Do I Have the Cow that is the Most Efficient Producer for My Environment/Management Level?

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Introduction

Efficiency of beef production is one of those terms that probably means something different to each person discussing the topic. Certainly, efficiency means something different to the packer than to the feeder or cow/calf producer. Beef production practices, and especially breeding, have been largely influenced by feed conversion (one measure of efficiency) in the feedlot and in dressing percentage (another measure of efficiency) at the slaughter facility. Under these influences, larger framed, growthier cattle that consume the most feed per day appear to be the most efficient feed converters. How do these influences affect the other segments of the beef industry?

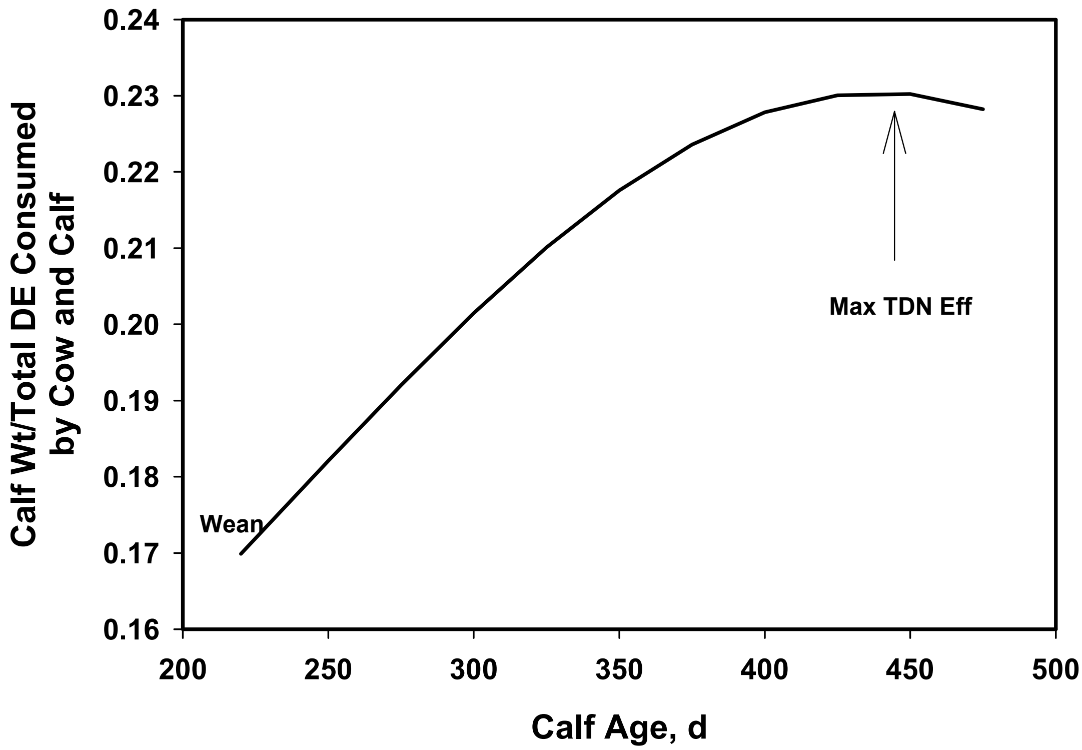
The Gulf Coast and Southeast contain almost 40% of the U.S. cow/calf population. The climate and soils of the region are well suited for production of warm season perennial forage grasses. These grasses produce large amounts of dry matter during the growing season, are low to moderate in quality, usually die with the first frost, and do not grow during the winter. Therefore, a cow suited to the region must be able to consume and process large amounts of this available forage, and perhaps to withstand the feast-famine production regime characteristic of the wet-dry tropics. Under this scenario, cows must be able to store energy and protein during the growing season for use during the dry season when forage is either limiting or of such low quality so that it will not support maintenance. The real difficulty occurs when the cow is asked to calve during, or just before the dry or winter season, when nutrient supply is at its lowest and requirements are at the highest. Some breed-types have adapted to such a regimen and have modified reproductive behavior in order to survive under the described circumstances. However, they are likely not as productive as those selected for high production when available feed supply is unlimited or matched to the production system. It is much easier (I think) to change or adapt an animal to fit the system, than it is to change the feed supply. However, most of the costs for producing a calf in the subtropical U.S. are for feed to winter a cow.

What Defines Efficiency in the Cow/Calf Sector?

