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### **Just How Important Are Carcass EPDs?**

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#### **Is Measurement of Carcass Performance Justified?**

The National Beef Quality Audit, conducted by Colorado State, Texas A&M and Texas Tech Universities in 1992, was a "wake-up" call to the beef cattle industry. The results of the audit of the slaughter cattle population, conducted in 28 plants from across the U.S., indicated a total of some \$280 in inefficiencies for each fed steer and heifer produced in the beef business. Furthermore, when these inefficiencies were categorized, it became apparent that the majority of these losses occur due to excess fat production with lower consistency in taste than desired. If the industry is to remain a viable sector of the food business, it cannot ignore the challenge presented by these results: **the beef cattle industry needs to achieve change at the carcass level, by implementing a combination of changes in feeding and management practices coupled with genetic improvement.**

If one reviews the history of the "carcass merit/value-based marketing" issue, the argument has repeatedly been raised by both industry **and** academia that goes something like this: "I do not get paid on the basis of carcass performance, and until I do, I see little justification for collecting carcass data. Furthermore, "value-based marketing" is a buzz word made up by the packing industry, for the benefit of the packing industry, that seems to keep getting delayed in its implementation." While this argument may appear to be historically true, it also is somewhat short-sighted. The fact of the matter is that the business of selling beef has become more challenging due to competition from the poultry and pork industries. The response of the beef packing and retail industries is beginning to be seen through the development of new closely-trimmed boxed beef. In the past two years, Excel, IBP and Monfort-ConAgra have all developed 1/4 inch trim (or less) boxed-beef specifications. Industry consensus is that approximately 40% of all boxed-beef trade will fall into this category by the end of 1995, with this percentage expected to increase in 1996 (NCA, 1995). One does not have to be very astute to realize the impact of this marketing change on the cow-calf industry. Furthermore, the Long Range Plan for the consolidated organizations of the beef industry lists "improving quality and consistency" of beef as its #1 leverage point. Collectively, these points reveal that **measurement of carcass performance is indeed justified.**

#### **Sure Carcass Merit is Important, But in a Down-Cycle of the Cattle Market?**

Traditionally, we have thought that in relative economic terms, reproductive efficiency is about twice as important as growth performance which is about five times as important as carcass merit (Melton et al., 1979). More recently, Bryan Melton of Iowa State has theoretically analyzed the importance of these three types of traits under a more current, value-based type of marketing system. He has concluded that the former 10 reproduction: 5 growth: 1 product ratio is now closer to 2 reproduction: 1 growth: 1 product (Melton, 1995). While this says that

reproductive performance is still the MOST important trait category for commercial cow-calf producers, it also says that we do need to be paying closer attention to carcass and end-product performance than in the past.

Some folks have argued in the last several months, as calf prices have continued to fall, that we were only concerned with carcass performance when the market was “rosy”. Now that the market has gone into a down-turn, these same folks are arguing that the only things that matter to a cow-calf producer in the next five years are to keep costs to a minimum and to maximize reproduction and growth for their environment. Such a short-term rooted philosophy, while understandable given the climate of the cattle market, is ill-advised. This turn of the cattle cycle will pass as others have. Some folks will not be in business at that point, and we will likely continue to lose market share to our other animal protein competitors **UNLESS** we plan for the long term to do something about it. It is certain that we have room to improve reproductive performance genetically with some of the new methodologies being aimed at female fertility (eg. stayability, first calf heifer conception rate, days to calving, etc.). This will also ultimately help us to better compete with the lower cost of production associated with litter-bearing species. But we will not be able to sell it for a desirable return if it is not acceptable to our consumers. The 1990s cliché of “build it and they will come” does not apply here. Just because we produce it does not mean that we will be able to do it profitably.

