annual discount rate is 3-5%. In an excellent review of systems research, Tess (1995) discusses these and other issues related to evaluating economic efficiency.

The search for the optimum cow is rigorous and seems never-ending. In recent years, the emergence of value-based marketing and an increased emphasis on the end-product has added a new dimension to the search. Dikeman (1995) stated it well when he said, The challenge to the beef industry is to retain marketshare by reducing fat and increasing palatability and consistency, while at the same time improving production efficiency and sustaining profitability . Based upon his review of research, Tess (1995) suggested that consideration of all such factors will favor intermediate genotypes or crossbred combinations of different biological types . Field (1994) cautioned cow-calf producers that before focusing extreme selection pressure on carcass traits, it is important to establish whether of not change in their herds is in fact needed. In other words, producers must ascertain their own position relative to current and potential future price discounts in the marketplace.

As noted before, the optimum cow is really a moving target in that she must vary with the production environment and the requirements of the marketplace. Nonetheless, Bob Taylor (1994) provided the industry with some realistic optimum ranges that would fit many commercial situations across the U.S. Taylor also made an important point when he said, Maximum profitability is usually achieved before maximum productivity, a statement that is in agreement with the economic principle that says the profit maximizing level of input use and subsequent output is less than the output maximizing level.

In the final analysis, each producer must analyze his own situation and fit the cow to that situation, but with a look to the future and with enough flexibility to make subtle alterations as conditions change. As an example of two commercial operations that have set goals and have been able to adapt to changing conditions, Tables 17 and 18 list maximum specifications for Jack Maddux, Wauneta, Nebraska, and goals for Rob Brown, Throckmorton, Texas, that were presented at a conference in December, 1992.

Table 17. Maximum for a commercial herd in southwest Nebraska[a].

Birth weight	100 lb
Weaning weight	600 lb
Commercial cow size	1200 lb
Frame score	6
Carcass weight	800 lb (1250 live)

[a] Jack Maddux, Wauneta, NE (Amer. Simmental Assn. Focus 2000 Conf., Dec. 11-12, 1992, Columbia, MO).

Table 18. Goals for a commercial herd in west Texas».	
1.	Calves weaned/cow exposed, 93% or better.
2.	Wean 600- to 650-lb calves at 7_ months that are 50-60% of their dam s weight.
3.	Retain ownership and slaughter steers weighing 1,200 to 1,300 lb at 15 months of age, with a feed conversion of 6:1 or better, and 60% grading Choice.
4.	Select for as much early growth as possible, within a moderate birth weight range.
5.	Targeted frame size range for Simmental commercial bulls of 5.5 to 7.5.

[a] Rob Brown, Throckmorton, TX (Amer. Simmental Assn. Focus 2000 Conf., Dec. 11-12, 1992, Columbia, MO).

In conclusion, I pose the following questions and answers as food for thought:

A. Is there an optimum cow? — Yes, for a given production and marketing environment.
B. Have we fully characterized those optimum cows? — No, but we are getting closer.
C. What is impeding our progress? — Antagonisms between reproduction, growth, and carcass traits.
D. Is there a solution? — Perhaps. Development of selection indexes within a production/ marketing environment is a possibility.
E. Is it do-able? — I would hope so!

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