Total requirements of TDN for producing a slaughter animal was developed by Neel (1973) when they fed cows during the period from calving to weaning. All feed for the cow and calf were recorded in dry lot. Milk production, calf and cow weight, backfat thickness, linear measurements, and condition scores were recorded. The efficiency of production (lbs calf/lb total DE consumed by cow and calf) was lowest at calving, and increased as the calf grew (Figure 1) from 0.17 at weaning to about 0.24, when the calf was about 14 months old, described by the author as the optimal time to slaughter. Furthermore, with this set of Angus cows, decreased efficiency was associated with increased cow weight.

How is efficiency affected by the type of cow I keep?

Figure 1. Total digestible energy required for production of a pound of calf at different times during the life of the calf.



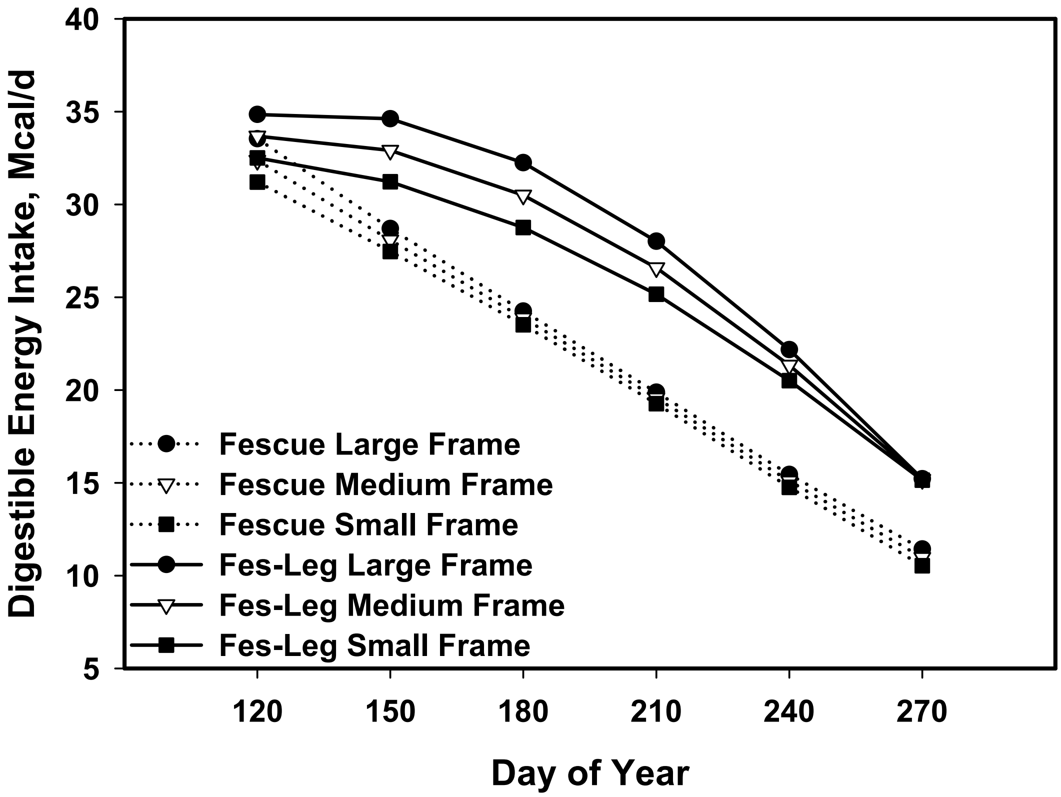
Interactions of Genetics and Location

A classic piece of research was conducted in the late ‘60s and early ‘70s at the Brooksville station in collaboration with the USDA station in Miles City, Montana (Burns et al., 1979; Butts et al., 1971). Two lines of cattle were compared. One was Line 1 Herefords developed in Miles City, the other was Line 6 Herefords developed in Florida. Each herd was split and part of the cows shipped to the alternate location (Table 1) and performance was monitored for many years. There were many aspects of the project, but I will concentrate on weaning weight and condition of the calves produced. Cows developed in Montana produced heavier calves at weaning than cows developed in Florida among those maintained in Montana. However, the reverse was true in Florida, demonstrating a classic interaction between genetics (Herd or line) and environment (represented by all the conditions of each location). The environment may have imposed stresses through heat load, pests, nutrition, or other mechanisms. The researchers did not determine the mechanisms for the interaction, but demonstrated clearly that it exists. Following this research producers were careful to buy breeding stock from ‘adapted’ herds or lines of cattle, usually buying breeding stock from the southeastern US and especially from those producers that paid attention to adaptation. We are 28 years removed from that research, and with the tremendous pressure for cow/calf producers to supply a ‘calf that will fit the box’, many have reached out to more northern climates for breeding stock. Have we traded away some of the traits that were necessary for a cow to compete in the environment that we have to deal with?