Commercial cow-calf producers in 1995 need to be able to manage risk associated with poor carcass performance. Those producers who are successful in making it to 1998 will be even more challenged in this area. The challenge to the industry is inescapable: ***we need reliable, user-friendly, and accurate tools to assess the carcass merit of our seedstock, i.e. the need for carcass EPD can no longer be paid lip service, IT IS REAL.***

### **Defining Carcass Merit**

The definition of “ideal” carcass merit is somewhat elusive under the current USDA yield and quality grade system. Rex Butterfield summed up the objective well when he said:

*“The ideal carcass is one which yields a maximum percentage of muscle, a minimum percentage of bone and enough fat to meet the minimum quality requirements of the marketplace. It must be produced economically within the limits of functionally efficient cattle.”*

This objective coincides with the fact that consumer preferences are “to keep the taste fat and get rid of the waste fat” (National Retail Consumer Beef Study (1989)). Excess fat production can be lowered substantially by changing feeding practices. However, it is generally thought that this will reduce the palatability of the end-product. Industry evolution in recent years has also resulted in specification markets for retail lean beef versus “white table cloth” niches. While these niche markets provide greater opportunities for matching diverse biological types to economic environments, they do dictate the need for genetic identification of specific components of carcass performance.

Our current USDA grading system uses yield grade (1 to 5) to predict the percentage of boneless, closely-trimmed retail cuts in the round, rib, loin, and chuck. Fat thickness and area of the ribeye at the 12th rib, along with hot carcass weight and percentage kidney, pelvic and heart fat, are used to predict yield grade in the carcass. The other side of the USDA grading system is quality grade (Standard through Prime) which is based on the amount of intramuscular fat visible in the cross section of the ribeye area at the 12th rib in “A” maturity carcasses.

Fortunately, collective research results over the past 25 years have indicated that genetic variation exists both between and within breeds for these measures of carcass merit. Levels of heritability for measures of retail yield and palatability are all in excess of what is generally observed for growth traits (Table 1). This indicates that genetic improvement from selection within breeds for these measures should be possible.

Table 1. Heritability ( $h^2$ ) Estimates of Carcass Traits in Beef Cattle  
(Adapted from Marshall, 1994)

Trait	No. Studies	Avg. $h^2$
Retail yield (%)	7	.43
Retail weight (lb)	5	.43
Carcass weight (lb)	11	.37
Ribeye area (in <sup>2</sup> )	10	.37
12th rib fat (in)	7	.41
Marbling (or Quality Grade)	11	.35
Warner-Bratzler Shear Force (kg)	6	.27
Sensory Panel Tenderness (1 to 8)	3	.13

(Numerical average of literature estimates)

Larry Cundiff and co-workers at the Roman L. Hruska U.S. Meat Animal Research Center have also reported that the magnitude of genetic variability between breeds is roughly equivalent to that within breeds (Table 2). This infers that improvement is also possible in carcass desirability of slaughter cattle through proper breed selection implemented in designed crossbreeding programs.

Table 2. Relativity of Variation Within and Between Breeds for Carcass Parameters in Beef Cattle (Adapted from Cundiff et al. (1990))

Trait	Number of Additive Genetic Std. Deviations Between Most Divergent Breeds
Retail product (%)	5.8
Retail product weight (458 days)	8.2
Marbling score	5.3

<sup>a</sup>Assumption is made here that within a breed there exists approximately six genetic standard deviations of variation in any trait.

## How Many of These Carcass Measures Do We Need?

Before discussing how particular types of data might be helpful in genetic improvement programs, it is important to provide some framework for what carcass merit EPD might look like. Many times lots of pieces of information are given to producers without any suggestion of how the pieces of the puzzle fit together into a picture. The carcass merit area is certainly one that might suffer from this problem.

Since the current USDA grading system is two-pronged for retail yield (yield grade) and palatability (quality grade), there are a number of factors used to estimate differences among carcasses. The attempt can be made to provide information for all of the components including ribeye area, fat thickness and carcass weight for retail yield and marbling for quality grade. There are strong arguments for including each of these traits as a part of national cattle evaluation (NCE) programs including: 1) specification marketing provides impetus for producers to need to know performance in each of the criteria to make sure they "fit the window", and 2) the need exists within some breeds to improve certain components (eg. excess carcass size, inferior muscling, etc.) while they may be acceptable in terms of the composite trait. The other advantage to component trait reporting is that more information exists regarding genetic parameters for the components along with the fact that any errors made in the component traits are magnified in the composite trait (eg. retail yield %). **Thus, it appears that the attempt should be made to provide predictions for the components. While this would provide a lot of valuable information, the overall message might fall between the cracks if the composite trait(s) of yield and quality grade are not also reported.**