Interactions of Genetics and Nutrition Level

Industry has identified a large framed feeder that will finish at high select or low choice, YG 2 at carcass weight < 950 pounds. What kind of cow is necessary to produce the

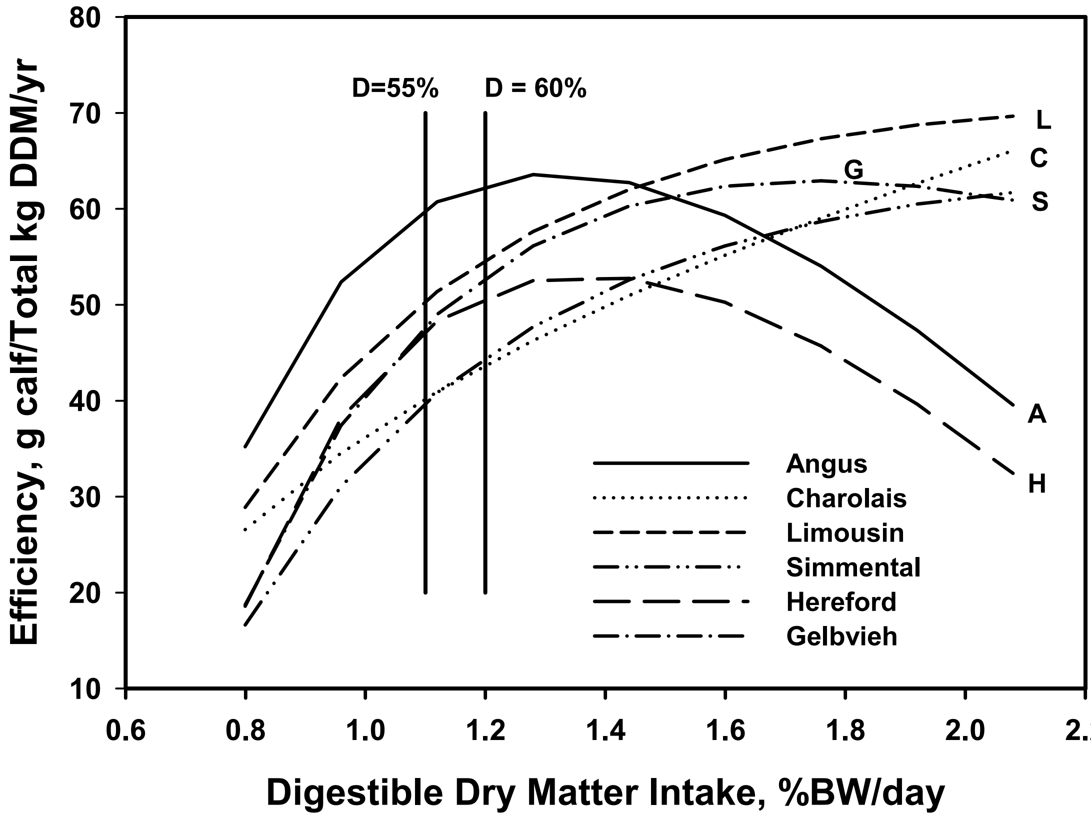
Figure 2. Relationship of cow-frame score and digestible energy intake of cows grazing fescue or fescue-legume at different times during the grazing season.



feeder to achieve that? Can alternative production practices produce the same carcass from different genetic types? Research that addresses one of the questions or causes involved in the interaction (nutrition) was conducted at the University of Tennessee (Holloway and Butts, 1984). Angus cows of different frame score were assigned to either fescue or fescue-legume pastures representing medium- or high-quality forage. Each year, intake was measured on the cows from May 1 to October 1. Cow weights, backfat thickness, calf weights, forage digestibility (digestible energy), and intake of both cow and calf were recorded (see Table 2). Large framed cows were about 200 pounds heavier at weaning than small framed cows. They produced more milk and about 30 pounds more calf, if adequate nutrition was available such as that provided by fescue-legume pastures. However, there were essentially no differences in milk or calf weaning weight among different size cows grazing fescue alone. This can be interpreted that large framed cows have the potential to produce, provided nutrition is available. However, these production parameters assume that each cow will produce a calf each year.

The amount of feed consumed by large and small framed cows on fescue alone indicates that only small-framed cows could consume 2% of their body weight per day, whereas all size cows could exceed this level on fescue-legume (Figure 2). When diet digestibility is considered, there were large differences in digestible energy intake (DEI) between the two pasture types, and among cow size on fescue-legume. However, little differences in total DEI were noted for different size cows on fescue. Efficiency of calf production is obtained by dividing calf weaning weight by total DEI (only for the 120-day test period). Cows grazing fescue

Figure 3. Efficiency of digestible dry matter intake conversion to calf weaning weight per cow exposed. Vertical bars represent 2% BW intake at 55 or 60% digestibility, estimated average for bahiagrass.



were much more efficient than those on fescue-legume, suggesting the fescue-legume pastures provided more energy than needed by the cows. This was borne out by the fact that cows on fescue-legume had 0.1 in more backfat at weaning than those on fescue alone. Little difference was noted among cows of different frame score, although there might be a tendency for small-framed cows to be more efficient.

The studies mentioned above largely involve comparisons within a breed. The work at USDA, ARS, Meat Animal Research Center (MARC) for years has compared sire breeds in different cycles, maintaining certain breeds in all cycles for comparison. Jenkins and Ferrell (1994) took the MARC comparisons one step farther and determined the feed efficiency of different breed types (F1 crosses representing different levels of production potential) at four levels of nutrition. The data in Table 3 represent two levels (1.21 and 2.18 % BW of diet with about 66% digestibility) of nutrition for a selection of the breeds compared. Body weight and condition score were linearly related to level of nutrition, but each breed type responded differently. For instance Charolais cows were heaviest at both levels of nutrition, but Hereford and Angus showed the most response in weight as a response to higher nutrition. The continental breeds had higher demands either for growth (larger frame) or milk production. However, calf weaning weight was the same within breed across all feeding levels, indicating that cow nutrition level did not appear to influence weaning weight. This experiment was conducted in dry lot and calves had access to an oat based creep to mimic what they would eat from pasture. However, calf weaning weights were about 79% of their contemporaries raised under more conventional pasture conditions.

When calving rate, survival rate, and calf weaning weight are multiplied, the result is calf produced per cow exposed. Angus and Limousin were the most productive at low levels of nutrition. Angus, Limousin, and Gelbvieh produced more calf at the higher level of nutrition. The 2.18% of body weight did not represent the highest level of nutrition, but in speaking with Dr. Jenkins he said that at the higher levels, most breed types became overly obese to the detriment of production.

Another measure of biological efficiency is the weight of calf weaned per unit of feed (or digestible energy) consumed by the cow and calf as discussed above for the Neel (1973) data. When plotted across all intake levels, breed types responded differently (Figure 3). At low to moderate levels of nutrition, Angus were the most efficient, whereas at higher levels the continental breeds were more efficient at converting feed to calf. Production at higher levels of nutrition were 3- to 4-times that at lower levels for all breeds suggesting the higher nutrition may be economically viable. However, keep in mind that the cattle were fed in confinement, and all components of production were less than their pasture reared counterparts. This was especially true for survival rate, which was much lower than one would expect in a production environment. All of the loss in production resulted from reduced calving and survival rates, because nutrition had no effect on weaning weight. Thus ranking among breeds for efficiency depended on DMI, yet the rank of the breeds across DMI was the same for calf growth alone (Table 3). Breeds with greater genetic potential for growth produced heavier calves. For an enterprise, evaluation of overall efficiency requires an appreciation of the interrelationships and requirements of the individual components contributing to the production system.

While data is scarce concerning the quality and availability of forage in Florida pastures, we assume a cow would limit her intake to about 2% of body weight (probably realistic for bahiagrass). We then bracketed digestibility at 55 and 60% on the figure. Florida pastures probably limit cows to the lower range of nutrition that Jenkens and Ferrell (1994) used. They fed a prepared feed that was approximately 66% digestible and available year round. When bahiagrass is high in quality (spring), it is often limiting in availability, thus limiting intake in a different manner.