**As an animal breeder who has "grown up" alongside of the development and implementation of EPDs in within-breed national cattle evaluation, I have fluctuated between thinking that we need to give producers "indexes" versus all of the individual pieces of the "index". It now seems clear to me, as is the case described for carcass traits above, that we should present the information both ways and allow the producers to access those which are most meaningful and useful to them. So, if we are to present both the components of the grading system as well as the composite traits, how should they be expressed to be most meaningful?**

Let's tackle the component traits first. Traditionally, we have presented most EPD as a deviation from the base of zero in units of the trait (lb of birth, weaning, yearling or mature weight, cm of scrotal circumference, days of gestation length, etc). This is possible because we are using differences between animals on the basis of EPD to select upon (within an accuracy level). As long as the breeder knows what range of EPD is acceptable for a given trait in his/her herd, this works great. It also works well for traits that are being selected "for". However, a lot of the traits in which we are interested in beef cattle breeding are what we refer to as secondary traits. While we are not selecting for "increased" performance in these traits, we do want to manage risk associated with them by having a handle on whether animals are acceptable or not. Most of the carcass traits we are discussing here fall into this category. For example, we are not necessarily interested in increasing tenderness of beef, we just want to know if it is tender enough to be satisfying. Quality grade, carcass weight, level of fatness, yield grade 1 or 2, all fall into

this type of framework. This makes these kinds of traits ones which need to be checked to see if they are O.K. after the primary criteria of reproductive ability and adequate growth performance have been documented.

Bruce Golden, one of my colleagues at Colorado State has done some very forward thinking regarding these types of traits. About two years ago, he and his associates at the CSU Center for the Genetic Evaluation of Livestock developed new carcass EPDs for the North American Limousin Foundation (Andersen, 1995). Instead of presenting a plus or minus units of marbling score EPD, they presented this trait as the probability that an animal would fall into an “acceptable” range of marbling (for NALF Slight90 or higher, corresponding to high Select or higher). Now the producer has a “checkpoint” to look at for marbling after he/she has identified a given animal based upon all other measures of performance to see if they “fit” on the basis of acceptability for marbling. This is an excellent example of identifying a window of acceptability for a given market in one of the components of carcass merit, here the retail lean beef niche market.

Currently, an effort has been initiated by the National Cattlemen's Association to develop EPD for carcass traits along these lines. The idea is to ensure that breeding animals selected for use in commercial cow herds “fit the projected window” for these traits by using these probability-based EPD. In addition to our group at Colorado State, Georgia, Iowa State, Cornell, Auburn, and the U.S. Meat Animal Research Center are collaborating on this effort. Given that we can amass the carcass data, the components are likely to be reported universally in this format in the future.

But, what about the composite traits?

I envision a two or three part system for reporting carcass composite traits. The first EPD needed is one that predicts the retail yield potential of a sire's slaughter progeny at a standard slaughter age. For example, the system could be based on percentage retail cuts in the four primal regions of loin, rib, round and chuck at a standard slaughter age of 15 to 17 months (i.e. to match USDA yield grade).

The second part of this system should consist of a breeding value estimate that would tell the potential of a sire's progeny to have carcasses that yield consistently palatable products. In the current USDA grading system, intramuscular fatness (i.e. marbling) is used to place cattle into quality grades. This is probably the most cursed and yet highly praised part of the industry. The best summary of the value of the quality grading system comes from work done by Smith et al. (1987) shown in Figure 1. If one is a protagonist on the value of marbling, these results indicate the ability of the quality grades to narrow the variation in overall palatability when moving from Standard up through Prime grade classes. The "risk factor" of getting a bad-eating piece of product goes down from 59.1% in Standard to 5.6% in Prime. Thus, the pro- viewpoint is from the perspective of an insurance policy. The antagonist viewpoint is that the system is not nearly "tight" enough because of the overlap of palatability between all four grades. This observation, coupled with the fact that the feedlot industry is driven to overfeed cattle to try to bump them into low Choice as well as increase dressing %, has resulted in several calls from

within the industry to either eliminate or change the quality grading system.

The real issue here is the need to be able to directly and objectively estimate tenderness. Consider the following conceptual hypothesis concerning the importance of the three sensory characteristics across the various quality grades. Under this model, the variability observed in overall consumer acceptance within the Prime grade is all due to tenderness since there is adequate marbling present to insure flavor and juiciness. As grade declines, however, the relative importance of the three characteristics shifts, placing increasing amounts of importance on flavor and juiciness. The take home message is that when the percentage of slaughter cattle falling into the various quality grade classes (based on National Beef Quality Audit (1992)) is weighted by the percentage unacceptable within each grade (from figure 1), **approximately 20% of the slaughter mix is unpalatable. Furthermore, using our conceptual model above, the majority of that problem can be attributed to inadequate tenderness.** This is the logic forming the basis for the current attention being given by the industry to improvement of beef tenderness (NCA Beef Tenderness Plan, 1994). The problem, however, is that the only direct way to genetically address tenderness is by obtaining progeny shear force data. As we will see later, this is, at best, a costly and difficult proposition.

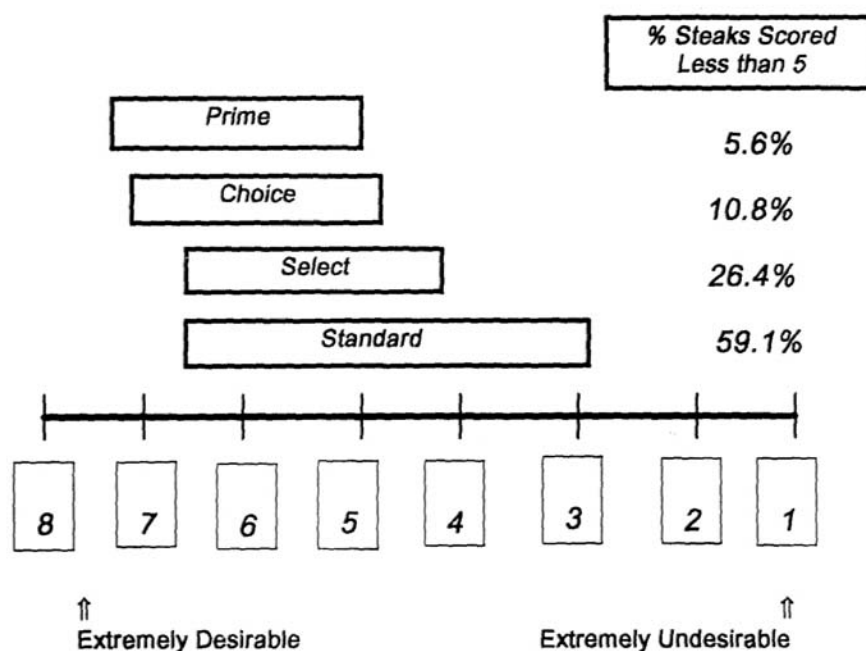


Figure 1. Relationship Between Palatability and USDA Quality Grade (Smith et al., 1987)

Given all of that background on the palatability portion of carcass merit, what is needed for a quality EPD? Since it is known from research results that the genetic relationship between percentage retail product yield and marbling is negative and antagonistic (Cundiff et al., 1990),

**the EPD for yield should be coupled to the EPD for quality.** This can be accomplished by expressing the quality EPD in terms of the potential of an animal's slaughter progeny for quality grade, marbling score or **MOST PREFERABLY TENDERNESS level at a specified industry target yield grade.** Such a system will allow definition of animals that excel in both characteristics simultaneously.

### **Why Do Carcass EPD Not Already Exist?**

If there is such a need for carcass EPD and the genetic bases of these traits is relatively high, why are they not already available? It is almost as if there has been a brick wall in front of carcass EPDs. Some of the factors contributing to this problem were discussed at an ultrasound symposium in 1990 (Wilson, 1992). Before the collection and use of data to allow these breeding values to become a reality is discussed, it is helpful to reiterate those points and others which have prevented carcass EPD in the past.