The cow/calf sector is unique because the predominance of feed and other resources are consumed by the cow, and yet the outcome or product is in the form of the calf. Therefore, one can reduce the cow costs in terms of maintenance and production costs, while increasing the potential for increased calf production with improved genetics of the sire (Gregory and Cundiff, 1980). This predicates on the ability to either keep a separate herd for replacement production, or buy replacements from an outside source. Only large producers can achieve the former, and it is likely not cost effective. The male counterparts must also be marketed through the normal production processes and may not fit high return markets. In all of the above discussion (except Jenkens and Ferrell, 1994), biological efficiency was defined as some measure of output per cow. It assumes 100% calf crop. What if that assumption is not true? And IT IS NOT!

Reproductive Efficiency

Reproductive efficiency is the most important economic trait in beef production. Net calf crop, often used as an indicator of reproductive efficiency, was 71% in a 14-year summary that contained 12, 827 observations (Bellows et al., 1979). Net calf crop is simply the number of calves weaned as a percentage of the number of cows exposed. The factor that accounted for most of the 29% loss in net calf crop was failure for 17.4% of the females to become pregnant during the breeding season (Table 4). Three additional factors were also reported, however, even when those losses were combined they did not approach losses associated with the primary factor. The secondary factor was a 6.4% loss in net calf crop due to perinatal calf deaths.

An important part in reproductive efficiency is matching the cow type to the environment in which she is asked to perform. This is particularly important in stressful environments such as the subtropics and tropics. Environment, however, is not simply related to geography or climate (temperature, humidity); it also includes nutrition (forages, minerals, supplements), disease, and pest prevalence. A classic example was provided by Koger et al. (1979) and Burns et al. (1979). They reported results from a study where Hereford cattle from Florida (Line 6) were swapped with Hereford cattle from Montana (Line 1). These herds were maintained in Brooksville, Florida and Miles City, Montana. Over the 11 years of the project that were reported on, it is obvious that pregnancy and weaning rates fluctuated from year to year (Table 5). Mean pregnancy rates in Montana for Hereford of Montana origin were 81% and of Florida origin were 83%. However, pregnancy rates in Florida for Hereford of Montana origin were 64% and of Florida origin were 86%. This line x environment interaction was evident for most of the traits that were studied and is commonly referred to as genotype by environment interaction. Mean weaning rate in Montana for Hereford of Montana origin was 73% and of Florida origin was 76% and in Florida Hereford of Montana origin was 59% and of Florida origin was 80%. In Table 6, these data are presented a little differently. Clearly the pregnancy and weaning rates are lowest in Florida for Herefords of Montana origin (72 and 65%, respectively). Line differences were observed for both pregnancy rate and weaning rate with both being greater for Hereford of Florida origin than of Montana origin. Location also affected pregnancy and weaning rates that were greater in Montana than Florida. What is most striking about these data, however, is that there was a 6.7% advantage in pregnancy rate and a 6.1% advantage in weaning rate for local over introduced cattle.

Another indicator of cow productivity that includes reproductive efficiency and maternal traits is annual production per cow calculated in the next example as the product of weaning rate x 205-day weight (Table 7). These data are from the same project that was just discussed. Clearly the 205-day weight (366.2 pounds) and annual production per cow (238.1 pounds) were the lowest in Florida for Herefords of Montana origin. Interestingly birth weights were smaller in Florida for both Herefords that originated in Montana and Florida. Thus birth weights were affected by location as well as line and origin. Calf 205-day weight was not influenced by line but was heavier in Montana than in Florida. In fact there was a 35.1-pound advantage for local cattle over introduced cattle in 205-day weaning weight. This combined with weaning rate led to a 48.9-pound advantage in annual production per cow for the local over the introduced cow herd. The researchers indicated that "the advantages of local over introduced lines were large enough to be of great economic significance in commercial beef production." It was concluded that the results should be considered in "commercial cattle production, performance testing, interregional exchange of seedstock, and sources of semen for AI in different environments."

Another important consideration in matching the cow to the environment involves the mature size of the cow in relation to the nutritional environment that is primarily forage based. At Brooksville, Florida, a relatively long term breeding study was conducted that involved breeding small, medium, and large frame size Brahman cows to like frame size Brahman bulls (Vargas et al., 1999). In that study, weaning rate was considerably lower for large frame size first-parity (46.2%) and second-parity (38.3%) dams compared to medium frame size first

(74.3%)- or second-parity (59.8%) dams and small frame size first (75.0%)- or second-parity dams (Table 8). Weaning rates did not differ among frame sizes in third or greater-parity dams. The question then becomes what was responsible for the decreased weaning rates in the large frame size first- and second-parity dams? For the first-parity dams, calf survival rate was significantly lower for large frame size (47.9%) than either small (80.7%) or medium (83.4%) frame size dams. This difference in calf survivability explains the decreased weaning rate observed for large frame size first-parity dams. Calf survivability did not differ among frame sizes for second- or third- or greater-parity dams. In second-parity dams, calving rate was significantly lower for large frame size (41.0%) dams compared to either small (65.8%) or medium (69.0%) frame size dams. This stage of production, that is raising their first calf and becoming pregnant with their second calf is a critical and stressful time in the subtropics. Thus the lower weaning rate observed in large frame size second-parity dams was due to low calving rates. There were no differences in calving rate among frame sizes in first-parity dams. However, interestingly calving rates were higher for small frame size (93.5%) than either medium (78.5%) or large (79.8%) frame size third-or greater-parity dams. This would suggest that from a pregnancy perspective the small frame cow was superior to the other frame sizes. Production per cow, however, really addresses the sum of the components that we have discussed as well as calf weaning weight. For both first- and second-parity, large frame size dams had significantly lower production per cow than either small or medium frame size cows that did not differ from each other. For third- or greater-parity dams there was no statistical difference among frame sizes in production per cow.

Development of replacement heifers is also critical to the economic efficiency of a beef cattle operation. In the context of matching cow size to the environment it is important to consider sire selection for use on the cowherd because in most instances heifer calves will be selected as herd replacements. In addition to the differences in productivity observed among the frame size groups of Brahman cows there were also ramifications observed in saving heifer calves as replacements. Large frame size heifers were 39 days older than small frame size heifers and 46 days older than medium frame size heifers at puberty. When managed in a defined breeding season these differences can be important even if breeding to calve first as three-year-olds.

Most commercial cattle production in the subtropics is based on crossbred Brahman cows. At Brooksville, Florida we developed a F1 crossbred cowherd about 10 years ago. Over two years using AI, we bred the Angus cowherd to Brahman, Senepol, and Tuli sires. Age at first conception (or puberty) did not differ among the F1 crossbred heifers and was 15.5 months for Brahman x Angus, 15.6 months for Senepol x Angus, and 15.3 months for Tuli x Angus heifers (Table 9). There were, however, large differences in body weight at first conception among the breed types. Angus bulls were used to breed the heifers for their first calf and Charolais bulls were used for second and subsequent calves. For first-parity, there were no statistical differences among breedtypes in age at first-calving, percentage of normal births, or calf survival (Table 10). For second and later parities, calf crop born was higher for Brahman x Angus (89.0%) and Tuli x Angus (94.7%) cows than Senepol x Angus (76.9%) cows. This indicated that under the conditions of this experiment the reproductive efficiency of the Brahman x Angus and Tuli x Angus cows was superior to that of the Senepol x Angus cows. The percentage of normal births was higher for Brahman x Angus (98.7%) cows than Tuli x Angus (91.6%) cows when bred to Charolais bulls. Calf survival was higher for Brahman x Angus (96.2%) than Tuli x Angus (91.1%) cows. Calf crop weaned (or net calf crop) was higher for Brahman x Angus (86.1%) and Tuli x Angus (86.5%)

cows than Senepol x Angus (70.2%) cows. Thus the relatively high calf crop born observed for the Tuli x Angus cows was tempered by relatively lower normal births and calf survivability. Charolais-sired calf weaning weights were heaviest from Brahman x Angus (592.8 pounds) cows, lightest for Tuli x Angus cows (514.6 pounds) and intermediate for Senepol x Angus (540.1 pounds) cows. However, when weaning weight was expressed as weaning weight per cow exposed (for three- to eight-year-old cows), the heaviest was from the Brahman x Angus (516.3 pounds), the lightest from the Senepol x Angus (381.5 pounds), and intermediate from the Tuli x Angus (461.0 pounds) cows. The advantage of Brahman x Angus cows over Tuli x Angus cows in weaning weight per cow exposed was therefore due to the heavier calf weaning weights because calf crop weaned was similar between Brahman x Angus and Tuli x Angus cows. However, maintenance costs of the cow are also important to consider in overall efficiency. As seven-year-olds, the Brahman x Angus cows were the heaviest (1,239 pounds), the Tuli x Angus cows were the lightest (1,130 pounds), and the Senepol x Angus cows were intermediate (1,186 pounds). Therefore when cow size is also considered the overall efficiency of the Tuli x Angus cows becomes closer to that of the Brahman x Angus cows. This is significant because there are few examples of F1 crosses that can compete with Brahman x Angus or Brahman x Hereford F1 crosses in the subtropics of the U.S. An additional factor that needs to be addressed is longevity of Tuli versus Brahman crosses because historically Brahman crosses have excellent longevity and hence lifetime productivity.