**The largest hindrance to collecting carcass information is that in the past we have had to solely rely on progeny data.** This type of information requires **time**, expense and labor to collect and also requires cooperation in the packing plant for accurate individual identification of carcasses. The combination of these factors has resulted in limited amounts of progeny data being placed into breed performance databases. The American Angus Association has had the most concerted effort in designed progeny testing of sires, yet only approximately 11% of their currently published sires have any carcass information (441 of approximately 4,000 with published EPD, 1,331 with interim EPD (Angus, 1995)). While this proves the difficulty of obtaining progeny data for carcass traits, it also emphasizes that useful carcass information can be obtained on a meaningful percentage of the breed. For instance, of the top 100 sires in the Angus breed on the basis of registrations, 76 of these have carcass EPDs. These sires represent 56,000 of last year's registrations. Several other breed programs are attempting to build databases with Limousin, Simmental, Charolais, and Salers having recently published carcass reports. Programs like the NCA's Carcass Data Collection Service and various state programs (eg. OK Steer Feedout, Texas A&M Ranch to Rail, Rocky Mountain Ranch to Rail, etc.) are helping in this area. As of December 1994, a total of 104,326 steers, 12,555 heifers and 1,972 bulls had been processed by the NCA program since its initiation two years before.

**The second hindrance has been the lack of ability to determine true carcass value differences on live, yearling seedstock cattle to circumvent the need for progeny data.** Ultrasound imaging technology has been pursued over the past ten years as the primary means to obtain these live animal measures. **A third question relates to whether there is adequate variation in breeding cattle for these measures of carcass merit. Fourthly, how much of the variation observed in these young breeding cattle is genetically inherited (i.e. how much is heritable)? Additionally, are there antagonisms between some of these traits which need to be given attention, particularly in the area of increasing mature size and decreasing reproductive efficiency when selecting for leanness? The last question is perhaps the most looming one of all. When differences between young, immature breeding cattle are measured, do they ultimately relate to those observed between their slaughter progeny?** While this may seem to be intuitively true, realistically it may not be. The yearling bull is a



physiologically different beast than a 15 to 17 month old slaughter steer or heifer.

### **How to Measure: Real-Time Ultrasound??**

Given the requirements described to obtain carcass EPD and the problems with obtaining adequate data for genetic evaluation, what is the solution? For the past five years, a national consortium of universities has been working in a project called NC-196 to determine the efficacy of using real-time ultrasound imaging to measure body composition and carcass merit traits in beef cattle (Bertrand et al., 1994; Green et al., 1994; Wilson et al., 1994). The conclusions drawn from a compilation of this research indicate: 1) assessment of retail yield amount or percentage on the basis of 12th rib fat thickness (FT) and 12th rib longissimus muscle (LMA) area is slightly less effective using ultrasonic measures on the live animal as compared to direct measures on the carcass postmortem (Hamlin et al., 1995; Herring et al., 1994; Perkins et al., 1992b); 2) FT is a better predictor of cutability than is LMA in the current cattle population (Hamlin et al., 1995; Herring et al., 1994) although not so of retail product weight, 3) ultrasonic measures of these retail yield indicators appear to be under a moderate degree of genetic control (weighted average  $h^2$  of .37 for FT and .26 for LMA (Evans et al., 1995; Shepard et al., 1995; Robinson et al., 1993; Johnson et al., 1993; Duello et al., 1993; Arnold et al., 1991; Turner et al., 1990; Lamb et al., 1990; deRose et al., 1988), 4) genetic correlation estimates between ultrasonic predictors of carcass merit and other economically important traits are sparse but indicate some antagonism between LMA and mature size (Shepard et al., 1995; Johnson et al., 1993), 5) prediction of intramuscular fatness and palatability traits is much more difficult using ultrasound, although rapid progress has been made in the past 24 months (Wilson et al., 1994), and 6) data to estimate relationships between ultrasonic retail yield indicators in yearling bulls and slaughter steer carcass retail yield and palatability is limited, but somewhat discouraging (Evans et al., 1995; Steinkamp, 1995; Diles et al., 1994a,b; Schalles et al., 1992).

### **Where Does Ultrasound Leave Us?**

Until recently, the summary of results presented above indicated to me that the technology to begin performance databases within breeds for derivation of ultrasonically predicted retail yield percentage EPD was essentially available. Yearling bulls and heifers could be measured ultrasonically for age-constant FT and LMA in designed contemporary groups to build the necessary database within breeds to allow prediction of carcass EPD. However, the last point mentioned above regarding the genetic relationship between yearling seedstock cattle ultrasound measures and actual carcass performance in slaughter animals is troubling.

The whole attempt to make real-time ultrasound useful has been based upon the idea that this genetic relationship is high (i.e. that genes that contribute to degree of fatness measured by ultrasound in yearling bulls and heifers also contribute in the same manner to fatness in a finished slaughter animal, along with the same argument for ribeye area). However, in a study reported earlier this year (Evans et al, 1995), that hypothesis is blown out of the water. In that study, John Evans, one of our M.S. students at CSU, working with data generated by the Red Angus Association of America, estimated genetic parameters associated with ultrasound measured fat thickness, ribeye area, and a gray shading score estimator of marbling. His data set

consisted of information on approximately 1,500 yearling bulls and 600 yearling heifers. His results for level of heritability of these traits agreed very closely with those already reported in the literature. However, what really raised a question in his analysis was the fact that the genetic correlation between fat thickness and ribeye area in the yearling ultrasound data was .38 while the same genetic correlation in slaughter steers has consistently been negative and high in the research literature (averaging -.31 from five independent studies). This stimulated John to further search the research literature to see if any other estimates had been reported for this correlation. When he did so, he found five estimates published since 1991 which all agreed with his Red Angus estimate (ranging from .05 to .48). The implication of John's finding is that these ultrasound measured differences in yearling cattle are not under the same genetic control as the same measures made on the slaughter steer carcass. John and Bruce Golden then developed a hypothesis which basically says that the cause of this result is that these measurements are being made at physiologically different points on the animals' growth curves. This result needs to be further substantiated in other breeds, but at this point it compels me to warn against placing too much faith in any retail yield EPD generated from yearling ultrasound information.

There is no doubt that the instrumentation/technology for assessment of "quality" attributes is still not to home plate yet. While results to predict intramuscular fatness (Iowa State) and marbling (Ag. Canada) from ultrasound in slaughter cattle look promising, the same type of potential problem discussed above for yield traits make the only logical solution to the **"quality"** issue to objectively identify marbling or better yet, tenderness differences directly on slaughter progeny.

Collectively, all of the discussion here leads to the conclusion that ultrasound may offer little more to us than use as a management tool for monitoring fatness/muscling in slaughter cattle. A number of efforts are now being directed at using ultrasound to sort incoming cattle at feedyards into "outcome groups". Given the current status of the yearling/slaughter trait relationship, this may be its limited and only appropriate application for improvement of carcass merit.

Given that ultrasound looks questionable and that there are no other potential methods for live animal scoring looming on the horizon, this means that if we want carcass EPDs, we must be willing to bite the bullet and collect the necessary progeny data. Several breed associations have now recognized this and have implemented more serious attempts at designed sire evaluation. The part you can play in this game is to demand carcass information on the seedstock you purchase. It is amazing what consumer demand will do to move something off of dead center. Seedstock producers can also work to develop calf buy-back programs to get carcass data. We can get the standard information if we try hard to do so. The only area that might be a little tough (no pun intended) is the trait of tenderness.

### **What About Tenderness?**

It seems like we have heard more about beef tenderness in the past two years than in all of the previous 100. As stated previously, beef is perceived to currently have a toughness problem, particularly in relation to cattle of *Bos indicus* descent. There are two ways to handle this

problem; tenderize the product post-mortem or genetically fix it. We have been working on the tenderness issue at Colorado State intensively for the past 18 months in a project for the National Cattlemen's Association as a part of the National Beef Tenderness Plan. In Phase I of the project, we evaluated tenderness of rib steaks from Limousin- and Charolais-sired steers and heifers aged to end-points of 1, 4, 7, 14, 21, and 35 days post-mortem. We evaluated sire differences in tenderness and in aging response and concluded that: 1) tenderness as assessed by shear force was heritable ( $h^2 = .38 \pm .20$ ); 2) 24-hour calpastatin activity, previously defined by Koohmaraie et al. (1993) as the primary contributing factor to tenderness variation, was highly genetically related to shear force and was heritable ( $h^2 = .48 \pm .21$ ); 3) aging time was overwhelmingly the single most important factor contributing to acceptable tenderness, and 4) a DNA test for differences in the calpastatin gene revealed statistically, but not practically, significant differences in tenderness.

Given that previous research has documented a major contributor of tenderness variation to be percentage *Bos indicus* inheritance (Sherbeck et al., 1995; Crouse et al., 1989), we are now concluding a second phase of this project using 585 cattle of varying Brahman percentage. Those data are now being completed with results to be presented at the NCA Annual Convention in San Antonio in January. We are anxious in this phase to see if the genetic effects will come out being of greater importance than the aging effects. If so, we will then be able to move toward devising strategies for "cleaning house" on tough *Bos indicus* sire lines using genetic screening either by shear force progeny testing or DNA testing for calpastatin.

At this point in time, breeders should position themselves on the tenderness issue by collecting progeny shear force data. The recommendation has been made out of our phase I NCA project that shear force data on steaks aged 14 days is needed on 35 progeny per sire in a designed test in order to discriminate the top 10% from the bottom 10% of sires for ultimate beef tenderness (Wulf et al., 1995). While this is relatively costly (\$10 to \$15 per head), perhaps we will be able to make this more economically attractive in the future. This is most necessary in the *Bos indicus* sources of germ plasm and should be a high priority piece of information for producers in the southern geographical zones of the U.S. who are using cattle of Brahman or other Zebu inheritance. For other breeds/breeders, tenderness is one of those "look-see" types of traits. Once you know where you are, you may not need to be too concerned. So a quick look now may be all that is needed.

### **DNA to the Rescue.....**

A lot of attention has been focused, as of late, on the DNA stairway to carcass heaven. A large industry-funded carcass gene mapping project is now being completed after five years of intensive effort at Texas A&M (Taylor et al., 1995). Other researchers have also been looking at various genes, or gene markers, to see if they are useful as "carcass tests". The calpastatin probe mentioned above is an example of this approach (Green et al., 1994, 1995) which is likely to yield significant accuracy-enhancers for traditional carcass EPDs generated from progeny data. However, gene markers may not have the same linkage relationships with carcass traits across differing breeds. This poses a significant hurdle to overcome before they can be widely used. For qualitative traits like black/red or polled/horned, DNA testing either is, or will be, readily

available. Unfortunately, this is unlikely to be the case for most of our economically important multigenic traits.

### **We Cannot Sacrifice Reproduction**

A last point needing emphasis concerns the relationship between carcass measures and measures of reproductive efficiency. There is generally a lack of this type of information in the research literature. The best existing data relating actual carcass measures to reproductive traits comes from a study by MacNeil et al. (1984) at the U. S. Meat Animal Research Center. Table 3 provides a summary of that information and indicates antagonistic relationships between selection to increase retail product yield and age at puberty, services required to settle a cow and mature size. When one considers these estimates in concert with the experiences of the swine industry with pale, soft, and exudative pork (PSE), a definite red flag is raised. **Use of any data for the genetic improvement of carcass merit needs to include potential effects on reproduction and maternal ability to prevent the loss of functional efficiency in the cow herd.**

Table 3. Genetic Correlations Between Measures of Carcass Merit and Reproductive Efficiency (MacNeil et al., 1984)

Female Trait	Postweaning Gain	Carcass Weight	Fat Trim Weight	Retail Product
Age at puberty	.16	.17	-.29	.30
Wt. at puberty	.07	.07	-.31	.08
Services/conception	1.33	.61	.21	.28
Gestation length	-.10	.03	-.07	.13
Calving difficulty	-.60	-.31	-.31	-.02
Birth weight	.34	.37	-.07	.30
Mature weight	.07	.21	-.09	.25

### **Implications**

Collectively, the information presented in this paper leads to the conclusion that the opportunity exists in the current cattle population to produce the kind of cattle desired at the end product level. Terminal sire lines selected for carcass merit matched with maternal dam lines where emphasis is placed on reproductive efficiency and matching of production potential to environmental resources offer the means to this end. **However, for this type of system to be effective, carcass merit expected progeny differences (EPD) like those described herein must be implemented in national cattle evaluation programs. Real-time ultrasound technology looks questionable as the solution to the problem. Progeny data for fat thickness, ribeye area, carcass weight, and shear force are needed. DNA markers may be of use to provide additional improvement in accuracy in the future but face significant hurdles yet before being widely useful. Short-term solution to the tenderness problem is available through post-mortem modifications, but in the long-term *Bos indicus* breeders**

**must identify genetically tough sire lines. Commercial beef producers should begin ASAP to not only ask for, but DEMAND carcass information from their seedstock suppliers. Seedstock producers, in turn, should develop strategic alliances with their customers to get carcass information from their calves to jump start this process. In the end, all parties in the industry will reap the rewards.**

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