Conclusion

The initial question “Do I have the cow that is the most efficient producer?” It depends! Interactions of cow genetics with environmental constraints such as nutrition, location, or climate are evident from several research trials. Cow type and size that is suitable depends on the resources, primarily nutritional, that are available. Therefore the dilemma! How do we maintain an efficient, yet productive cow that weans a high quality, growthy calf that does well in the other segments of the industry?

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Table 1. Weight and growth characteristics of calves born to Montana Line 1 and Florida Line 6 Hereford cows each located in Montana or Florida (1964-1974).

Item	Originated in Montana		Originated in Florida	
	Florida	Montana	Florida	Montana
Birth weight, lb*	64	81	66	77
205 day weight, lb*	365	434	403	402
Daily gain, lb	1.46	1.72	1.64	1.59
Body length, in*	39.2	40.9	40.1	40.0
Condition score*	8.3	8.6	9.5	8.9

*From Burns et al., 1979.

Table 2. Interaction of forage type (nutrition level) with frame score in Angus cattle.

Item (at weaning 240 d)	Frame score					
	Fescue			Fescue - Legume		
	Small	Medium	Large	Small	Medium	Large
Cow weight, lb	941	1,036	1,124	963	1,064	1,154
Milk, lb/day	9.53	9.79	9.47	10.57	10.86	12.16
Calf weight, lb	508	514	495	518	529	548
DMI by cow, %BW	2.00	1.87	1.68	2.29	2.16	2.10
Digest. energy intake (cow only, Mcal)	2,759	2,856	2,813	3,330	3,480	3,660
Efficiency of calf prod. lb calf/Mcal DE	.184	.179	.176	.155	.152	.150

(Adapted from Holloway and Butts, 1984).

Table 3. Weight and condition score of cows from different breed of sire and fed at different levels of production.

	Cow weight, lb		Condition score		Calf weight, lb	Calf weight/cow exposed	
DMI, %BW	1.21	2.18	1.21	2.18		1.21	2.18
Sire breed							
• Angus	1,000	1,230	4.1	6.3	445	127.6	409.9
• Charolais	1,300	1,490	4.3	5.6	489	96.4	332.3
• Gelbvieh	1,110	1,280	4.3	5.3	478	67.9	393.8
• Hereford	1,096	1,307	4.7	6.6	394	67.4	344.7
• Limousin	1,067	1,270	3.5	5.4	446	104.8	405.2
• Simmental	1,100	1,319	3.5	4.9	485	60.3	343.2

(Adapted from Jenkins and Ferrell, 1994).

Table 4. Factors affecting net calf crop.[a]

Factor	Number of females	Reduction in net calf crop, %
Female not pregnant at end of breeding season	2,232	17.4
Perinatal calf deaths	821	6.4
Calf deaths birth to weaning	372	2.9
Fetal deaths during gestation	295	2.3
Total potential calves lost	3,720	29.0
Net calf crop weaned	9,107	71.0
Totals	12,827	100.0

[a]From Bellows et al., 1979.

Table 5. Annual pregnancy and weaning rates of two lines of Hereford in two locations.[a]

Location and line	Year 64	65	66	67	68	69	70	71	72	73	74	Mean
	Pregnancy rate, %											
Montana												
M line 1	89	84	63	81	65	85	90	83	79	85	82	81
F line 6	82	78	87	73	89	94	96	88	73	73	77	83
Florida												
M line 1	83	36	83	78	72	85	59	39	73	44	55	64
F line 6	90	90	84	80	93	81	82	77	98	94	83	86
	Weaning rate, %											
Montana												
M line 1	83	70	57	77	60	73	86	76	68	83	69	73
F line 6	79	69	81	68	82	87	92	78	69	65	67	76
Florida												
M line 1	83	36	71	78	71	75	59	31	58	33	55	59
F line 6	79	86	75	74	86	78	75	75	90	91	66	80

[a]From Koger et al., 1979.

Table 6. Reproductive performance of two lines of Hereford at two locations.[a]

Item	No. of matings	Pregnancy rate, %	Calf survival, %	Weaning rate, %
Subgroups				
• M line 1 in MT	948	81.6	90.3	73.7
• F line 6 in MT	526	82.8	91.9	76.1
• M line 1 in FL	1,007	72.0	90.3	65.0
• F line 6 in FL	464	86.5	92.1	79.7
Line				
• M line 1	1,995	76.8	90.3	69.4
• F line 6	990	84.7	92.0	77.9
• P <		0.01	ns	0.01
Location				
• MT	1,474	82.2	91.1	74.9
• FL	1,471	79.3	91.2	72.3
• P <		0.01	ns	0.01
Origin				
• Local	1,412	84.1	91.2	76.7
• Introduced	1,533	77.4	91.1	70.6
• Difference		6.7	0.1	6.1
• P <		0.01	ns	0.01

[a]From Koger et al., 1979.

Table 7. Reproductive performance of two lines of Hereford at two locations.[a]

Item	No. of calves born	Birth weight, lb	205-day weight, lb	Production/ cow, lb
Subgroups				
• M line 1 in MT	727	81.1	435.4	321.0
• F line 6 in MT	405	77.2	403.2	306.9
• M line 1 in FL	677	63.9	366.2	238.1
• F line 6 in FL	363	65.7	403.9	321.9
Line				
• M line 1	1,995	72.5	400.8	279.5
• F line 6	990	71.4	403.7	314.4
• P <		0.05	ns	----
Location				
• MT	1,474	79.1	419.3	313.9
• FL	1,471	64.8	385.1	280.0
• P <		0.01	0.01	----
Origin				
• Local	1,412	73.4	419.8	321.4
• Introduced	1,533	70.5	384.7	272.5
• Difference		2.9	35.1	48.9
• P <		0.01	0.01	----

[a]From Burns et al., 1979.

Table 8. Reproductive performance of small, medium, and large frame size Brahman.[a]

Item	First-parity dams	Second-parity dams	Third or greater-parity dams
Weaning rate, %			
• Small	75.0[b]	64.9[b]	71.8
• Medium	74.3[b]	59.8[b]	68.5
• Large	46.2[c]	38.3[c]	75.8
Survival rate, %			
• Small	80.7[b]	97.5	77.6
• Medium	83.4[b]	88.1	86.9
• Large	47.9[c]	93.9	95.7
Calving Rate			
• Small	93.5	65.8[b]	93.5[b]
• Medium	88.5	69.0[b]	78.5[c]
• Large	97.3	41.0[c]	79.8[c]
Weaning weight, lb			
• Small	424.8[b]	422.0	439.2[b]
• Medium	476.8[c]	422.8	448.2[b]
• Large	498.2[c]	427.5	509.7[c]
Production/cow, lb			
• Small	315.9[b]	268.5[b]	310.0
• Medium	356.9[b]	254.4[b]	331.4
• Large	226.8[c]	177.5[c]	389.8

[a]From Vargas et al., 1999.
[b,c]Means with a different superscript letter within a column and item differ ($P < 0.05$).

Table 9. Puberty in Brahman x, Senepol x, and Tuli x Angus heifers.

Item	Brahman x Angus	Senepol x Angus	Tuli x Angus
Number of heifers	42	34	50
Age at puberty, months	15.5	15.6	15.3
Weight at puberty, lb*	765	719	679

*$P < 0.001$.

Table 10. Reproductive performance of Brahman x, Senepol x, and Tuli x Angus cows.

Item	Brahman x Angus	Senepol x Angus	Tuli x Angus
First-parity, Angus-sired calves			
• Age at first calving, days	752.5	751.3	743.2
• Normal births, %	90.3	88.4	93.7
• Calf survival, %	88.4	90.9	90.5
• Weaning weight, lb	470.7[a]	429.7[b]	422.2[b]
Second- and later-parities, Charolais-sired calves			
• Calf crop born, %	89.0[a]	76.9[b]	94.7[a]
• Normal births, %	98.7[a]	93.3[ab]	91.6[b]
• Calf survival, %	96.2[x]	91.2[xy]	91.1[y]
• Calf crop weaned, %	86.1[a]	70.2[b]	86.5[a]
• Weaning weight, lb	592.8[a]	540.1[b]	514.6[c]
Weaning weight/cow exposed, lb			
• 3- through 8-year-olds	516.3[a]	381.5[c]	461.0[b]

[a,b,c]Means with a different superscript letter in a row differ ($P < 0.05$).
[x,y]Means with a different superscript letter in a row differ ($P < 0.10$).

Notes: