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Beef Improvement Federation
39th Annual Research Symposium and Annual Meeting
Fort Collins Hilton, Fort Collins, Colorado
June 6-9, 2007

Wednesday, June 6, 2007
12:00 p.m. Registration
5:00 p.m. 40 Years of Innovation: Colorado Welcome Reception
7:00 p.m. National Association of Animal Breeders (NAAB) Symposium
40 Years of Beef Artificial Insemination (AI) - Robert Walton, former ABS President
Making Money with Commercial AI - Tim Sutphin, Virginia

Thursday, June 7, 2007
7:30 a.m. Spouse/Family Tour bus departs Hilton, North Entrance
8:00 a.m. Colorado Welcome
8:45 a.m. Introduction to Audience Input
Performance Programs at a Crossroads - Tom Field, Colorado State University
8:55 a.m. Genetic Improvement and Who Benefits, at What Cost and Who Pays? - Dr. Kent Andersen, Executive Vice President, North American Limousin Foundation
9:30 a.m. Are Beef Genetics Research, Education and Extension Relevant? - Ronnie Green, National Program Leader, Food Animal Production, USDA-ARS; Brian McCulloh, Woodhill Farms Inc., Viroqua, Wis.
10:10 a.m. Break
10:40 a.m. What is Your Approach to Genetic Improvement? Audience participation moderated by Tom Field, Colorado State University
10:50 a.m. Roundtable Discussion: Does the Seedstock Industry Focus on the Needs of the Commercial Cow-Calf Producer? Moderator - Ron Bolze, Director of Commercial Marketing, Red Angus Association of America
11:35 a.m. Defining the Ideal Beef Animal. How Will We Get There? - Tom Field, Colorado State University
11:50 a.m. Lunch, presentations of Frank Baker, Continuing Service and Commercial Producer awards
2:00 p.m. Committee Meetings
Live Animal, Carcass and End Product
Selection Decisions
Genetic Prediction
5:30 p.m. Shuttle buses begin for Equine Center, North Entrance of Hilton
6:00 p.m. Foam on the Range, Equine Center
8:00 p.m. Shuttle buses begin return trip to Hilton

Friday, June 8, 2007
8:00 a.m. Outline of first day’s audience input - Tom Field, Colorado State University
8:10 a.m. Can We Build the Ideal Beef Animal? - Darrh Bullock, Extension beef specialist, University of Kentucky
8:25 a.m. Users of Technology — Quality Grade: Why Haven’t We Seen an Improvement in Quality Grade?
A genetic improvement perspective - Dan Moser, Associate Professor of Animal Sciences and Industry, Kansas State University
An environmental perspective - Pete Anderson, Vice President of Sales and Technical Services, VetLife
9:15 a.m. Are There Sacrifices in the Chase for Carcass Merit? - Bob Weaber, Assistant Professor of Beef Cattle Genetics, University of Missouri—Columbia
9:45 a.m. Break
10:15 a.m. Users of Technology — Are There Benefits to Using DNA Markers?
A Producer perspective - Luke Lind, Vice President of Marketing, Five Rivers Cattle Feeding
An Academic perspective - Jerry Taylor, Professor and Wurdack Chair of Animal Genomics, University of Missouri
11:00 a.m. Pioneer and Seedstock Awards, President’s address
12:00 p.m. BIF Board Elections
12:30 p.m. Lunch
2:00 p.m.    Committee Meetings
            Cow Herd Efficiency and Adaptability
            Producer Applications
            Emerging Technology

Evening on your own in beautiful “Old Town” Fort Collins

Friday, June 8, 2007
7:00 a.m.    Producer Tour – Buses Depart Hilton North Entrance
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Forty Years of Beef AI

Dr. Robert Walton
Former ABS President

I deeply appreciate the invitation and the opportunity to be a part of this 40th Anniversary B.I.F. program. Although I’m supposed to be retired, I do run my own herd with 50 registered Simmental cows at home, and try to keep in touch with the industry a bit, so preparing for this presentation has been a delight and a wonderful opportunity to revisit people and events of a long, and for me, a grand career in livestock improvement. If you haven’t read Courageous Cattlemen, Bob DeBaca’s wonderful book in recent times, I recommend that you do so. I know almost everyone he wrote about in the book, but I still learned lots of new things about them and it was refreshing to recall the road many of us have traveled together. Jay L. Lush, Ray Woodward, Martin Jorgensen, Ferry Carpenter, Buddy Cobb, Frank Baker, Richard Willham, H.H. Stonaker, Jim Brinks, George Chiga, Don Vaniman, Sally Forbes, Roy Beeby, Tom Lasater, Lou Chestnut, Harry Furgeson, Dave Nichols, Roy Wallace and Bob DeBaca were among those I worked closely with, and several were my classmates with Dr. Lush and to whom I had the privilege of presenting the ABS Animal Breeding and Genetics as award at ASAS.

My direct involvement with AI began in 1962 when I was elected by ABS to design and implement this dairy progeny testing program in the Holstein breed. In that role, I developed and implemented the ABS EDS (Estimated Daughter Superiority) sire evaluation system in 1963, which was adapted and renamed the Predicted Difference System by USDA in 1965. That basic system is still in place and used around the world and in the beef industry; although it has evolved greatly with the availability of faster and more powerful computer systems, and with the application of great scientific minds to improve the mathematical adaptation to the specific traits of economic interest. The Animal Model or reduced Animal Model is the most modern revision.

Dr. Ray Woodward and I became acquainted when I joined ABS. He had already been there 3 years in developing the 1st Beef Progeny Program. We obviously had many mutual interests as geneticists. In 1965, during a time of reorganization at ABS when I was basically put in charge of the company – including the marketing operation and the genetic programs including beef cattle – Ray became my mentor on the beef industry, and I became his champion. ABS was approaching the 100,000 beef units/year sales volume, but couldn’t get over that level. I declared that we were either going to really get serious about the Beef AI business or we were going to get out.

I really had no intention of getting out, but I wanted to be sure I got the full attention of a staff that was very good, but had always been focused on the dairy side of our business. I recognized that Ray Woodward had been fighting a valiant but lonely battle up to that time and I was determined to get him some help.

As most of you know, Ray Woodward had been a longtime proponent of performance testing and that him coming to ABS signaled his realization that Beef AI done right would be a perfect compliment to performance testing. While some of our beef semen was going into dairy cows, most of the time beef breeding with AI was to a group of performance oriented commercial producers across the upper
Midwest, using several British breeds and who were followers of Ray Woodward’s philosophy.

It was obvious that three things were needed for an expansion of Beef AI, besides the commitment of a primarily dairy marketing team -

1. Someone to get the cows bred – our traditional AI Technicians were a long way from the beef cows – so we began developing the ABS Field AI Training Program at locations all over the country wherever we could congregate enough cattlemen to run a school. By the time I retired in 1991, we had trained our 125,000 cattlemen and dairymen in these schools.

2. Longer holding time liquid nitrogen refers – that could be leased to ranchers along with the semen needed for their breeding season without the need for N² refill during that time and could be returned with unused semen intact and nitrogen remaining at the end of the season. The Linde Company got the job done 1st and I’m still using one of those tanks on my farm that is nearly 35 years old. We would buy as many as 4,000 of these tanks at the beginning of each season and resell them after they returned as “field tested” to dairymen the rest of the year. (I.e. lowering my inventory cost and providing income).

3. A system for estrus synchronization to minimize the labor required or to even make it possible to implement a Beef AI program on a real cattle operation. That was a tough one to crack and it’s gone through many systems, but today, probably 90% or more of Beef AI is done using these protocols.

As these things were happening at ABS in the mid to late 60’s, some tough battles were happening elsewhere with P.R.I. and then B.I.F. I was aware of this through Ray and others on our staff, but I had my hands full with similar battles going on in the dairy field – I.e. who was going to control the AI industry, the AI companies or the dairy breed registry associations. I was elected to the NAAB Board, became its President, and led the battle which we won on this critical issue. It was also during this time that I brought in a beef registry executive, Bill Durfey from AICA, to become the NAAB Executive Secretary and give new leadership to the organization. Ray Woodward was my primary contact enticing Durfey to join us. This also helped the beef industry know that we were serious about Beef AI.

Back at ABS, with the AI Training School rolling, the longer holding time refers on the way, and a start on estrus synchronization, our Beef AI program began to take off and really laid the groundwork for the exciting 10 years to follow. With the interest in locating new genetic material to product beef with less fat, rather than undoing 200 years of selection for more fat as we had done in the British breeds to fit the market in the past, the recognition that Charolais, in this country, did have less fat led to going back to France to get more Charolais genetics to augment what had gotten to the U.S. via Mexico and from upgrading several decades before. Senator Harry Hayes of Canada, a real shaker and mover, led the way making a route available through Canada in 1965 with a number of Charolais and one Simmental (Pie Rouge) coming in that 1st year. ABS had long had a presence in Canada, so we had an inside track in securing many of these bulls as they came to Canada in the years following with over 20 breeds brought in. Ray and I made numerous trips together to Europe in selecting the specific animals to bring in. We established a stud site at Bragg Creek near Calgary, which became a mecca for these new breeds and we produced millions of units of semen there for export to the U.S. and all over the world.
As I said earlier, we had already set the table with our beef preparation in training, distribution, and management and we had this great network of performance oriented people excited about AI. That led to explosive growth in Beef AI. We sold enough beef semen to breed over one million cows in both 1973 and 1974, before the recession hit the whole country and particularly the beef industry. It was a heady time!

As some of you may remember, the British beef registry associations, except for Red Angus, had opposed allowing registration of AI offspring except on a very restricted basis through the 60’s. With the explosion of popularity of the “exotic” breeds, which adapted open AI policies, and many commercial breeders using Beef AI, some enlightened Angus breeders in particular, and Martin Jorgensen specifically (one of your founders, past president, and recipient of the Seedstock Breeder Award) began challenging the breed’s policy. Ray Woodward kept me informed on these developments and we were quietly behind the scenes giving full support to this truly courageous cattleman.

In 1974, the Angus Association acknowledged the impossible legal position the Board was in, and changed their policy. To their credit, the Angus breeders in this country jumped on this new opportunity and new tool with both feet, recognized the potential of large databases with widespread use of AI, soon had a national-sire summary with help from my friend, Richard Willham, and have never looked back. As an aside, it should noted that the American Simmental Association had the 1st national beef sire evaluation program and as a Simmental breeder, I often wonder why we didn’t just leave those Angus breeders alone in the dark ages. But I had to wear my other hat as ABS President, and we couldn’t walk away from the potential in a great breed like the Angus.

In 1968, we developed and introduced the ABS Genetic Mating Service, which combined a linear evaluation system for functional dairy conformation for each cow with a computer decision process utilizing all possible mating sires to determine the best possible mating for that cow. Millions of commercial dairy cows around the world have now been mated using this system that combined the wisdom of the dairyman with the power of the computer. This was another industry first.

I had intended to introduce a similar system in our beef breeding program, but the recession and many other problems interfered with that plan, including my resignation from ABS in 1982. Peter Grace would not accept my resignation, but instead changed the whole management system we reported to within The Grace Company, and gave me a free hand to rebuild the ABS that had been almost destroyed the previous 7 years. There was so much to be done, but we got it done including the 1st clones in the animal world with the creation of Fusion and Copy long before Dolly the sheep was even heard of. Gene was also conceived before Dolly, but because of the longer gestation period for cattle, was born just after Dolly. Anyway, we finally introduced the ABS Genetic Type Summary to the beef industry in 1988 and it has added immensely to the effectiveness of beef cattle breeding.

That recession in 1974-75 really put a crimp in most businesses and certainly in agriculture. The beef business took a real beating as the previous years had been so good that cattle numbers had continued increasing in defiance of the typical 10 or 11 year cattle cycle, so the supply of beef far exceeded demand. Thus, President Nixon’s freeze on beef prices and other communities acerbated the crunch on beef producers’ income. Instead of a normal product cycle curve, the Beef AI business fall was precipitous as producers got out of the business or hunkered down and minimized all
outgo just to survive. The supply of top proven beef bulls from our long-term progeny testing programs greatly exceeded the demand, and many outstanding bulls were sent to market or sold at a great discount for natural breeding service as all segments of the industry contracted to weather the storm.

The bloom was off the “exotics” and many of the newly introduced breeds never got a chance to be adequately tested in our beef production systems. Those that were better established and had a database and genetic evaluation systems in place were able to survive if they had real merit, but it was a severe testing time and many fell by the wayside.

The Angus breed, which really got their act together after the legal case was resolved, began to make significant genetic progress using AI and their new sire evaluation systems. As the industry began to recover, they were in the best position to take advantage of the new growth opportunities and have rightfully claimed their spot at the top of most Beef AI breeding programs.

As synthetics or composites have been developed and the power of hybrid vigor has been understood more widely in commercial beef production, several other breeds have regained their footing and are finding major niche positions in crossbreeding programs for beef production.

Some breeds or breeders tried to be all the things to all genetic needs in the industry, but I sense that most of them now recognize the specific strengths and/or weaknesses of their breed and are seeking to find their best fit in the national breeding program.

I’ve not been to Brazil or Argentina for at least 20 years, but I understand the beef industry there has gone way past us in percent of beef cows bred AI in commercial herds using much of the technology we developed here. We’d better take a lesson from that and do a better job of practicing what we have been preaching!

Like in the dairy business, the cows never stay milked and you have to keep doing it everyday. We have developed magnificent tools and management systems for Beef AI in commercial production, but we have to keep moving ahead as markets and conditions change. We have to keep our genetic tools sharpened and aimed in the right direction. Yesterday’s solutions are soon out of date.

One final note regarding one of our heroes… it was a great privilege to play a role in the nomination of Dr. Ray Woodward to have his name and portrait hung in the Saddle and Sirloin Gallery of leaders in the livestock industry at Louisville, KY about 15 years ago. His presence certainly adds to the prestige of the gallery.

Now back to the stories exemplified in Courageous Cattlemen… As I reread those stories, I gained a new appreciation for those individuals who reflected the very best of human attributes. Many were truly 1st or 2nd generation pioneers who were clear and courageous thinkers, who battled formidable circumstances, or people in bringing about what we now call performance testing. They were strongly committed to doing what was best for the industry without concern for personal gain. That was the heritage of the B.I.F. They and you are to be commended for courage, integrity, dedication and foresight in making B.I.F a real cornerstone of the beef industry. I tip my hat to you and to them, and am proud to say that I know I was friend to so many of them and to so many of you.

Thank You
I would like to thank the Beef Cattle Improvement Federation for the opportunity to present my information at this prestigious forum. Although this data would not pass scientific muster, it is of the real beef cattle world and is the support that confirms to me that my work is feasible and is adding value to my end product.

Hillwinds Farm has been operating for 20+ years in the Blue Ridge Mountains of Southwest Virginia. We have a family run operation that we started. The operation includes my wife, Cathy, and our four children, Laura, Alison, Caroline, and Heath. The operation consists of 1047 acres of owned land and about 1000 acres of leased land. We pasture all of this and make 500 acres of hay. We are primarily a commercial cow/calf business with 709 Angus cross cows. We calf in the spring and fall and retain ownership of the calves until slaughter. The calves are custom fed in Nebraska. We also purchase and background 1000 stocker calves each year and we retain ownership on these calves as well. Hillwinds Farm is the home to the Southwest Virginia BCIA Bull Test Station where we develop about 200 bulls each winter. We also have 150 commercial Suffolk ewes.

Today I want to talk about net return to the cow. There are several measures we use to gauge productivity: percent calf crop weaned, weaning weight, average daily gain, percent choice or better. However, any of these by themselves don’t mean a lot. They are all factors in profitability but to achieve maximum levels of performance in any one of these usually hurts overall profitability. Net return is the one measure that we would like to maximize.

I believe that some of the best ways to increase net return is through estrous synchronization, artificial insemination (AI), and retained ownership through slaughter. The data presented, I hope will support this statement. We have been using estrous synchronization and artificial insemination on a whole herd basis since 1999 and retained ownership since 1996. The information presented is the actual field, feedyard, and harvest figures.

We start with the cost to create a pregnant cow either from AI or natural service.

<table>
<thead>
<tr>
<th>Artificial Insemination</th>
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</thead>
<tbody>
<tr>
<td>Semen</td>
<td>$12.00 per straw</td>
</tr>
<tr>
<td>Prostaglandin</td>
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<tr>
<td>GnRH</td>
<td>$3.00 per 2 (1.5 cc doses)</td>
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<tr>
<td>Chute Charge/Heat Detection</td>
<td>$6.00</td>
</tr>
<tr>
<td>Insemination</td>
<td>$2.50</td>
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<tr>
<td></td>
<td>$25.65</td>
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$25.65/ 65% AI conception rate = $39.46/AI Pregnant Cow
### Natural Service

<p>| | |</p>
<table>
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<tbody>
<tr>
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<tr>
<td>Bull Maintenance Cost ($450/year)</td>
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</tr>
<tr>
<td></td>
<td>$30.00</td>
</tr>
</tbody>
</table>

$30/ 90% conception rate = $33.33/ Natural Service pregnant cow

This results in a $6.13 advantage for the natural service pregnant cow. There is also a cost of time, planning and stress on cattle, facilities, and people when implementing an AI program. We believe that the benefits of synchronization and artificial insemination outweigh this cost.

Prior to starting our AI program, we had pregnancy rates of 93 to 95% and had 70% of the cows calving in the first thirty days of ninety day calving seasons. The past six years, we have had between 95 and 97.5% pregnant cows with 85 to 90% of cows calving in the first thirty days and the calving season is 65 days in length. This has happened because nearly all of the cows are bred on day 1 of the breeding season and we can routinely back up our later calving cows some as much as 60 days. The average AI sired calf is 27 days older than the average natural service calf. Also our average calf on a herd basis is 16 days older now than before we started the AI program. The fall group from 2006 was pregnancy tested earlier this year with the following results:

<table>
<thead>
<tr>
<th>Group</th>
<th>% Pregnant</th>
<th>% Bred AI</th>
<th>% AI Pregnant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers</td>
<td>90</td>
<td>90</td>
<td>61</td>
</tr>
<tr>
<td>2 Year Olds</td>
<td>96</td>
<td>96</td>
<td>74</td>
</tr>
<tr>
<td>Cows</td>
<td>97</td>
<td>93</td>
<td>74</td>
</tr>
</tbody>
</table>

We work to be consistent in our AI program and to pay attention to details such as timing of injections, semen handling, and cattle stress. We use bulls that have high quality semen, high conception, and are proven.

Our heifer program is the 7 day CIDR protocol. We breed on standing heat with no timed AI. The 2 year olds have exposure to a teaser bull 50 days prior to breeding and then we use the Ov-Synch with a CIDR program. The cows are on a regular Ov-Synch schedule.

AI calves that are born at Hillwinds have required delivery assistance 1.3% of the time whereas as non-AI calves are assisted 2.9% of the time. The difference is due to higher accuracy on birth weight and direct calving ease EPDs for AI sires. Ninety percent of assists occur in first calf heifers.

AI sired calves from birth to harvest had a death loss of 3.5% compared to 5.5% for non-AI calves. This is due to closer observation at
calving and lower birth weights of AI calves. In addition, the older AI calves have more resistance to pneumonia and scours. Losses occurring after weaning are not significantly different between the two groups.

The spring steer calves from 2006 were born in February and March, weaned in early September, backgrounded 45 days, and sent to feed in late October. The steer calves are divided into four groups based on the parentage. The following weights were taken in October:

<table>
<thead>
<tr>
<th>Group</th>
<th>Ave Weight</th>
<th>Age</th>
<th>Wt/Day of Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sire AI Dam AI</td>
<td>775</td>
<td>262</td>
<td>2.96</td>
</tr>
<tr>
<td>Sire AI Dam Non-AI</td>
<td>740</td>
<td>255</td>
<td>2.9</td>
</tr>
<tr>
<td>Sire Non-AI Dam AI</td>
<td>707</td>
<td>237</td>
<td>2.98</td>
</tr>
<tr>
<td>Sire Non-AI Dam Non-AI</td>
<td>673</td>
<td>233</td>
<td>2.89</td>
</tr>
</tbody>
</table>

The steers were shipped to Nebraska on October 24, 2006 and harvested in four marketing groups from April 4, 2007 to May 10, 2007. The feedyard performance on each group is as follows:

<table>
<thead>
<tr>
<th>Group</th>
<th>Live Wt. at slaughter (4% Shrink)</th>
<th>Days on Feed</th>
<th>ADG</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI/AI</td>
<td>1311</td>
<td>170</td>
<td>3.21</td>
</tr>
<tr>
<td>AI/Non-AI</td>
<td>1260</td>
<td>172</td>
<td>3.18</td>
</tr>
<tr>
<td>Non-AI/AI</td>
<td>1241</td>
<td>179</td>
<td>3.14</td>
</tr>
<tr>
<td>Non-AI/Non-AI</td>
<td>1235</td>
<td>189</td>
<td>3.13</td>
</tr>
</tbody>
</table>

The steers were age and source verified and sold grade and yield. Carcass performance and net return are listed by group:

<table>
<thead>
<tr>
<th>AI Bulls on AI Cows</th>
<th>Quality Grade</th>
<th>Yield Grade</th>
<th>Percentage</th>
<th>Avg Premium Base</th>
<th>Net Return</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>97% Choice</td>
<td>2 &amp; 3</td>
<td>94%</td>
<td>$78</td>
<td>$1,390 (gross return)</td>
</tr>
<tr>
<td></td>
<td>3% Select</td>
<td>4</td>
<td>6%</td>
<td></td>
<td>-$364 (feed cost)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-$54 (trucking)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$972</td>
</tr>
</tbody>
</table>

$972 net to cow divided by 775 pound delivery weight = $1.25 breakeven price
### AI Bulls on Non-AI Cows

<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Yield grade</th>
<th>Percentage</th>
<th>Avg Premium Base</th>
<th>Net Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>85% Choice</td>
<td>2 &amp; 3</td>
<td>92%</td>
<td>$67</td>
<td>$1,331 (gross return)</td>
</tr>
<tr>
<td>15% Select</td>
<td>4</td>
<td>8%</td>
<td>$67</td>
<td>-$368 (feed cost)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-$52 (trucking)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$917</td>
</tr>
</tbody>
</table>

917 net to cow divided by 740 pound delivery weight = $1.24 breakeven price

### Clean Up Bulls on AI Sired Cows

<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Yield grade</th>
<th>Percentage</th>
<th>Avg Premium Base</th>
<th>Net Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>74% Choice</td>
<td>2 &amp; 3</td>
<td>100%</td>
<td>$56</td>
<td>$1,290 (gross return)</td>
</tr>
<tr>
<td>26% Select</td>
<td>4</td>
<td>0%</td>
<td>$56</td>
<td>-$383 (feed cost)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-$52 (trucking)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$857</td>
</tr>
</tbody>
</table>

$857 net to cow divided by 707 delivery weight = $1.21 Breakeven price

### Clean Up Bulls on Non-AI Sired Cows

<table>
<thead>
<tr>
<th>Quality Grade</th>
<th>Yield grade</th>
<th>Percentage</th>
<th>Avg Premium Base</th>
<th>Net Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>61% Choice</td>
<td>2 &amp; 3</td>
<td>100%</td>
<td>$32</td>
<td>$1,248 (gross return)</td>
</tr>
<tr>
<td>39% Select</td>
<td>4</td>
<td>0%</td>
<td>$32</td>
<td>-$404 (feed cost)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-$47 (trucking)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$797</td>
</tr>
</tbody>
</table>

$797 net to cow divided by 673 delivery weight = $1.18 Breakeven price

### Overall Spring 2006 Steers

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average live weight</td>
<td>1262</td>
<td>lbs</td>
</tr>
<tr>
<td>Average days on feed</td>
<td>174</td>
<td>days</td>
</tr>
<tr>
<td>Average daily gain</td>
<td>3.2</td>
<td>lbs</td>
</tr>
<tr>
<td>Gross return per steer</td>
<td>$1,317</td>
<td></td>
</tr>
<tr>
<td>Feed cost</td>
<td>-$372</td>
<td></td>
</tr>
<tr>
<td>Trucking</td>
<td>-$50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$895</td>
</tr>
<tr>
<td>Sire AI Dam AI</td>
<td>% Choice</td>
<td>YG 3 or better</td>
</tr>
<tr>
<td>----------------</td>
<td>----------</td>
<td>----------------</td>
</tr>
<tr>
<td>97</td>
<td>94%</td>
<td>$78</td>
</tr>
<tr>
<td>Sire AI Dam Non-AI</td>
<td>85</td>
<td>92%</td>
</tr>
<tr>
<td>Sire Non-AI Dam AI</td>
<td>74</td>
<td>100%</td>
</tr>
<tr>
<td>Sire Non-AI Dam Non-AI</td>
<td>61</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Group Average</strong></td>
<td><strong>80</strong></td>
<td><strong>96%</strong></td>
</tr>
</tbody>
</table>

If we compare a calf that is AI sired and out of an AI sired cow with a calf that is sired by a cleanup bull and a non-AI sired cow, the difference in the end value is $175. Maybe a better way to look at the difference is to calculate out net return using the entire calf crop on our current program. That figure is $775/cow.

Now, pull out the cows that are not AI sired and have calves that are not AI sired and the net return/cow is $685. That is a difference of $93. Subtract from that the extra AI cost of $6. In our herd, we see an added $87/cow in net return. On a herd basis, this is worth over $60,000/year in net return which more than makes the payments on 500 acres of our land.

I hope that it is now clear why we use estrous synchronization and AI in our program. When we began our beef cattle operation I wanted to operate within the main stream of the beef cattle industry. We were told by many people that there was no money in cattle and that you can’t make a living let alone purchase land. You know, they were right! Except they assumed we would operate our farm their way. We found our own way. Again, thank you very much.
A Look Back at BIF History

A.L. (Ike) Eller, Jr.

Any look back at BIF’s 40 year history has to be about three things – People, Leadership, and Technology. It is really not about cattle – cattle don’t have ideas and cattle don’t have emotions. Cattle don’t have need to make change…but people do.

Improvement of cattle and other livestock certainly predates Robert Bakewell (1725-1795) who first suggested that “Like begets like.” At Bakewell’s time, the mode of inheritance was unknown. Gregor Mendel did some fascinating work with peas and other vegetables in the monastery garden that proved that genes expressed themselves in a predictable and mathematical way, so discovered the principals of genetics in 1866, since known as Mendelian segregation. His work was rediscovered about 1900. Then in early to mid- twentieth century Sewell Wright and R.A. Fisher brought modern livestock breeding, from a statistical standpoint, into the area of science. Wright’s principals of genetic relationships among relatives in one of the essential principals of our modern EPD (Expected Progeny Difference) calculations.

Long before we turned to science, the method of evaluating animals became the “eye of the master” visual appraisal along with a published pedigree, and it stayed that way into the latter third of the 20th century.

No idea is of much value until its time comes according to Victor Hugo. Certainly beef cattle performance testing fit the mold.

Before we get the “Cart before the horse,” let’s consider the genesis of scientific cattle breeding in the U.S. By 1900, livestock breeders of the mid-west had imported enough British stock to become breeders and provide ranchers and stockmen with Shorthorn and later Hereford sires. Grading up from a Longhorn or Shorthorn base to Herefords was accomplished in a short 20 or so years. These earlier maturing kinds became popular, reducing the age to harvest and fit into a growing cattle finishing business which added value.

The Chicago International opened in 1900. Grands in the British breeds became smaller and fatter particularly from the 30’s on. College judges were predominant, but were in tune with most industry desires. The rise of the influence of breed associations was monumental. The use of pedigree and the eyeball to secure adherence to breed type was the basis of successful breeding.

This system worked because value was attached to show ring standing and winnings, so change came slowly. Compact and comprest selection continued until dwarfism reared its ugly head in two types. University researchers got in the act and in concert with breed associations took a scientific approach to identify and eliminate carrier animals.

The gulf coast needed more. King Ranch in Texas developed the first American breed, Santa Gertrudis, with 5/8 Shorthorn and 3/8 Brahman blood in the 1920’s. Beef breeding at the USDA Range Station at Miles City, Montana beginning in 1924 was to change the direction of the beef industry. In the 1936 Yearbook of Agriculture, Lush and Black called for objective measures of merit in beef cattle. Heritability estimates for growth by Knapp and Nordskog and weight adjustments by Koger and Knox stimulated research interests.
The first bull gain test was conducted in Texas in 1941. The Charolais breed was introduced into Texas from Mexico in 1936 but did not spread across North America until the 1960’s. Some have called Charolais the “Babcock Test” of the beef industry because of the change this breed brought about.

The early research work at Miles City lead to developing a cattle production records program in Montana by 1936. Performance programs, as such in beef cattle, started before WWII but were not developed until much later in the period 1950-1980. A number of breeders such as the Bell Ranch, Wye Plantation, and John Rouse developed in-herd programs of record utilization. Between 1945 and 1950, state Extension beef improvement programs (BCI) were started noticeably in California, Colorado, New Mexico and Montana and were run by Extension specialists. Virginia organized the first state Beef Cattle Improvement Association in 1955 and many states followed suit. In the same year, with Extension help, cattlemen in Texas formed Performance Registry International (PRI). PRI became the focal point of the industry for performance. PRI’s program was patterned after state programs except that records of weights were certified and a notable Certified Meat Sire Program was developed. State BCIA’s were given director seats on the PRI board.

The Red Angus Association, formed in 1954, was the first to require performance data for registration. The other established breed associations were registering record members of cattle in the 1950’s and ‘60’s and showed only modest interest in jumping into the performance pool but many breeders were pushing for such.

The growing feedlots were getting disappointing performance from the British breeds and many even preferred the long-tailed “Okies”. Several bull studs had started buying tested bulls from reputation performance herds. Jerry and Charlie Litton of Missouri were a force in the Charolais Congress in Kansas City. They later promoted performance with the development and use of the LCR-Breeding Value Analysis program (developed by Richard Willham at Iowa State) used in the Litton herd.

By 1964, five breeds had announced or were contemplating announcements of breed association sponsored performance programs. The Extension Beef Improvement committee of the American Society of Animal Science, chaired by Curtis Mast of Virginia pursued the interest from three regional Extension conferences in beef performance testing. From this, Charlie Bell, U.S. Extension Animal Scientist, Curtis Mast, Everett Warwick (ARS) and Frank Baker (Bell’s replacement) formulated a plan to achieve some standardization and coordination of beef performance programs. Baker put together a working group of twenty-five including extension, research, breed association and PRI personnel. The U.S. Beef Cattle Records Committee Report of 1965 was subtitled, “Recommended Procedures for Measurement of Traits of Economic Value in Beef Cattle.” It was a landmark piece of work that was strong input to the later workings and guidelines of B.I.F.

There was great concern in many corners as to who or what would or should happen to bring about progress in harnessing known technology in a system of beef cattle improvement and increased profitability. PRI was poised to take over the performance movement. State BCIA’s were strong and self reliant. Breed associations were weak in terms of performance programs and were quite independent.

In rides Ferry Carpenter, an 80 year old lawyer and former overseer of U.S. public grazing lands. Carpenter was a Hereford breeder and staunch member and supporter of PRI as well as Colorado BCIA and the AHA TPR program. Carpenter conferred with Frank Baker and Charlie Bell about putting together an industry-
wide performance meeting in Denver at the National Western. The government men pledged support and invitations went out widely for the meeting which was held January 14, 1967. It was titled, “International Conference of Beef Cattle Performance Testing Associations.” The meeting was well attended by those representing many state BCIA’s, breed associations, and PRI. Several speakers representing USDA Research and Extension, beef breeds, dairy breeds, the American Society of Animal Science, feeders, and A.I. organizations made presentations basically in favor of getting together. Later, 27 state program representatives made reports along with four National breed associations. The younger and smaller state BCIA groups generally favored a national program but the older, larger state groups were leery of a national effort unless the National program suited them in view of their current success.

At the end of the day, no consensus was reached but a volunteer committee was formed to plan a move to a positive solution. The committee was comprised of Ferry Carpenter, L. A. Maddox, Bob Brandenburg, Stan Anderson, James Lingle, Lloyd Schmitt, Charles Codd, Jesse Malone, Roy Beeby, M. K. Cook, Ray Woodward, Harry Herman, George Nimick, Matt Sutton, John Airy, Bob deBaca, and John Sullivan.

The committee met later the same day under the chair of Frank Baker. At this meeting it was voted unanimously that it was necessary:

1. To correlate the present performance testing organizations and agencies into a national organization, and
2. Such a national organization should have such functional powers as the members cared to give it.

During the next year the ad hoc committee became the focal point. The fight was whether the national organization should:

1. Be a council of member organizations with limited operational powers, or
2. A direct membership organization with strong operational authority. Ferry Carpenter favored the latter.

In the course of deliberations Sally Forbes of Wyoming wrote and circulated a most insightful letter in support of the council or federation type structure which would allow organizations to operate independently under a loose set of guidelines. The name Beef Improvement Federation was finally approved along with a revised set of by-laws.

On January 12, 1968, the B.I.F. organizational meeting was held in Denver with Frank Baker presiding until a president was elected. Curtis Mast from Virginia gave the keynote address and 25 state BCIA’s, nine national breed associations, NAAB, ANCA, PRI, and three A.I. studs became charter members. A very large crowd representing every segment and area of the beef industry was in attendance. The by-laws were accepted and directors were seated including Mack Patton, Bob Purdy, Dave Nichols, Lloyd Schmidt, Harold Thompson, John Sutton Jr., A. F. Flint, Henry Matthissen, John H. Wilson, Ray Meyer, Stanley Anderson, Harry Herman, Everett Warwick ex-officio and Dixon Hubbard ex-officio. Clarence Burch was elected president and Lloyd Schmidt vice president. Frank Baker accepted the job of executive director. The work of B.I.F. had its beginning with the annual meeting and research symposium in April 1969 in Kansas City.

Committee work began with the aim of producing the first printed guidelines. Since that time, guidelines have been revised as needed and reprinted regularly based on the work and recommendations coming out of committees and approved by the board of directors.
Cutting edge research has been presented at each annual meeting and research symposium. Many young researchers have “earned their spurs” by bringing new information and becoming active in B.I.F. The synergism between researchers, breeders and their associations through BIF has been truly amazing.

B.I.F. annual meetings and research symposia have deservedly earned the reputation of being the best meeting on the annual national beef industry calendar in the eyes of many involved leaders. Printed proceedings have become reference items with lingering benefits.

A real work horse and visionary leader during the first half of the life of B.I.F. was Richard Willham of Iowa State. He lead in the development of the B.I.F. sponsored computer cow game which was used widely to teach the principles of record- based selection. Willham also had a strong hand in developing Estimated Breeding Values (EBV’s) which were the forerunner to EPD’s. He worked closely with the breed associations. He later lead the Sire Evaluation committee in the development of EPD’s along with Larry Cundiff, Charles Henderson, John Pollak, Richard Quaas and others.

A number of sticky problems came along and were dealt with such as:

- Deciding to express EPD accuracy in terms of a percentile rather than possible change
- Deciding to formulate a frame score chart based on hip height.
- Deciding not to take over Ideal Beef Memo and print a B.I.F. paper
- Deciding to recommend procedures for the use of ultrasound for the evaluation of carcass traits, including the regimen for training technicians.
- Deciding not to recommend procedures for grading based on visual appraisal.
- Trying unsuccessfully to preserve and strengthen state BCIA’s

Breed associations that may have been “foot draggers” early on have stepped up, have innovated, have educated their memberships, and have become the users of vast amounts of data which they own. B.I.F. has come of age, and with little power except the power of persuasion and with little money has lead a giant industry to greater productivity and profitability. BIF, in truth, has done very little but member organizations through BIF have accomplished much.

Is the work all done? Surely not! Population genetics has been the name of the game and will probably continue to be. The basis of EPD’s is the individual record as a deviation from the mean of a true contemporary group. Now that the bovine genome has been sequenced (at least in part), how will data used in selection programs look 10 or 20 years from now? Stay tuned and stay involved!

Some of the stalwarts of the performance movement that I’ve known include:

**Industry:**

<table>
<thead>
<tr>
<th>Dale Lynch</th>
<th>Forest Bassford</th>
<th>Willie Altenburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roy Wallace</td>
<td>Bob de Baca</td>
<td>Jim Gibb</td>
</tr>
<tr>
<td>Harry Herman</td>
<td>Keith Vandervelde</td>
<td></td>
</tr>
</tbody>
</table>
### Breeders:
- Farrington Carpenter
- Waldo & Sally Forbes
- Frankie Flint
- Jerry & Charlie Litton
- Martin Jorgenson
- Dave Nichols
- Jack Cooper
- Les Hoden
- Lyle Lingle
- Glenn Butts
- Jess Kilgore
- Carlton & Murray Corbin
- George Chiga
- Glenn Burrows
- Burke Healey
- Dale Davis
- Gene Schroeder
- Jim Leachman
- Bill Borrer
- Max Hammond
- Clarence Burch
- Ray Meyer
- Buddy Cobb
- Doug Bennett
- Lou Chestnut
- Henry & Mark Gardner
- James & Paul Bennett
- Steve Radakovich
- Rob & Donnell Brown
- Glenn Brinkman
- Mrs. R.W. Jones
- Garald Parks
- Roy Beeby
- Henry Matthiessen

### Researchers:
- Ray Woodward
- Doyle Wilson
- Larry Benyshek
- Richard Quaas
- John Pollak
- Jim Brinks
- Marvin Koger
- Charles Henderson
- Paul Miller
- Everett Warwick
- Richard Willham
- Keith Gregory
- Robert Koch
- Larry Cundiff
- Tom Marlowe
- C.J. Brown
- Charles Kincaid
- Gordon Dickerson
- Merlyn Nielson
- David Notter
- R.T. Clark
- Richard Quesenberry
- John Knox
- Bradford Knapp
- Jay Lush

### Extension Workers:
- Frank Baker
- Charlie Bell
- Paul Pattengale
- Ruben Albaugh
- Curtis Mast
- Dixon Hubbard
- M.K. Cook
- Carroll Scoonover
- O‘Dell Daniels
- Bill Wharton
- Melvin Bradley
- Harlan Ritchie
- Dean Frischknecht
- L.A. Maddox, Jr.
- John Massey
- Pete Patterson
- Roger McCraw
- Bobby J. Rankin
- J.D. Mankin
- Daryl Strohbehn
- Twig Marsden
- Jim Gosey

### Breed Associations:
- Art Linton
- C.D. Swaffar
- H.H. Dickerson
- Richard Spader
- John Crouch
- Bill Durfey
- Stanley Anderson
- Don Vaniman
- Orville Sweet
- Fred Francis
- Craig Ludwig
- Mack Patton
- Jim Gibb
- C.K. Allen
Today's Beef Cattle Genetics Research and Education Engine: Ready and Primed for the Industry's Future?

Ronnie D. Green
National Program Staff
USDA-Agricultural Research Service
Washington, D.C.

Introduction

Genetic improvement in livestock has a truly amazing history, with the beef industry having been blessed with many of the major scientific innovations that have occurred along the way. In recent years, it has been nearly impossible to miss seemingly daily news reports about exciting discoveries in the new field of molecular genetics and genomics. While most of these reports have focused on the unraveling of the human genome and its implications for human health, there has been significant spillover into plant and animal agriculture as well. At times over the past 15 years, it has seemed that this new and exciting field would hold all of the immediate answers to breeding better beef cattle. Today we have an initial DNA sequence assembly of the cow genome completed and made publicly available along with a host of rapidly developing diagnostic tools. Along with a number of major societal shifts that are predicted to result in changes of epic proportions for the beef industry and its producers, the question is being posed as to whether existing U.S. programs and infrastructure in beef cattle genetics research and education are “in tune” and adequate to address future needs. The objectives of this presentation are to: 1) provide a historical context for how we have arrived at where we are in 2007; 2) discuss the major societal issues that are predicted to change the landscape of the beef industry and beef cattle genetic improvement in the near term; and 3) discuss the current and future challenges of the beef genetics research and education community in being properly primed and ready to serve the current and future needs of the industry.

A Brief History of Beef Cattle Genetic Improvement

It is believed that cattle were domesticated over 5,000 years ago. Only in the last few hundred years has the human race applied systematic animal breeding programs to these amazing animals to mold them into more specific roles – i.e. meat, milk, or draft. Today the number of distinct cattle breeds numbers in the hundreds across the world.

In the U.S., our cattle industry quickly developed as segregated into dairy and beef sectors. By the dawn of the 20th century, the beef part of this industry had essentially become made up of three breed populations – Aberdeen Angus, Hereford, and Shorthorn. It is unlikely that our ancestors engaged in the beef business at that time – for most of us our grand- or great-grandparents - would have been able to predict the dramatic changes that would take place in the next 100 years.

The first half of the 20th century was an immensely prolific time in agricultural science. Arguably, the most dramatic discoveries were actually in the fields of genetics and statistics. During the 1920s and 1930s, the field of population genetics came of age – primarily as a means of quantifying and describing Darwin’s writings from the late 1800s. The emerging leaders of this field helped to describe the concepts of genes, gene loci, chromosomes, and cellular reproduction. They also were
instrumental in establishing the field of biometrics – statistics as applied to biological phenomena. These early statisticians developed much of the underlying theory used broadly in science today. What most people do not know is that they originally were geneticists trying to describe how populations of animals change over generations! Also, at the same time there were pioneering scientists who had the foresight to develop populations of beef cattle upon which they began to practice long-term selection and inbreeding – ones like the Miles City Hereford lines that gave us the Line 1 of today.

Scientists also made what seemed to be an unrelated, but extremely valuable, discovery in plant genetics during this same time period. Scientists observed that when two unrelated lines of germplasm were crossed – or “hybridized” – the resulting crossbred progeny had better performance than the expected average of the parents. The concept of heterosis between lines was born – and with it the seed industry and crop agriculture was revolutionized. At the time, livestock breeders did not see any great benefit from this phenomenon – but as we now know, that would dramatically change later.

The post-WWII era was a particularly exciting time for livestock genetic improvement, as it was in many fields. The 1940s saw some of the greatest minds to ever grace the study of livestock genetic improvement at their prime. Jay Lush, who many refer to as the modern day father of animal breeding, was busy defining with co-workers Lanoy Hazel and Gordon Dickerson the concept of the “selection index” and “breeding value”. The field of biometrics had matured to the point where it was now possible to determine from experimental populations that performance for traits affecting production could be measured – and that many of these traits appeared to be heritable.

In 1953, James Watson and Francis Crick presented for the first time in the scientific literature the molecular structure of the genetic code – i.e. DNA. Combined with the theories of genes and heritable variation of traits, it was now possible to visualize how these genetic differences at the gene level might one day be exploited for genetic improvement.

Also, in the 1950s, two significant events occurred which would permanently change the nature of cattle breeding. The first was that artificial insemination techniques matured to an adoptable level for cattle breeders – especially dairy producers. Coupled with the institution of the Dairy Herd Improvement programs of USDA a bit earlier, volumes of data began to accumulate matching pedigrees to milk production records. At the same time, computing technology was beginning to surface as a usable tool – even though it was rudimentary to what we now have today. Dairy cattle breeders had enough foresight, however, to understand the power of coupling quantitative genetics theory to artificial insemination and as a result genetic evaluation as an applied science was born. Now, through all of the technological and computing improvements of the last 45 years, we have seen that this works – to the tune of almost 100% improvement in milk yield per cow!

Thankfully, the plans of the dairy industry did not go unnoticed by beef cattle breeders. The American Angus Association and the American Hereford Association quickly established performance recording programs for their breeders – focusing initially on 205 day weaning weights within herds. In the late 1960s, some visionary cattle breeders, including Sally Forbes, Frank Baker, Jim Brinks, Bob deBaca and others, formed an organization called the Beef Improvement Federation. This organization was instituted to take on the task of developing uniform guidelines for performance recording programs, the same task that it still performs 40 years later. One of the initial visions of this group was that it would soon be able to develop methodology to compare
animals across herds – making the standardization of performance recording critical.

The late 1960s and early 1970s was the next time of great change in beef cattle breeding. Two things occurred somewhat simultaneously – the importation of semen from a number of continental European breeds of cattle and the next generation of computing technology coming of age. As a result of their higher growth rates, size, and muscularity, a number of these breeds quickly took a strong foothold in the beef cattle seedstock industry – especially Simmental, Limousin, and Charolais. As the American Simmental Association took its first steps, it carefully studied the performance recording movement and was quick to the chase to be the first group to recommend that they should attempt to take advantage of the improvements in genetic prediction methodology, artificial insemination and computing technology to compute and make publicly available the first “across herd” comparisons. They did so, using what was called a “sire model” developed at Iowa State University by Richard Willham in 1972. This allowed the prediction of “estimated breeding values” (EBVs) for the growth traits by tying herds together through a reference sire network. The era of true beef cattle evaluation was now born. Shortly thereafter, maternal grandsires were added to the evaluation framework – allowing “maternal” weaning weight EBVs to be added.

At the same time, it was clear that much more information was needed for beef producers to effectively sort out the widening levels of genetic variation available to them for commercial production. Additionally, producers discovered that hybrid vigor was indeed possible – and very economically beneficial – when many of the new breeds were bred to the available Hereford and Angus cows. Crossbreeding and hybrid vigor seemed to have a place at the table. Fortunately, USDA’s Agricultural Research Service saw the need for scientific data in this area. As a result, the US Meat Animal Research Center at Clay Center, NE was born and within a short time initiated two monumental projects – the Germ Plasm Evaluation (GPE) program led by Larry Cundiff and the Germ Plasm Utilization (GPU) program led by Keith Gregory. At the same time the Fort Robinson station was being closed, and the selection lines of cattle there were relocated to MARC – becoming the third piece of the puzzle led by Bob Koch. Over the next 30 years, this collective effort produced the fundamental body of knowledge now used world-wide to understand genetic variation, and how to effectively use it in beef cattle production.

The 1980s was a true time of transition for beef cattle breeding. Computing technology had now matured to the level where statistical methodology developed by a dairy geneticist named Charles Henderson in the 1950s could be applied to beef and dairy performance data – so called BLUP (Best Linear Unbiased Prediction) methodology. Scientists worked out the kinks and were successful in using these methods to compute for the first time what we now know as EPDs – Expected Progeny Differences within breeds. These new genetic evaluation tools were significantly more powerful and accurate to allow breeders to sort not only bulls – but also cows -- than the previously used EBVs from the sire/maternal grandsire model approach. Over the ensuing 20+ years we have become the beneficiaries of continual refinement in genetic prediction methodology, including more accurate predictions as well as a plethora of new traits added to the evaluation pipeline. We would even see the US MARC GPE populations serve another useful role, when in the early 1990s, data from the breeds evaluated in the GPE project coupled with breed genetic evaluation data, were used to develop an “across-breed” adjustment process allowing commercial producers for the first time to compare bulls across not only herds, but also across breeds.
The other monumental event in the 1980s was the unleashing of a new field of science referred to as “genomics”. This term was first used in 1986 to collectively describe the scientific discipline of mapping, sequencing, and analyzing genomic level DNA information. A technology called “polymerase chain reaction”, developed in 1987 by Kary Mullis in California, literally unleashed the forces of research into the genetic code of plants and animals. It had only taken 34 years to go from understanding the structure of DNA to being able to start the process of deciphering the code!

As molecular genetics tools became available to lab scientists in the late 1980s, researchers began the arduous process of genetic mapping. Because they were unable at that time to know the base sequence of the DNA code, they had to use a somewhat “black-box” approach to identify locations on the chromosomes that might contain genes affecting these traits. This process, called linkage mapping, took advantage of DNA polymorphisms called microsatellite markers, a type of variation found readily throughout the genome. In 1994, the first genetic linkage maps of cattle detailing a few hundred markers were published by USDA-ARS scientists from US MARC and Australian CSIRO scientists. Today, these linkage maps, combined with what are known as radiation hybrid and bacterial artificial chromosome maps, are much better defined with a total of over 21,000 individual markers identified and localized to chromosomes in the recent “composite bovine map” spearheaded by US MARC’s Warren Snelling (http://genomes.tamu.edu/cgi-bin/gbrowse/bosmap2/).

The availability of the first linkage maps allowed researchers to begin the search for regions of the genome harboring genes containing polymorphisms causing differences in performance for economically important traits – what have become known in the jargon as quantitative trait loci (QTL). This research, conducted at several locations in the US, Australia, New Zealand, and Canada first required the establishment of cattle resource populations that would have a high probability of having different copies of the genes on an individual animal’s maternal versus paternal chromosome. A number of these resource populations were formed at the US Meat Animal Research Center and subsequently utilized to identify over 25 QTL affecting a wide variety of traits on 11 different chromosomes. Other research groups also identified a number of QTL, principally the Angleton population at Texas A&M funded primarily by the beef checkoff and the CRC/MRC projects in Australia. The results of these projects were exciting and stimulated a considerable amount of attention in the beef industry in the mid to late 1990s. Unfortunately, as is too often the case, in the rush to find the silver bullet, the immediate promise of genomics was clearly oversold, as it has since become clear that the identification of QTL was only the first “baby step” in the process to bringing these results to a practicable technology.

Fortunately for the cattle genomics community, the US government had placed a high priority through its human medical research arm – the National Institutes of Health (NIH) – on deciphering the human genetic code. The idea was very similar to what has been described in this paper for cattle – except that in this case the target was to develop new ways to combat human disease / improve human health. Initially, many of the same approaches of linkage mapping were used in human genomics, with the additional twist that model organisms were intensely studied as proxies for man – principally the laboratory mouse and rat. This was possible because as we began to be able to see small regions of DNA code, the similarities between species were remarkably high – usually at the 90% or higher level. Scientists also observed that while the arrangement of the pieces of the genetic puzzle was not the same
across species, large regions of the genome had been conserved throughout evolution. This now allowed the opportunity to take information from species being studied with very large research budgets in comparison to cattle to infer what might be the case in cattle using “comparative mapping”. While this approach did yield results, including the identification of the myostatin gene causing double-muscling in cattle, only a handful of genes have been mapped in cattle to date through the “QTL-search followed by comparative mapping / fine mapping” approach.

The human genetics community quickly recognized that if progress in building new tools through genomics for human health applications was to occur expeditiously, infrastructure needed to built right up front. Linkage maps, QTL searches, comparative mapping and some fine mapping were useful, but extremely inefficient, timely, and high in cost. Thus, in the last half of the 1990s, the National Institutes of Health, through its National Human Genome Research Institute (NHGRI), built a plan for sequencing the human genome, along with the highly used lab species of the mouse and rat (http://www.genome.gov/10001691). The project became broadly known as the “Human Genome Project” and involved a network of “sequencing centers” contracted to do high-throughput sequencing (i.e. determination of the DNA base code) of the human genome. An initial rough draft of the human genome sequence was completed in 2001, followed by a complete, finished sequence in April of 2003, fifty years after Watson and Crick’s initial elucidation of the double-stranded helical nature of DNA! The Human Genome Project was not cheap (in the billions rather than millions of dollars), but is widely believed by many to be the most important scientific project in the history of mankind to date.

The cattle, poultry, and swine industries, however, were placed in a position to reap huge rewards from the infrastructure built by NHGRI to sequence the human genome. In order to build the most comprehensive infrastructure to capitalize on the human genome for discoveries in human health, NHGRI launched down a path in 2002 of supporting the sequencing of a number of other genomes (http://64.225.252.6/nstc/html/IWGGAD2004.pdf). These were chosen to most highly leverage the investment in human genomics, as based on comparative mapping and medical model species use. Fortunately, the cow has been widely used as a model species in a number of areas for human medicine, especially in the area of reproductive physiology. As a result, the agricultural community developed a “partnership” approach in 2003 with NHGRI to move forward the sequencing of livestock genomes, including the bovine which was launched in December of 2003 at the Baylor College of Medicine in Houston, TX (http://www.hgsc.bcm.tmc.edu/projects/bovine).

The bovine genome sequencing project was a first in cattle genetics in many ways. The first was that it required $53M in funding which came from an international consortium including NHGRI ($25M), USDA ($11M), the state of Texas ($10M), Genome Canada ($5M), Australia and New Zealand ($1M each) and the national, Texas, and South Dakota beef councils ($1.2M). This followed an initial investment of over $4M to develop the scaffolding, called a bacterial artificial chromosome (“BAC”) map, invested by an international consortium of ten laboratories in seven countries, led by USDA-ARS. The animal providing the DNA for the sequencing project was a Line 1 Hereford female from the USDA-ARS long-term linebreeding and selection project at the Fort Keogh Livestock and Range Research Lab at Miles City, MT. All sequence information from the project was immediately deposited in the public domain, through the NIH’s National Center for Biotechnology Information (NCBI , http://www.ncbi.nlm.nih.gov/), allowing all researchers around the globe to have access to spurn forward developments.
In September 2006, the assembly (7.2-fold sequence coverage) of the bovine genome was announced by the project team. Additionally, light sequencing of animals representing the Holstein, Jersey, Angus, Limousin, Brahman, and Norwegian Red breeds allowed detection of over 2M new single nucleotide polymorphisms (SNPs) and the process of validating a set of 39,000 of these SNPs has been carried out on a panel of 19 breeds to evaluate genetic diversity of the world cattle population and to develop a haplotype map of the bovine genome. Additionally, the Hereford female used for the sequencing project and one of her progeny supplied a wide array of tissues to the project team to allow development of 10,000 full-length cDNAs for the study of gene expression. Currently the genome sequence is being annotated by a group of researchers around the globe to provide a full picture of the “gene atlas” of the species. The availability of the genome sequence is expected to speed gene discovery by a factor of 100 fold!

As the bovine genome sequence was being completed over the past few years, the development and release of commercial DNA tests began to escalate. With several companies now in the market space for this group of technologies, most with quite different business models, a variety of tests and platforms have come of age. Beginning with the initial release of the GeneSTAR Marbling test based on a polymorphism associated with the thyroglobulin gene to now several GeneSTAR and other tests for calpastatin and u-calpain, leptin, DGAT, and others – the field of DNA diagnostics is rapidly growing. The recent release of multiple marker platforms by Merial, Igenity, and MMI Genomics has moved this technology fully on to the radar screen of the industry and has many wondering whether the DNA age has truly arrived. Exciting times do appear to be upon us – including the potential for whole genome selection using haplotype maps developed from dense SNP maps.

As the genome is mined over the coming years, what can beef cattle producers expect to see as a result? Will DNA selection tools essentially replace breed genetic evaluation programs / EPDs as we know them today? Will we no longer need to worry about collecting expensive performance data? Will we essentially be able to know the genetic value of a calf in utero? Will we be able to predict the perfect range cow for a given production environment, sort that cow out with genomics, and then mass clone her?

As genomics technology matures in the coming decade, we will undoubtedly see an explosion of genes that are identified for various traits. It is easy to predict that as we identify many of the genes underlying variation in performance for traits, we will identify more questions than we do answers. Some of those are likely to be:

1) **What is the function of these genes in the physiology of the animal and how is this function altered by changes in the production environment?** We are now routinely talking about the next big opportunity area of livestock genetics research being in “functional genomics” using “systems biology” to develop “precision mating” followed by “precision management systems”.

2) **How do the various genes impacting economically important traits interact with one another at the genome, proteome, and metabolome levels?**

3) How many animals within a population (i.e. a herd or a breed) need to be “DNA profiled” in order to get enough information?

4) Will “whole genome selection” using large panels of SNP with linkage disequilibrium work – will this approach replace progeny testing and performance data?

5) **Can we combine phenotypic performance information with gene level DNA information to come up with**
“DNA-enhanced EPDs”?  WHO IS GOING TO DO IT – and who is going to be the service provider to the breeders?

6) How will the free enterprise system embrace this technology – i.e. what is the best business model to capitalize on these advances?  DNA testing companies, AI / genetics companies / supply chain alliances / feeding companies / big pharma / breed associations / something yet to be defined???

7) How will the cost of this technology be borne by the industry?  One cannot expect the genetics or commercial sectors of the beef industry to pay several hundred dollars to profile a narrow set of characteristics to identify the top sires as has been proposed in the initial ventures of gene testing in to the public marketplace.  The value capture of this technology is likely to require a new type of business model unlike anything we have seen previously in cattle genetics.

This somewhat exhaustive and comprehensive history lesson has been presented here to intentionally bring light to the fact that the process of getting to today’s state of the art beef cattle breeding has not been easy, or achieved quickly.  One could argue that 100 years in the bigger picture of 5,000+ years of domesticated livestock production is a drop in the bucket.  However, most of us would still argue that those 100 years have been a monumental and unprecedented effort.  As we enter the era of “genome-enabled” genetic improvement – we must be careful to remember the big picture, and that while these new tools are fascinating and almost unbelievable to many of us, they are simply the next pieces of the puzzle in a long process of continual refinement and improvement as beef cattle breeders.

Is Society Re-Drawing the Landscape of the Beef Industry?

One might argue that the past five years have revealed the beginning of major shifts in our society that are changing the “look” and activities of the beef industry and its producers.  From the impact of the first few (and only) cases of BSE in the American cattle population on world beef trade dynamics to various issues associated with food safety and biosecurity to dissension within the industry in terms of:  1) trade policy; 2) national animal identification; 3) country-of-origin labeling; 4) increasing integration / consolidation and impacts on market structure and price discovery; and 5) research and promotion through the producer beef checkoff program; the past few years have undoubtedly been volatile.  Add the recent impact and ripples being felt throughout the industry from increased fuel prices, and now competition for feedstuffs (i.e. code language for cheap corn) from biofuel production, and we are seeing industry leaders now talk about the biggest paradigm shifts in the industry’s history in North America.  The following are societal and industry shifts and changes that are occurring around us as we speak that are certainly requiring us to think differently about the next generation than many of us might have anticipated:

1) An increased call from the general public for decreasing the environmental footprint of livestock and poultry production, including range, water, and air quality.

2) Competition for energy sources and feedstuffs for alternative energy production, heightening the emphasis on improved energy utilization and animal adaptability to production environments.

3) Increased attention to animal well-being and welfare, pointing out the need for robust scientific criteria to actually assess animal well-being in our production systems.
4) Increased “brand” / process / historical identity of products being called for in the marketplace by retailers and their consumers.

5) Increased interest and purchasing power, whether deserved or not, of consumers for organic / natural / grass-fed beef products.

6) Recognition that we are concerned about the narrowing of the gene pool – while also recognizing the need to increase product uniformity and consistency. Considerable debate and disagreement in the industry regarding the value and usefulness of heterosis in the commercial sector exists.

7) The need for information continues to accelerate – with the cry for emphasis on Economically Relevant Traits to the commercial industry – yet we have done little to put in to place evaluation for animal health, functionality, and adaptability traits (i.e. still heavy on outputs with not much to work with on the input side of the profit equation).

8) We have lived in a “breed” world through the history described above, yet the commercial cattle producer of today need’s BEEF CATTLE gene pool-wide evaluation more than they need breed-specific tools.

9) Mining the genome in the post-genome sequence world is here to stay, yet we are woefully inadequate in being set up to handle all of the information that is upon us in a practically meaningful way.

Some will argue the long-term relevance and impact of this list of concerns. Yet, there is no doubt that they all deserve our rather immediate attention if we are to provide the leadership needed to guarantee a successful and sustainable beef industry in the future.

Are We Ready and Poised for These Challenges?

One does not have to be a rocket scientist to quickly come to the conclusion that we are far from done in the field of beef cattle breeding and genetics. One might, in fact, argue that we are entering a “Renaissance” period for the field. The issues above, coupled with the fact that we are now fully headed in to the age where we have more data than we know how to effectively handle in an era where technology is outpacing our abilities to utilize it, lead me to the conclusion that we need to significantly “re-engage” the troops. No longer can the industry be passive in championing the need for a re-building of our infrastructure in this area.

While the ushering in of the genomics era has been immensely exciting scientifically, it has not come without significant and tangible costs. This research is expensive to conduct, requires large project teams, is lab intensive, and brings the new elephant to the table of intellectual property rights. As research and education programs around the U.S. geared up to make inroads in to this arena, other programs were often sacrificed to chase molecular dreams. As a result, the vast majority of traditional beef cattle breeding positions and research herds in the land grant university system were eliminated, or re-directed, into genomics and molecular biology, over the past 20 years.

A noticeable outcome of the “re-direction” of quantitative genetics programs into genomics and molecular biology was the need for the few remaining beef cattle quantitative genetics programs involved with national cattle evaluation research, discovery and tech transfer to band together in to the National Beef Cattle Evaluation Consortium (NBCEC). Over the past decade, these four universities have been able to attract federal earmark funding within USDA’s Cooperative State Research, Education, and Extension Service (CSREES) to provide infrastructure for this important area.
This only happened, however, due to the foresight of a small group of geneticists and producers who recognized that unless something was done to support this area of research and education, the critical mass of beef cattle breeding and genetics expertise would have continued to dwindle to non-existent levels. The NBCEC is now fighting for its life in the funding arena with an attempt being made to provide a permanent structure for funding this effort in the future. This must be done to address the long laundry list above, and it needs to be done at a level that will add significant critical mass to the effort – including extension and outreach.

The following are questions that the U.S. Beef Improvement Federation and its constituencies need to carefully consider to ensure future success in the industry:

1) Where are the scientists with practical knowledge of the needs of the industry going to come from who can navigate these waters? We are churning out some very highly skilled molecular biologists, but the vast majority of them do not know one end of a cow from the other?

2) We are facing a huge deficit of quantitatively skilled people to be able to make sense of all of these data. Do we need to re-open the textbook on quantitative beef cattle genetics?

3) Who is going to educate the public? Just as we needed a major public outreach effort to educate the industry on EPDs and associated tools, we now have the same need on “genome-enabled selection”, precision mating and management systems with phenotypes and genomic tools. Where has extension gone and what have we replaced it with?

4) What is going to be the role of breed associations in the future? Is there a new service sector set to emerge or will the genetics industry adapt? This is eerily reminiscent of the discussion that circled in the industry throughout the past 15 years on what should the role be of the Livestock Marketing Association and its sale barn members in the new era of “value-based marketing”. There are opportunities out there, but who is going to “seize the day”?

5) We may not be looking hard enough at some of our international competitors – careful study of what is happening in Australia, Brazil, New Zealand, as well as competing protein industries, is a very good idea.

6) Is it possible that animal agriculture in the U.S. could eventually be shipped off-shore? There are certainly factions at work in the public who cleverly have this as a goal cloaked underneath other agendas (animal welfare, environmental protection, vegetarianism, humanitarianism). I recall telling students in my Beef Production course in 1989 that they should be prepared for the day when grain became too expensive to feed to cattle. They looked at me like I was from Mars, just as the reader might feel after reading this concern – but in 2007 we actually find that prediction to now be coming true?

7) Is there adequate funding available in today’s research and higher education and outreach system to address these challenges? Assuming that the answer is a resounding NO, what should be done about it, and, who is willing to champion the cause?

The last point is certainly multi-faceted. It is worth noting that the trend in publicly funded research and higher education over the past couple of decades has been to shy away from production-oriented “traditional” agricultural research in favor of “sexier” areas such as animal health, food safety, human nutrition (with the current buzz being obesity), and environmental management and protection. While there is no doubt that these areas are
important and deserve attention, it is extremely short-sighted to say that we are done addressing the challenges of how to produce more with less. The recent turn of events that led to $4 corn this past year should be a wake-up call to this industry to be vigilant in supporting production research as well, and, the critical need to convince the policy and legislative arenas to do likewise.

Our family had the pleasure of seeing our oldest child, Justin Lucas Green, matriculate from the secondary school system and head off in to the world of higher education this past month. Watching him and his three siblings mature over the past several years has given my wife Jane and I pause to think about the future and what will be required for these young people to accrue the same benefits we have enjoyed in our lives. This generation of young people is impressive, bright, aggressive, and bold. They are capable of accepting challenges and they seem to understand that much will be required of them. They have been compared in many ways to the generation that responded to Hitler and World War II, only they are the ones who saw the WTC towers collapse as opposed to Pearl Harbor being bombed.

I would argue that we need to regain some of their 18-year old idealism and “wide-eyed vision” in order to provide the leadership so direly needed to address the questions facing the beef genetics sector. I have no doubt that the leadership and passion to do so exists within the ranks of those who have lived our lives serving and producing in this industry. It does seem, however, that we need a jump start, and it is my hope that this presentation and discussion will provide such a charge. We all must be vigilant in thinking through the solutions to these questions. Can we in 2007 think and act big enough to ensure that the history of beef cattle improvement can be looked back on in 2047 with thanks and gratitude? Sal Forbes, Frank Baker, Bob DeBaca, Howard Stonaker, Jim Brinks, and their colleagues did in the late 1960’s. I do think we can do so as well in the late 2000’s. Q.E.D.

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Why Haven’t We Seen an Improvement in Quality Grade?
A Genetic Improvement Perspective

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Perhaps one of the most perplexing questions facing the U.S. beef industry is “Given the amount of perceived emphasis placed on genetic selection for carcass traits, why has the percentage of carcasses grading choice not increased over that period?” Like any complex question, this one has a complex answer, where a number of genetic and environmental factors interact to determine the distribution of quality grades. While the accompanying paper and presentation will address the environmental factors, a number of genetic considerations merit consideration as the industry examines how greater genetic improvement of beef quality might be created in the future.

Rate of Genetic Change. Bourdon (2000) explains the factors affecting the rate of genetic change with the following equation:

$$\Delta_{BV}/t = \frac{r_{BV,EBV} i \sigma_{BV}}{L}$$

where $\Delta_{BV}/t =$ rate of genetic change per unit of time (t)

$r_{BV,EBV} =$ accuracy of selection

$i =$ selection intensity

$\sigma_{BV} =$ genetic variation

$L =$ generation interval

Each of these four factors impact the rate at which genetic improvement of beef quality is occurring, and each is a result of decisions made by breeders and their organizations. Let’s examine each of factors more closely, discuss their current status with regard to beef quality, and evaluate how breeders might alter them to result in more rapid genetic improvement.

Genetic Variation. While our industry is often scolded for the great diversity of genotypes that exist within its population, animal breeders view that variation as an asset, not a liability.

“Variation – differences between individuals – is the raw material on which the breeder works,”
Lush, 1945

Indeed, greater genetic variation does result in greater genetic change through selection, because the “best” animals have greater advantage over the average of the population. But highly effective directional selection typically results in loss of genetic variation, as only the most desirable animals contribute genes to the next generation. Selection for increased milk production in Holsteins is a classic example, and the amount of genetic diversity that remains in that population is minimal, leaving the breeder with limited opportunities for further genetic change. While the beef industry still enjoys both a relatively large number of significant breeds, and a reasonable amount of variation within those breeds, Cundiff and others at the U.S. Meat Animal Research Center (MARC) report that the major beef breeds are less divergent than they once were, with British breeds increasing in growth rate and mature size similar to that found previously in continental breeds. From the standpoint of beef quality improvement, it is fortunate that the most prevalent breed at the current time is superior for this attribute. Still, greater change would be possible if other breeds would more aggressively develop superior meat quality lines, enabling commercial producers to emphasize quality when selecting sires of multiple breeds for crossbreeding systems.
Other than black Angus, most beef breeds show a relatively flat genetic trend for marbling score over the last two decades, and even black Angus cattle of the current day under perform those of the 1970’s with regard to marbling score. While genetic variation increases and decreases with aggregate breeder selection decisions, this factor is largely out of the control of the individual breeder.

**Selection Intensity.** While genetic variation describes the potential advantage that could be realized through selection of superior genetics, selection intensity describes how much of that potential has been realized. Selection intensity is the superiority of the animals selected to be parents of the next generation, compared to the average of population from which they were chosen. Maximum selection intensity occurs with single trait selection, but the greater the number of other traits selected for, the less intensity and less change resulting for each trait. This is one reason that the rate of genetic change for any trait in beef cattle is relatively slow. With the non-integrated, independent structure of the beef seedstock industry, many individual breeders make different selection decisions. Marbling score is but one of a large number of economically relevant traits, and breeders have differing opinions as to the true economic reward of increased marbling, especially if feed conversion suffers or cow maintenance costs increase as a result. While grid marketing provides economic rewards to those selling high marbling cattle, ownership of fed cattle is retained by a relatively small proportion of cow/calf producers. Our feeder cattle marketing system insufficiently values calves with superior genetic potential for quality grade, although progress is being made in this area. If market signals more clearly indicated significant increases in profit associated with higher marbling scores, more intense selection would likely occur. Selection intensity is also limited when genetic correlations with other traits are unfavorable, but in the case of marbling score, there is little evidence that serious unfavorable correlations exist.

**Accuracy of Selection and Generation Interval.**
This juxtaposition of these factors is to illustrate how they interact to have a significant impact on the rate of genetic change. High accuracy of selection can almost always be achieved for a highly heritable trait like marbling, but accumulating the necessary data takes time, lengthening generation interval. Likewise, generation interval can be shortened by the use of younger, less proven sires, but accuracy suffers under that scenario. The greatest opportunity for the beef industry to enhance the rate of genetic improvement for marbling lies in technologies and techniques that provide more accurate information on sires at an earlier age.

Traditional selection using EPD calculated from progeny carcass data, while accurate, is far from timely. A sire must be at least four years of age by the time progeny carcass data is included in EPD calculations. The premise of ultrasound estimation of marbling score and other carcass attributes of live breeding animals is that by scanning the potential sire at a year of age, a more precise estimate of that animal’s genetic merit can be made at that time, allowing relatively accurate selection with a dramatic reduction in generation interval. Also, ultrasound scanning should identify the most promising animals for progeny testing. However, the implementation of ultrasound evaluation has been less than optimum, and some changes might make this an even more useful tool for genetic enhancement of beef quality.

One misuse of ultrasound information that limits genetic progress is the use of actual or adjusted scan data in selection and marketing, rather than EPD. While centralized processing of ultrasound images should reduce technician bias and make scan measurements seem more comparable across herds, environmental influences still exist that significantly bias the
actual scan measurement as an indicator of genetic merit. Furthermore, like any prediction equation, those equations used to predict intramuscular fat (IMF) from ultrasound images are most accurate on animals are near the center of the distribution. In contrast, the animals sought in selection are the most extreme, highest IMF animals, thus their predictions are subject to the greatest error. Use of IMF EPD for selection tempers that error, by including pedigree information in addition to the animal’s own evaluation. But because of this, the resulting interim EPD tend to remain closer to the breed average than the actual scan measurements, so the more extreme actual values may command more interest when used in marketing, despite the fact that they are poorer predictors of true genetic merit.

Ultrasound measures of IMF are also useful tools in evaluating a young sire’s first calf crop, and a sire’s first groups of scanned yearlings are often the best indicators of what his marbling EPD will ultimately be. Still, the timeliness of information transfer is somewhat limited by our traditions. Most breeds conduct two complete genetic evaluations (BLUP runs) per year. Usually one is done in late fall, after spring-calving herds have submitted weaning weights, and fall calving herds have submitted birth weights, yearling weights, and scan data. Sometime in the summer, a second run is conducted, including new weaning data from fall calving herds and new birth, yearling and scan data from spring calving herds. Since most U.S. herds are predominately spring calving, the bulk of the scan data is collected in January through March, and is first fully analyzed in the summer. If a spring-born sire’s first yearling progeny are scanned when he is three years of age, his IMF EPD will reach a relatively high accuracy level in time for use when he is four years of age, similar to a carcass data evaluation. Interim EPD are provided on the progeny that are scanned, but their sire’s EPD is not updated until the next full run of the evaluation. If an additional run could be conducted in March, a significant amount of new scan data would be included compared to what was available in November or December, yet results could be communicated before breeding for the next year’s spring calf crop. No doubt this additional run would require additional coordination and communication on the part of breed associations and artificial insemination organizations, but the full-year reduction in generation interval could be well worth it. If merited, a fourth run could be conducted in mid-fall for the benefit of fall matings. Eventually, beef genetic evaluations might be run weekly or even nightly, rather than semi-annually.

Another issue with ultrasound data arises from the way the resulting EPD are presented. Most beef breeds combine carcass and ultrasound data into one marbling EPD, as well as one EPD for ribeye area and one for fat thickness. But at least one major breed still publishes separate carcass and ultrasound EPD. A few breeds with a combined evaluation publish the ultrasound EPD for the indicator trait of IMF, instead of the marbling EPD on the economically relevant trait. Reasons for doing so may be legitimate, but accuracy of selection suffers. In fact, when EPD are presented for ultrasound IMF instead of carcass marbling score, the associated accuracy values are overestimated, because they reflect the accuracy of selecting for the correlated trait (IMF), not the true economically relevant trait of marbling.

Most estimates of the genetic correlation of IMF measured in breeding bulls and heifers with carcass marbling in fed steers and heifers hover around 0.70, although estimates are lower in some continental breeds. Some producers and scientists incorrectly interpret this correlation to imply that with infinite ultrasound IMF progeny data, the accuracy of selection for marbling is capped at 0.70. This would be true if U.S. beef genetic evaluations expressed accuracy values as the correlation between true breeding values and their estimates. But at a BIF meeting over
20 years ago, it was decided to use a more conservative accuracy number to create a greater range of accuracy values between young animals and proven sires. So our interpretation of this correlation’s impact on indirect selection for marbling using ultrasound IMF needs to be adjusted to the BIF accuracy scale currently used. Examples follow in the table below, with the result being that selecting on an IMF EPD of 0.90 gives the same accuracy of selection for improving marbling as a carcass marbling EPD with accuracy of 0.28 on the BIF scale. In fact, an infinite amount of IMF progeny data, with IMF EPD accuracy approaching 1.0, would be equivalent to a carcass marbling EPD accuracy of 0.29.

<table>
<thead>
<tr>
<th>Accuracy of IMF EPD, BIF Scale</th>
<th>0.900</th>
<th>0.700</th>
<th>0.500</th>
<th>0.300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation of IMF EBV and IMF true BV</td>
<td>0.995</td>
<td>0.954</td>
<td>0.866</td>
<td>0.714</td>
</tr>
<tr>
<td>Genetic Correlation between IMF and Marbling</td>
<td>0.700</td>
<td>0.700</td>
<td>0.700</td>
<td>0.700</td>
</tr>
<tr>
<td>Correlation of IMF EBV and Marbling true BV</td>
<td>0.696</td>
<td>0.668</td>
<td>0.606</td>
<td>0.500</td>
</tr>
<tr>
<td>Accuracy of Selection on IMF EBV to improve marbling, BIF Scale</td>
<td>0.282</td>
<td>0.256</td>
<td>0.205</td>
<td>0.134</td>
</tr>
</tbody>
</table>

This isn’t to say that ultrasound IMF measurements aren’t useful, in fact, for young animals, they are likely the most powerful selection tools currently available. An EPD accuracy of nearly 0.30 conveys useful information, just less than a higher accuracy one. However, producers make more informed and correct selection decisions when carcass and ultrasound data are combined into a single set of EPD, with the EPD and accuracy values published for the carcass traits. A subcommittee of the BIF Genetic Prediction Committee made this very recommendation in 2006.

Whenever producers discuss calculation of carcass EPD, the endpoint used for adjustment of the data is often raised. In nearly every case, beef carcass genetic evaluations adjust data to a constant age. Yet, age is usually unknown and rarely a consideration when marketing decisions are made. Frequently, fat thickness, weight or marbling score are offered as more appropriate endpoints for carcass data.

Some of the early carcass EPD used a fat thickness endpoint, but when measurements are adjusted in this way, no fat EPD is calculated. Rather, selection for reduced fat would result from bulls with higher carcass weight EPD, so that their progeny would be leaner at a constant weight. Furthermore, rate of growth and age at finishing are economically important traits, and while some cattle are inherently younger or older at harvest due to the length of the backgrounding period, this variation should be consistent within contemporary group. Using a fat thickness endpoint would be somewhat risky, since fat thickness may be incorrectly measured due to hide removal, and that incorrect measurement would be used in adjusting all other traits.

Furthermore, there is good evidence that the results of genetic evaluation for carcass traits are consistent regardless of endpoint. Most studies have found that heritability does not change across endpoints. A recently published study by Rumph et al. (2007) found that rank correlations among most carcass EPD were high whether the endpoint used was age, fat, carcass weight, or ribeye area.

DNA tests are another category of tools that like ultrasound, aims to provide accurate information upon which to base selection early in the animal’s lifetime. Since the first DNA test for
marbling was announced at the 2000 BIF meetings, a number of competing products have entered the marketplace, most focused on meat quality attributes like marbling and tenderness. The primary DNA test for marbling, and the only to be validated by the National Beef Cattle Evaluation Consortium, is GeneSTAR Quality Grade. GeneSTAR Quality Grade is a panel of four single nucleotide polymorphisms, and evolved out of the original thyroglobulin SNP test introduced in 2000. Recently, MMI Genomics began marketing Tru-Marbling, a panel of 128 markers associated with marbling and quality grade.

While these tests have great potential, they also have limitations. Marbling is a complex trait likely influence by a large number of genes, as well as many environmental influences. While some of the current tests may include markers linked to some genes influencing marbling, researchers are unlikely to have markers for all marbling genes any time in the near future, and it is difficult to estimate exactly what proportion of the genetic variability is explained by these tests. Statistical significance of many of these tests in independent validations has appeared marginal, and cost is a significant barrier to widespread utilization. Gene frequency is also a consideration, especially when the proportion of certain favorable alleles is as low as four to six percent in some tested populations of major breeds.

While such tests have the potential to greatly add to the genetic information known on a young animal, they provide little new information for selection on proven sires with high accuracy marbling EPD. It would be a serious mistake to not use a highly proven sire with superior marbling EPD, just because his DNA tests were unfavorable. The favorable EPD indicates he must have a large number of desirable marbling genes, but perhaps not the ones identified by the DNA tests.

Lost in the discussion of new tools is the increased opportunity for greater collection of traditional carcass data. While a national animal identification system may be off the front burner, a large number of source-verified feeder cattle programs have been developed. These programs lend the ability to track animal and sire identify from ranch to cooler, greatly reducing the management required to obtain carcass data on the calves, and submit that data to the breed association. Automated grading and data collection systems are in place in several major packing plants. While these systems, like live animal ultrasound, are not perfect evaluators of marbling score, neither are USDA graders or carcass data collection services. All data collection is subject to some error, but the large amount of data that might be captured by these systems could greatly add to our genetic evaluations for marbling and other carcass traits.

A final consideration is likely both the least controversial and the most important. Cattle breeding is a long-term proposition, where generation interval averages five years or more. When you consider that we measure genetic change in seedstock populations, but evaluate phenotypic change in commercial cattle, it’s not surprising that there is a time lag between genetic and phenotypic change. The combination of patience, a necessary but somewhat scarce ingredient for successful cattle breeding, coupled with critical evaluation of technologies old and new, should result in visible improvement of beef quality in the future.

References


Non-Genetic Factors that Affect Quality Grade of Fed Cattle

Pete Anderson and Justin Gleghorn
VetLife Technical Services
Overland Park, KS

Introduction

Quality grade of fed cattle is an important economic trait since approximately half of US fed cattle are marketed through value-based systems where carcasses are priced individually based on quality grade, yield grade and other factors. Quality grade of young cattle is primarily determined by marbling, a complex biological trait that has multiple controls and is not well understood. Once the genetic capability of the animal has been determined, there are still numerous factors that can negatively influence the quality grade. Recent research has indicated that there are other influences that can positively influence grade as well.

Trends in quality grade of US fed cattle

The VetLife Benchmark Performance Program collects live performance, carcass and financial data from approximately 40% of all US fed cattle. The volume and diversity of the data provide an estimate of industry-wide results. Benchmark data allow more specific analyses than use of USDA or other sources because of the amount of detail collected.

The percentage of cattle grading Choice or higher in the Benchmark database has declined slightly since 1999. This has occurred despite heavier harvest and carcass weights and increased days on feed. During this time the percentage of carcasses receiving USDA yield Grades of 4 or 5 (overfat) has increased as well. All indications are that carcasses are heavier and fatter than they were a decade ago, yet USDA quality grade has not increased.
While percentage Choice and marbling score are the most commonly reported response variables in fed cattle research, the percentage of other quality grades should be considered as well; since both premium grades like Prime and CAB, and penalty grades like Standard and no-roll, greatly influence carcass value.

**Non-genetic factors that affect quality grade**

Non-genetic factors that affect quality grade will be grouped into four categories:

- Placement factors (demographics)
- Pre-feedyard nutrition, health and management
- Feedyard nutrition, health and management
- Endpoint

Within each of these categories, several factors that could potentially affect quality grade will be discussed. Another area of significance is post-mortem treatment and handling but that subject is beyond the scope of this paper.

**Placement factors (demographics).** Quality grade results differ based on sex, placement weight, and season fed. Below are carcass results from over 20 million steers and heifers fed since 2000 in the two largest Benchmark regions, the Central Plains and the High Plains. These regions include all of Kansas and Oklahoma as well as most of Texas and Southern Colorado. Most of these cattle were sold on grids, but cash (non-grid) cattle are included as well.

<table>
<thead>
<tr>
<th></th>
<th>Steers</th>
<th>Heifers</th>
<th>dif</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dressing percentage, %</td>
<td>64.1</td>
<td>64.2</td>
<td>0.1%</td>
</tr>
<tr>
<td>Hot carcass wt, lb</td>
<td>803</td>
<td>734</td>
<td>69 lb</td>
</tr>
<tr>
<td>Premium QG, %</td>
<td>4.8</td>
<td>8.1</td>
<td>3.3%</td>
</tr>
<tr>
<td>Choice or higher, %</td>
<td>42.8</td>
<td>54.0</td>
<td>11.2%</td>
</tr>
<tr>
<td>Penalty QG, %</td>
<td>6.3</td>
<td>4.6</td>
<td>1.7%</td>
</tr>
<tr>
<td>YG 1 or 2, %</td>
<td>64.5</td>
<td>57.2</td>
<td>7.3%</td>
</tr>
<tr>
<td>YG 4 or 5, %</td>
<td>4.0</td>
<td>6.7</td>
<td>2.7%</td>
</tr>
<tr>
<td>Dark cutters, %</td>
<td>0.5</td>
<td>0.7</td>
<td>0.2%</td>
</tr>
<tr>
<td>Light, %</td>
<td>0.6</td>
<td>1.6</td>
<td>1.0%</td>
</tr>
<tr>
<td>Heavy, %</td>
<td>3.8</td>
<td>0.5</td>
<td>3.3%</td>
</tr>
</tbody>
</table>

In terms of carcass value, approximately half of the differences between the sexes favor heifers. Differences that result in increased carcass value for heifers are underlined. On a population basis, heifers grade higher than steers with more premium quality grades and fewer penalty quality grades. Heifers also have fewer YG 1 and 2’s and more YG 4 and 5’s, indicating that they were fatter and less muscular. At least a portion of the higher grade of heifers is due to industry practice of feeding them to fatter endpoints than steers.

Placement weight of steers and heifers affects quality grade as well. In general, cattle placed at heavier weights grade lower than those placed at light weights. This is particularly true of cattle placed at 900 lb or higher.

In the Benchmark database, steers with placement weights of 500-599 lb graded higher than steers placed between 800 and 899 lb. Some caution is necessary when interpreting data of this type. It cannot be assumed that the genetic capabilities of the two populations are similar. The wisdom and experience of cattle producers influence decisions regarding management strategies for groups of cattle. There are reasons that some cattle are fed as
calves and others as yearlings and the objectives for the groups are not often the same.

With population data we can assess statistically whether two groups are different, and these are. What cannot be assessed is the causality of those differences. While results from 500 lb steers were different than from 800 lb steers, we must turn to research to determine if the variable that caused the difference in results was the initial weight or some other factor. In research, weight and age generally cannot be separated as variables so we are still left to decide on our own. While weight differences can be accounted for statistically using blocking or covariate analysis, age differences are typically unknown and unaccounted for.

<table>
<thead>
<tr>
<th>Placement weight of steers</th>
<th>500-599 lb</th>
<th>800-899 lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dressing percentage</td>
<td>64.3</td>
<td>63.8</td>
</tr>
<tr>
<td>Hot carcass weight, lb</td>
<td>774</td>
<td>833</td>
</tr>
<tr>
<td>Choice or higher, %</td>
<td>46.2</td>
<td>42.1</td>
</tr>
<tr>
<td>Premium grades, %</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Penalty grades, %</td>
<td>6.1</td>
<td>6.5</td>
</tr>
<tr>
<td>Yield grade 4 or 5, %</td>
<td>5.0</td>
<td>5.5</td>
</tr>
</tbody>
</table>

While placement weight of feedlot cattle is easy to quantify, incoming age is not. Greater quality grade in 500 lb steers than 800 lb steers is not quite proof that younger cattle grade higher, but certainly can be used to oppose the common viewpoint that older cattle grade higher. On average, a population of 400 lb steers will be younger than a population of 800 lb steers at the time of harvest but the range within either population could be substantial. The practical application of this is that numerous people believe calves don’t grade, proving that numerous people can be wrong. Research has shown that calves reach subcutaneous fatness endpoints at lighter weights and younger ages than cattle fed as yearlings. In other words, calves grade better!

The authors believe that feeder cattle are younger, although not lighter than they were 10 years ago and that youth has not contributed to poorer grade. Experiments at the University of Illinois provide strong evidence that youth does not necessarily inhibit grade. Early weaned (approximately 100 days of age) calves are placed directly on feed, consuming high energy diets, with no growing program. These cattle are harvested at approximately 1 year of age and regularly grade 90% Choice or higher with a high incidence of premium grades.

Another placement factor with a significant effect on quality grade is season. Quality grade of the US slaughter population follows a predictable seasonal trend. Grade is highest in January and February and lowest for cattle harvested in September and October. Several analyses of population databases have shown this to be true and Benchmark data indicate that both sexes and all weights behave the same way. Clearly, the effect is due to some seasonal aspect and not just changes in the demographic characteristics of the harvest population.

There are at least two seasonal factors that are likely to influence quality grade. The first of these is photoperiod. In all species, animals entering short daylight times of the year deposit fat and as they enter longer daylight periods they deposit more lean mass. The benefit of this pattern for survival is pretty obvious and it makes sense that it would occur in domesticated animals, even after generations of selection. A chart of percentage Choice of the harvest population would resemble a chart of the total hours of daylight that cattle were exposed to in
the four or five months prior to harvest. The same could be said of heat units, but experiments with controlled lighting and temperature have shown that seasonal effects on both reproduction and composition of gain are due to photoperiod, not heat. Also, Vitamin D has been shown in vitro to inhibit conversion of undifferentiated cells to pre-adipocytes. The conversion of undifferentiated cells to pre-adipocytes results in greater intramuscular fat when adequate energy is present, so preventing the conversion could limit marbling.

A less obvious factor might be the seasonal influence on pre-feedyard nutrition as reviewed by Berger (2005). Recent research has shown that Vitamin A also inhibits conversion to pre-adipocytes. Most cattle harvested during the low grading months spent time on lush pastures prior to entering the feedyard and consumed high levels of Vitamin A during that period. Cattle that are harvested during the high grazing months likely did not consume the same levels of Vitamin A during their growing phase. Depletion of high levels of stored Vitamin A requires about 100 days. The implication is that pre-feedyard consumption of lush forage, with its high Vitamin A content, combined with exposure to daylight (Vitamin D) while on feed, is a worst-case scenario for marbling. Heifers are slightly less impacted by the seasonality, adding credence to both theories. In other species estrogens and progestins have been shown to modulate gene expression in ways that could make females more tolerant of Vitamin A.

**Pre-feedyard nutrition, health and management.** An area of great interest in recent years is that of pre-feedyard health and nutrition and its affects on marbling of fed cattle. This is the result of a significant paradigm shift among scientists. Most of us were taught that marbling was a late maturing fat depot. After all other fat depots were about as full as they could get, the animal decided to deposit some marbling if there was any energy left over. This line of thinking placed great emphasis on the last 30-45 days of the feeding period as the time that most marbling deposition occurred. We now know that the situation is much different and that marbling can be deposited at any stage of growth. Marbling deposition can also be impaired at any stage of growth.

**Key Point #1:** Marbling deposition is a lifetime event, not just the late stage of the feedyard phase.

**Key Point #2:** Marbling is separate from subcutaneous fat. They are different tissues with different regulatory pathways.

Intramuscular fat (marbling) has been shown to result from a different embryonic tissue layer than subcutaneous fat (backfat). At birth, cattle have non-differentiated cells within their muscle that have at least three choices: turn into muscle cell nuclei, turn into fat cells, or do nothing. The various stimuli that determine which direction they go are not fully understood, but this is an active area of current research. What we do know is that those cells can be coerced to increase either the muscling or the marbling of the animal and that this coercion may occur at any time in the life of the animal. We also know that the signals that stimulate development of intramuscular fat cells, resulting in increased marbling, do not necessarily require high levels of empty body fat. In other words, the potential exists to preferentially stimulate marbling without making the cattle excessively fat.

**Key Point #3:** Any nutritional insult, at any time in the life of the animal, will reduce marbling.

Nutritional insults include drought, poor milking cows, etc. Research has shown that creep feed improves grade if the calves are on poor milking cows but not so much if the cows milk well. Corn-based creep improves marbling but not other energy sources. Use of feedstuffs that preferentially make glucose available to the
muscle can increase marbling to a greater extent than external fatness.

**Health and Quality Grade.** One of the strongest statistical relationships in the Benchmark database is a negative correlation between either death loss or medicine use, and percentage Choice. Those lots of cattle that have high morbidity and mortality invariably grade poorly, relative to the rest of the population.

Cattle that get sick often go off feed and expend more energy fighting the negative effects of the disease. This can result in reduced or even negative energy balance, even in the presence of a well formulated, highly palatable diet. This condition can persist for days or even weeks in individual animals. Cattle that are sick while on grass could lack the energy to graze and consume adequate energy. Data are limited on the relationship between pre-feedyard health (calves or stockers) and quality grade but it stands to reason that those cattle that suffer disease at any time in their lifetime could have an impaired ability to deposit marbling, regardless of how fat they ultimately get.

One source of lifetime data is the Texas A&M University and New Mexico State University Ranch to Rail Programs. Yearly summaries show similar results in terms of the effects of morbidity on ADG and profitability, but the effects on carcass traits are more variable. For instance, the 1999-2000 summary of the Texas A&M Ranch to Rail Program (McNeill, 2000) showed that cattle treated at least once for BRD had 31% fewer carcass grading Choice. However, data summarized by Waggoner et al. (2007) for cattle on feed from 2000 to 2003 indicated no differences in carcass grade relative to morbidity. Certainly changes in genetics and environment could explain a portion of the discrepancy between years, but a definitive explanation is not readily apparent.

Indirect evidence that poor health is related to reduced carcass quality comes from the Benchmark Program. Many Benchmark member feedyards assess the health risk of incoming feeder cattle. High risk cattle could result from all types of pre-feedyard stress but weaning, extended transit and evidence of disease are among the most likely causes. While these risk scores are arbitrary, we have confidence in the wisdom and experience of the cattle producers and death loss and medicine consumption data bear out that the cattle were indeed higher risk in most cases. Increased risk is associated with poorer grade, even when the cattle get straightened out and achieve carcass weights equal to or greater than the lower risk cattle.

<table>
<thead>
<tr>
<th>--Assigned health risk category--</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 lb steers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCW, lb</td>
<td>755</td>
<td>766</td>
<td>772</td>
</tr>
<tr>
<td>Choice or higher, %</td>
<td>52.1</td>
<td>46.7</td>
<td>44.0</td>
</tr>
<tr>
<td>600 lb steers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCW, lb</td>
<td>789</td>
<td>778</td>
<td>792</td>
</tr>
<tr>
<td>Choice or higher, %</td>
<td>44.6</td>
<td>43.2</td>
<td>38.7</td>
</tr>
</tbody>
</table>

We can’t tell from these data which aspects of the high risk designation are related to the poorer grade. Numerous factors are likely involved.

Many nutritional insults are deliberate. Feeder cattle buyers have long preferred cattle that are at least slightly thin. Research has shown that thin cattle will often have compensatory gain during the early part of the feeding period,
which improves feed efficiency and lowers the cost of production in the feeding phase. Feeder cattle producers have responded by giving the buyers what they want – thin cattle, or at least not cattle that could be described as fleshy. While this industry-wide strategy is likely positive for feedyard performance, we need to study whether it has negative impacts on grade.

For example, Grona et al. (2002) determined that cattle classified as slightly- to very-fleshy had higher marbling scores than cattle that were thinner at the beginning of the feeding period. This supports early weaning research that shows that cattle placed on feed earlier will develop marbling sooner than cattle that are grown on diets with less energy concentration (Wertz et al., 2002 and Myers et al., 1999).

As discussed previously, management of body condition is used by most cattlemen to achieve various outcomes. Although research has indicated higher marbling scores for cattle that are placed on feed at an earlier chronological age or cattle that enter the feedyard with more condition, the effects of early condition on the lifetime marbling potential and subsequent feedlot performance is still not clear. Brethour, 2004 showed that carcass backfat is a poor indicator of carcass marbling score. In addition, backfat measurements taken 43 or 50 days prior to slaughter did not predict feedlot performance, ADG and F:G. Therefore, beef producers should not assume that body condition will not predict future feedlot performance, nor will body condition accurately predict the ability of an animal to grade Choice.

**Feedyard nutrition and management.** The primary reason that cattle are fed in feedlots is so that they can receive large amounts of high energy feed, in order to gain weight efficiently. By definition, feedlot diets are high in energy and 100 days or more of high energy feed results in fatter, more highly marbled carcasses and a product that consumers prefer. In general, the more energy cattle consume above their maintenance requirement, the fatter they will get. There are five ways to increase the cumulative quantity of energy available in excess of the maintenance requirement:

- Increase daily feed consumption.
- Increase the energy concentration of the feed.
- Increase the number of days fed.
- Improve efficiency of digestion or absorption.
- Lower the maintenance requirement.

**Effects of Feed Intake on Quality Grade.** Daily feed intake has shown mixed results on carcass traits in various research settings. Management strategies that limit intake have decreased quality grade and/or marbling score in feedlot cattle (Hicks et al., 1990 and Erickson et al., 2003). However, others have shown no difference in carcass characteristics when intake is deliberately restricted (Rossi et al., 2001) or between cattle that have low or high relative feed intakes (Castro Bulle et al., 2007). Variation in carcass characteristics among research trials demonstrates the inherent variability in cattle populations and their ability to express marbling. It should stand to reason that in order for cattle to express their genetic potential to marble they have to have daily caloric intakes adequate to sustain normal levels of growth. Recent interest in slick bunk management has again posed the question, ‘will limited intakes, although slight, cause a change in quality grade?’

Using the Benchmark database, we assessed the importance of five performance parameters relative to percent USDA Choice: average daily gain, daily intake, feed conversion, final weight, and percent yield grade 4’s. Seven hundred to 749 lb steers and heifers from the four largest Benchmark regions from 1996 through March 2007 were included. The results are summarized below.
### Table

<table>
<thead>
<tr>
<th>Item</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Daily Gain</td>
<td>0.0043</td>
</tr>
<tr>
<td>Daily Intake</td>
<td>0.0372</td>
</tr>
<tr>
<td>Feed Conversion</td>
<td>0.0055</td>
</tr>
<tr>
<td>Final Weight</td>
<td>0.0146</td>
</tr>
<tr>
<td>% YG 4</td>
<td>0.0039</td>
</tr>
</tbody>
</table>

Total Lots: 22,090  
Total Carcasses: 3,484,149

It is clear that substantial variation exists in the population, and our ability to predict carcasses grading Choice relative to basic feedlot production parameters is poor. As managers of a diverse population we have to manage for the worst in the population to make sure the best in the population can express their genetic potential.

Increased processing of grain, such as steam flaking makes starch more available and is a common means of increasing the energy content of the diet. The effects of grain processing on carcass characteristics have been measured in numerous research trials. Most often as cattle are harvested at equal endpoints (e.g. percent empty bodyfat) they tend to have similar carcass traits (Brown et al., 2000 and Scott et al., 2003). Differences in energy concentration among diets and within grain sources are most often compensated by daily intake. Steam-flaking corn, compared to dry rolling, increases its energy content and improves feed efficiency by 10% compared to dry rolling (Owens et al., 1997). Improvements in feed conversion are also noted for steam-flaked sorghum and wheat compared to dry rolling but not for steam-flaked barley or oats (Owens et al., 1997). Although differences in feed efficiency are observed with various grain processing methods, the effect is determined by changes in intake, not changes in daily gain.

Different feed sources have been implicated as being detractors of quality grade. Duff et al., (2002) evaluated two steam-flaked grain sources, corn and sorghum, and found no differences in carcass traits of feedlot cattle between the two grain sources. In a recent analysis of published research (69 trials), it was determined that increasing level of metabolizable energy in beef cattle diets increases subcutaneous fat and KPH. No differences in other carcass traits were observed (Kreihbiel et al., 2006). Therefore, it may be assumed that cattle fed rations with higher energy will become fatter, but the increased energy content does not affect muscling, as indicated by ribeye area, or marbling score.

It appears that by providing the beef animal with nutritionally consistent feedstuffs at levels that enable them to gain at normal production levels their ability to marble is not limited nutritionally. Certainly differences exist in growth rate, but if cattle are harvested at similar endpoints there is no difference in marbling characteristics among differently processed grains.

**Effects of implants and other growth promotants.** Use of implants and other growth promotants in feedyards are an important consideration in quality grade. Implants are used in more than 95% of all fed cattle. With the exception of cattle fed for natural programs (and not all of them) it is safe to say that virtually all feedlot cattle are implanted at least once.

Research has shown that implants reduce quality grade in most studies. The VetLife Implant Research Database includes data from 325 published implant studies. These studies include 579 treatments groups in which ADG of implanted steers or heifers was compared to a
negative control, and 356 treatment groups in which percentage Choice was compared to a negative control. Across all treatment groups, the average increase in ADG due to implants was 16.2%, the average reduction in percentage Choice was 10.8 percentage units (i.e. from 65% Choice to 54.2%). Across a wide spectrum of use and practices, implants can have a negative impact on quality grade but many highly efficacious implant programs have only minimal effects on quality grade.

### Percentage change vs. negative control

#### Published implant research

<table>
<thead>
<tr>
<th></th>
<th>ADG</th>
<th>Choice+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of comparisons</td>
<td>579</td>
<td>356</td>
</tr>
<tr>
<td>All steers or heifers</td>
<td>16.2</td>
<td>-10.8</td>
</tr>
<tr>
<td>Steers, no TBA</td>
<td>14.4</td>
<td>-8.7</td>
</tr>
<tr>
<td>Steers, TBA</td>
<td>20.2</td>
<td>-14.3</td>
</tr>
<tr>
<td>Steers, TBA &lt; 200 mg</td>
<td>19.2</td>
<td>-4.3</td>
</tr>
<tr>
<td>Heifers, no TBA</td>
<td>10.2</td>
<td>-3.1</td>
</tr>
<tr>
<td>Heifers, TBA</td>
<td>12.2</td>
<td>-4.6</td>
</tr>
</tbody>
</table>


As usually happens though, the simplest answer can be somewhat misleading for three reasons. First, many of the implant treatment groups used in studies do not reflect what actually happens in the industry. Thus, using broad averages of studies could paint an inaccurate picture of what commonly occurs. For example, products containing 200 mg of TBA are used in only a small percentage of steers. When these products are excluded, the effect of TBA-containing implants on steers is only a reduction of 4.4 percentage units. Second, steers are disproportionately represented in study results. The negative effect on grade of heifers is less than steers.

Third, among commonly used programs, many studies did not employ management practices that could reduce the negative impact of implants on grade. Examples of these include altered nutrition, extended days on feed, etc. Research (Anderson, 1991) has shown that higher protein levels ameliorate the negative marbling effects of potent implants. In addition, several studies have shown that grade of implanted cattle if they are fed to greater weights.

Anderson (1991) calculated weight and days on feed differences required for animals implanted with multiple doses of TBA to reach marbling endpoints, relative to non-implanted animals (see below). Cattle used in this study were large framed, exotic crossbred steers, the type that were common in 1991 but can hardly be found today. In this work, cattle of that type required 235 lb more live weight to achieve an average marbling score of small 50.

Increased days on feed or live weight required to reach average marbling scores.

<table>
<thead>
<tr>
<th>Slight 50</th>
<th>Small 0</th>
<th>Small 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>+2</td>
<td>+8</td>
</tr>
<tr>
<td>Weight</td>
<td>+112</td>
<td>+174</td>
</tr>
</tbody>
</table>


Industry implant practices have changes only slightly in the past decade. The table below includes Benchmark data since 1999. To
smooth out year to year variation, each mean includes two years of data. While the number of implant doses per head has increased slightly during that time, it is largely a reflection of more days on feed. The number of days per dose has not decreased. While the percentage of cattle that receive TBA has increased, it is largely due to use of lower potency (intermediate dose) products. Thus when implant programs are scored according to potency (1 = no TBA, 2 = intermediate doses only, etc.) the average implant potency score has trended downward.

Industry implant practices:

<table>
<thead>
<tr>
<th>Two years beginning with…</th>
<th>1999</th>
<th>2001</th>
<th>2003</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implant doses</td>
<td>1.85</td>
<td>1.96</td>
<td>2.09</td>
<td>1.96</td>
</tr>
<tr>
<td>Percentage TBA</td>
<td>90</td>
<td>94</td>
<td>95</td>
<td>96</td>
</tr>
<tr>
<td>TBA doses</td>
<td>1.13</td>
<td>1.21</td>
<td>1.28</td>
<td>1.29</td>
</tr>
<tr>
<td>Implant score</td>
<td>3.15</td>
<td>3.08</td>
<td>3.11</td>
<td>3.06</td>
</tr>
<tr>
<td>Days on feed</td>
<td>154</td>
<td>169</td>
<td>164</td>
<td>170</td>
</tr>
<tr>
<td>Days/dose</td>
<td>83.5</td>
<td>86.4</td>
<td>78.3</td>
<td>86.8</td>
</tr>
</tbody>
</table>


In short, implants do reduce quality grade as commonly used, but the effect has probably not changed much in the past decade. The key to minimizing implant effects on quality grade is to look for favorable risk:reward trade-offs. Here are some examples:

- TBA has almost no effect on grade in heifers and multiple doses of TBA have only a small effect. Heifers can be aggressively implanted for performance with limited effect on grade. The same is not true in steers.
- Programs containing 120 mg of TBA products in steers deliver near-maximum performance with only moderate effects on marbling.
- Delayed implanting may result in increased marbling in some production situations but can result in reduced performance if not tightly managed.

As a rule, implant potency should be matched to the genetic capability of the animal to deposit muscle, and the energy consumption above maintenance. Moderate potency implants should be used for low consuming cattle or those with high maintenance requirements due to disease, weather, etc.

Nearly all U.S. heifers are fed melengestrol acetate (Heifermax® or MGA®) because the estrus suppression and improved behavior make management of heifers much easier and provide excellent economic return. In the most recent research, representing the average result in 13 studies, melengestrol acetate increased ADG by 7.9% and improved feed conversion by 4.3%. Hot carcass weight (HCW) was 18 lb heavier for treated heifers and they had 4.5% more Choice or higher grading carcasses. The improvement in quality grade is greater than would be predicted by carcass weight alone, suggesting that grade is preferentially improved. The percentage of feedlot heifers that received melengestrol acetate is very high (estimated at 85-90%) and has not changed much in the past decade.
An industry practice that has changed in the past few years is use of the beta-adrenergic agonist, ractopamine (Optaflexx®). Ractopamine is a potent muscle growth stimulant that is typically fed for the last 28 days of the feeding period. HCW is increased by 14 lb, on average with ractopamine and it is reasonable to ask whether that could result in reduced marbling or quality grade. A series of published studies indicates

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Optaflexx</th>
<th>SEM</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steer studies</td>
<td>495.8</td>
<td>495.4</td>
<td>3.6</td>
<td>NS</td>
</tr>
<tr>
<td>Heifer studies</td>
<td>503.7</td>
<td>501.0</td>
<td>6.4</td>
<td>NS</td>
</tr>
</tbody>
</table>

that marbling score of steers or heifers is unaffected by feeding 200 mg per head per day of ractopamine (see below). The same may not be true of other beta agonists with greater potency.

Marbling scores of steers or heifers fed Optaflexx or control diets:

Corn co-products. Another industry practice that has changed is feeding of corn co-products generated by the ethanol industry. Co-products could potentially affect marbling because they are: high in NDF (negative for marbling), high in fat (-), palatable (+), and comparatively inexpensive (+). The site of digestion and profile of metabolic products could result in reduced glucose availability to the muscle and thus less marbling, despite equal or greater fatness.

Co-products have received a great deal of scrutiny regarding their potential negative effects on marbling but as often happens, the truth is too long to fit on a bumper sticker. Reinhardt and DiCostanzo (2006) reviewed 21 studies which included 106 co-product treatment groups and provided the following summary relative to carcass quality:

- At high yield grade endpoints (high days on feed, early-maturing cattle or heifers) co-products increase marbling at low to intermediate inclusion rates.

It is uncommon, but not unheard of, to feed more than 20% of the diet as co-products. In addition, plant to plant variation, differences between wet, dry and modified sources, etc. make blanket statements regarding co-products dangerous at this point (except that one).

Endpoint selection. As cattle fatten, subcutaneous fat increases in a fairly predictable manner. While marbling is highly correlated with external fatness, neither can perfectly predict the other. In addition, since quality grades are based on marbling thresholds, percentage Choice does not increase in a straight line, either with increased weight or increased external fatness. The chart below, from Lawrence et al., 2001, displays the relationship between fat thickness (horizontal axis) and percentage Choice or percentage yield grade 4 (or 5). These data are taken from individual measurements of over 65,000 steer carcasses.
In this data set, as fatness increased to around .65 inches, grade increased in more or less a straight line. Beyond that level of fatness grade continued to increase, but at a slower pace. At no level of fatness were all of the carcasses (or none of them) Choice. Fatness alone will not guarantee grade. YG 4’s were nonexistent at fat thickness below .5 inches and at .8 inches, 50% of the carcasses were YG 4’s, as the yield grade equations would have predicted.

Depending on the premiums and discounts in a given system, carcass value would be maximized at approximately 0.6” of average fatness. Feeding cattle to a fatter endpoint would increase grade but any increases in value would be likely offset by a poorer yield grade profile. The average fatness can be misleading since the range is as important. Carcass value will probably be maximized if most carcasses within a group have between 0.4” and 0.6” of external fat. Recent data from the Certified Angus Beef® program indicate that if premium grades receive a high premium, the ideal range could be slightly fatter. In any system, narrowing variation and getting more carcasses near the mean will increase value.

Summary

Among commonly measured traits in beef cattle production, marbling has about the poorest relationship between understanding and economic importance. Many factors contribute to an animal’s ability to express marbling. The current feeding environment includes high grain and roughage prices, extremely volatile markets, strong consumer demand for high quality beef products but slowing demand for mid and low quality products, and international trade limitations. In this environment, producers and managers have to be aware of how changes in management and selection affect the beef business as a whole.

Since marbling deposition is a lifetime event, all segments of the industry will have to focus on quality in order to make significant progress. Research has shown that early weaning and consumption of diets high in concentrates will increase marbling. The health status of cattle, especially early in the feeding period, appears to
have an effect on performance and carcass characteristics. Growth promotants can affect marbling, but the effects are dependent upon sex and dosage of the product. Endpoint selection influences quality grade, yield grade, and other economically important carcass traits.

The complexity of marbling allows some opportunity. While traditional wisdom states that marbling can be reduced by negative lifetime events but not increased, recent research indicates that opportunity exists to increase marbling. This should be an active area of future research.

**Literature Cited**


Round Table Discussion

Does the Seedstock Industry Focus on the Needs of the Commercial Cow/Calf Producer?

Moderator:

Ron Bolze
Director of Commercial Marketing
Red Angus Association of America

Panel Members:

Mark Gardiner
Gardiner Angus Ranch
Ashland, KS

Steve Radakovich
Radakovich Cattle Company
Earlham, IA

Mike Kasten
Kasten Ranch
Millersville, MO

Chip Ramsey
Rex Ranch
Ashby, NE
Successful purebred breeders have always focused on the needs of commercial producers. However, the needs expressed by commercial cattlemen have changed over time.

During the 1970’s and 80’s the focus of commercial producers was on maternal ability. Consequently in addition to the constant emphasis on growth, purebred breeders placed more emphasis on increased milk production and the popularity of dual purpose cattle increased. Milk EPDs became a major selection component. Emphasis on maternal ability is still evident today, but concerns over the costs of larger cow size and relative efficiency have reduced the unabated selection for more milk.

Beginning in the 1990’s and continuing until today, the demands of commercial producers have moved toward increasing end-product value and expecting more customer service before and after the sale. Some of the ways breeders have addressed these demands are:

**Emphasis on End-product Value**
- Providing genetics that allow commercial producers to capture added value through value based marketing with companies like US Premium Beef to increase profits of commercial producers.
- Sharing and educating producers about true economic signals has finally sent the “right” signals up and down the beef production chain.
- Emphasizing growth and carcass traits to create a “pounds in the right package” allows the commercial cattleman to produce cattle adapted their operation’s environment, but also to hit the targets of economic importance in order to enhance profitability.

**Emphasis on Customer Service**
- Maintaining an emphasis on breeding soundness- fertility is still the # 1 performance trait no matter how we measure it.
- Offering bull guarantees is more important than ever. Seedstock producers today become customer service representatives after the sale.
- Sponsoring sales and marketing opportunities for commercial customers. Successful seedstock producers spend as much or more time marketing their customers’ cattle as they do their own through many of the following programs:
  - Breeder influence sales
  - Buy back programs
  - Coordinating sales via order buyers
  - Feedlot relationships and retained ownership arrangements
  - Sharing value based marketing incentives
  - Implementing age- and source-verified ID systems

Meeting and exceeding the needs of commercial producers has been and will continue to be the objective of successful seedstock breeders. After all, they are our customers!!
“If you always do what you’ve always done, you will always get what you’ve got.” Anonymous

The seedstock industry has historically given the cow calf producers what they have needed IN EXCESS. If a little is good, more is better.

“When one tugs at a single thing in nature, he finds it attached to the rest of the world.” John Muir

Fad x Publicity\(^2\) = Fact

Seedstock producers are offering commercial cattlemen an ever increasing accuracy for genetic value.

A majority of cow-calf suppliers do not have profit as their highest priority:
- Tax break
- Hobby
- Ego
- Youth programs
- Environmental improvement (weed and brush control)
- Complimentary grazing program with sheep and wildlife
- Recreation (bucking bulls)

“Genetics are not an important economic driver on my ranch unless it causes a wreck.” Pete Marble, 71 Ranch, 1980

“Our goal is to stay out of the way of natural sources.” Dale Lasater, from the DVD Holy Cow

“It’s not the strongest of the species that survives. It’s not the most intelligent. It’s the one most responsive to change.” Charles Darwin

Cow-calf priorities of need change with:

Advisors:
- Veterinarian
- Semen provider
- Sale barn
- Seedstock breeder
- Cattle buyer
- County fair

Season:
- Calving
- Breeding
- Weaning
- Wintering
- Feedlot
- Product

The great increases in corn yields are largely due to the “adaptability” of plants to the stress of increased plant population.

The one big injustice of the seedstock industry is evaluating and supplying over managed, over fed, fossil fuel dependent bulls to cow-calf producers forced to survive on solar energy and low-cost production.

The future of beef production will be determined by the ruminants’ ability to adapt to limited solar produced forages and agricultural co-products.
Mike Kasten  
Kasten Ranch  
Millersville, MO

- From the standpoint of producing high quality genetics that fit the different geographic areas where cattle are produced, I think seedstock producers are doing a good job.
- I think the industry as a whole has been doing a much better job than in the past on focusing on genetics that fit the needs of our beef consumers.
- In the future, providing top quality genetics for your customers is going to be a given notion. How you help them capitalize on those genetics will become more important.
- The beef industry is going to have to answer the question, “How are you going to change your genetics to adapt to higher feed costs that commercial producers are incurring and will continue to incur because of the ethanol industry?”
- With the higher cost of production and the continuing trend of commercial cattle production becoming a recreation rather than a business, another question in our future is how is the seedstock industry going to educate these individuals on genetics specific to end product?
- In the future is the seedstock industry going to be the gateway to limited integration in beef marketing?
- Is commercial producer loyalty going to be driven more by services provided than genetics?
- Are breed associations going to give their seedstock producers the tools they need to provide their commercial customers with the services they want and expect?

I think we are at a point of tremendous change in the beef industry. The seedstock producers have always been put in the leadership role when it comes to change. How we adapt to the changes ahead will certainly determine our future. The items above are just a few of the challenges I think we will be addressing in the near future.
The practice of free-enterprise or capitalism has served this country well over the years when compared to any other economic system throughout the world. I would say that the cattleman clings to these economic principles as much or more than any other industry; and rightfully so in my opinion. However, capitalism does not focus on the needs of the consumer but rather the wants and desires of the consumer. Capitalism assumes that the consumer knows what he needs and will include that in his wants. Capitalism focuses on being profitable.

There are several segments making up the seedstock industry: producers, breed associations, auctioneers, breeding service companies, scientists and technicians of various disciplines, etc…The only common thread or goal that each of these diversified segments share is the desire to make a good return on their investment of time, effort, and capital. Therefore, they are focused on providing the service or product that their clientele are asking of them. For example, bulls don’t need to be that fat to breed cows but try to sell one that isn’t. As a whole, the people involved in this industry want to make the cattle better but not at the expense of their living.

Before the commercial cow/calf producer points his finger at the seedstock industry for delivering something that he has asked for that he later found that he didn’t need, he should ask himself this question. If someone said they would give you a $20 per cwt. premium on your calves if they could be kept “all-natural”, would you do it? Even though, there is absolutely no proven health benefit to those people who eat “all-natural” beef are you willing to deliver it to them if they are willing to pay more for it? Is that what they need?

If the commercial cow/calf producer wants something that he needs, the progressive, well-intending people involved throughout the seedstock industry will deliver it, if the cow/calf producer is willing to pay for it. Those forward thinking people in the seedstock industry that try to do the right thing and are willing to take the risk in the near term are usually rewarded with long term success rather than a short term opportunistic profit.

The commercial cow/calf producer needs the truth. We need to know with as much accuracy as possible what that bull is going to do for us in our herd. We need accurate whole-herd reporting in the seedstock industry, accurate across-breed EPDs, accurate estimates of heterosis benefits, etc… We need these services for as low a cost as possible, which means less overhead costs. But the fact of the matter is; we may just want to be fed a steak and buy a fat bull with a guarantee close to home so that we can get the crop in on time. That’s why we live in America; it is our right to choose what we want because we will reap the success or failure of our decisions.
Are there sacrifices in the chase for carcass merit?

Bob Weaber, Ph.D., PAS
State Extension Specialist-Beef Genetics
University of Missouri-Columbia

Introduction:

As the beef complex has become more consumer focused and more cattle are individually priced through various value-based marketing systems or grids, seed-stock and commercial producers have been motivated to place more selection pressure on carcass traits by downstream industry partners. A number of grid pricing systems exist that significantly reward cattle that grade in average Choice or better and meet other production specification for branded beef programs. Economic incentives and the publicity surrounding branded programs have raised industry awareness of the value of carcass merit. At least a portion of this motivation for selection to improve end-product quality and consistency comes from the National Beef Quality Audit (NCBA, 2000) which identified a variety of attributes that needed improvement to expand beef demand. Among the top ten challenges identified in the strategies portion on the audit were inappropriate carcass size and weight, inadequate tenderness, excess external fat cover, insufficient marbling and inappropriate USDA Quality Grade mix.

The above deficiencies were selected by the author as they each have a genetic component that may contribute to the problem. A wide range of carcass traits, or their live animal indicator traits measured via ultrasound, have been shown to be moderately to highly heritable (Shackleford et al., 1994; Dikeman et al., 2005; Minnick et al., 2004; Crews et al., 2003) and lowly to moderately correlated with production traits including cow body condition score, direct and maternal weaning weight (Eborn, 2007). Many breed association sponsored genetic evaluation systems now include routine production of Expected Progeny Differences (EPD) for carcass traits including: carcass weight, marbling, rib-eye area, 12th rib fat thickness and yield grade or percent retail cuts. Several breed organizations include either ultrasound based indicator traits of carcass merit which consist of scan weight, percent intramuscular fat, rib-eye area and 12th rib fat thickness or include this data in a multiple trait genetic evaluation. Seedstock producers are utilizing these EPD to change genetic merit of seedstock animals and their germplasm as evidenced by the genetic trends within breeds (Am. Angus Assn., 2007; Am. Simmental Assn., 2007).

Increased emphasis on phenotypic performance has motivated commercial producers to seek out animals with enhanced genetic merit for carcass traits. Seedstock producers have responded by implementing carcass testing programs, ultrasound data collection systems and the use of DNA markers to differentiate their products. Considerably more selection pressure is placed on carcass traits today, by a wider range of seedstock and commercial producers, than ever before. The increased selection pressure is justified to some extent by the increased relative economic importance of carcass traits for commercial producers that decide to retain ownership of their calves through harvest. Melton (1995) states than for an integrated production firm reproduction is twice as important as growth or carcass traits. So, as value differences in beef carcasses widen due to further market differentiation, it is sensible to investigate the
changes in genetic merit of other economically important production traits due to correlated responses when selecting for carcass traits. The purpose of this work is to investigate the potential genetic and economic consequences of selection for increased carcass merit, particularly increased intramuscular fat or marbling.

Materials and Methods:

To simulate realistic changes in phenotypic marbling scores associated with varying percentages of cattle grading USDA Choice and higher, mean marbling scores were derived by finding the truncation points for right tail areas 50%, 60%, 70%, 80%, and 90% of a standard t distribution with mean equal zero and variance equal to one. Then the typical equation for computing critical values of t distributions;

\[ t_{crit} = \frac{X - \bar{X}}{S_X} \]

was solved for the mean, such that,

\[ \bar{X} = X - S_X \cdot t_{crit} \]

Where, \( \bar{X} \) = mean pen marbling score, \( S_X \) = marbling phenotypic standard deviation (0.7744), \( t_{crit} \) is the truncation point for the specified right tail area, and \( X \) is 5.00, the minimum marbling score required to grade USDA Choice. The solutions for the required average marbling score pens to grade varying levels of percent USDA Choice and higher are reported in Table 1.

The resulting average marbling scores were deviated from 5.0 (the minimum marbling score required to grade USDA Choice equivalent to Small 00) to determine the increase in average marbling score required to move from a 50% USDA choice and higher to 60%, 70%, 80%, and 90% USDA Choice and higher. These phenotypic deviations were divided by the marbling genetic standard deviation of 0.5196 (\( h^2 = 0.35 \)) to compute the number of genetic standard deviations required to move the pen to the various levels of percentage of cattle grading USDA Choice or higher. Then incremental requirements were computed to determine the genetic improvement required at each 10% increase in percentage of cattle grading Choice or higher from 50-90% Choice. These results are presented in Table 2. Figure 1. illustrates the shift in the distribution of phenotypic pen average marbling score as the percentage of choice cattle in a pen increases from 60% to 80%.

Figure 1. Simulated differences in mean marbling score for pen of cattle grading 60% USDA Choice and higher (left most) with mean marbling score = 5.196, and a pen of cattle grading 80% Choice and higher (right most) with mean marbling score = 5.652.

Genetic variances and covariances for a variety of beef production traits used to construct selection indexes were obtained (W. Shafer, personal communication). The genetic variances and covariances were for traits included in either the breeding objective or selection criteria of the all-purpose selection index (API) computed for the American Simmental Association and constructed by Dr. Mike MacNeil, USDA-ARS-LARRL. The API index is used to describe economic differences
due to genetic merit in a production system that sells calves at harvest on a grid pricing system and keeps replacement females from the herd. The genetic covariances between traits in the breeding objective and selection criteria are reported in Table 3. The genetic (co)variances between traits in the selection criteria are reported in Table 4. A description of each trait is provided in Table 5. Additive genetic correlations between traits in the breeding objective and selection criteria and among traits in selection criteria are reported in Table 6 and 7, respectively.

Two sets of genetic multiple regressions were computed. One set of regression coefficients were computed for the regression of traits in the breeding objective on those in the selection criteria. The other regression was among traits in the selection criteria. All regressions took the form of $b_{YX} = \frac{\text{cov}(X,Y)}{\text{var}(X)}$. Coefficients for the regression of traits in breeding objective on those in the selection criteria are reported in Table 8, while coefficients for regressions among traits in selection criteria are in Table 9.

Predicted responses for traits in the selection criteria and breeding objective were computed for perturbed values of marbling associated with the proportional increases in marbling score for each level of percentage of cattle grading USDA Choice or better computed earlier.

The predicted values of the traits in the breeding objective were weighted by breeding objective economic value weightings for the API indexes produced in 2006 and 2007 by MacNeil (Shafer, personal communication). Likewise, the predicted selection criteria values were weighted by the selection index economic weights for the 2006 and 2007 API. Note that only the 2006 index values have been implemented by the American Simmental Association. The 2007 values represent a new simulation model with added stochastic elements for several trait complexes including BWT-CE(d)-SURV and carcass traits and evaluates the revenues and costs of a sires daughter during her productive life, discounting revenues and costs to the point in time when a replacement females is selected. Relative economic values in the 2006 API place considerably more emphasis on STAY, FERT, SURV and CE(d) and CE(m) than does the 2007 API which places considerably more weight on growth and carcass traits that other traits in objective.

Results and Discussion:

Predicted genetic responses for correlated traits in breeding objective to selection for marbling are reported in Table 10, while predictions for traits in selection criteria are reported in Table 11. In each case Marbling predictions are percentage increases above a base of 5.0 (Small 00) and relate to the 50-90% USDA Choice and higher pen averages. In general, the changes the correlated traits in the breeding objective and selection criteria were small in magnitude. When moving pen percent USDA Choice and higher from 50-90%, MWT decreased by nearly 7 pounds, WW(m) was nearly unchanged, marginal improvements in FERT and SURV. ADG, FI, and DP increased numerically. For traits in selection criteria, response in correlated to traits to selection for MRB reveals a 1 unit decrease in STAY, a small increase in CE(d) and small decrease in CE(m) and WW(d). WW(m) increased approximately one pound while YW increased 5 pounds. YG was only marginal increased.

These predicted responses to selection for marbling are not equivalent to the traditional computation of correlated response to selection as they have not been scaled by either accuracy of prediction, selection intensity or generation interval. The computations assume the accuracy of prediction of 1.0 and that the genetic differences are fully expressed in phenotypes.
Once the predicted genetic changes were weighted for their economic contributions to profit using either the economic values for the 2006 or 2007 API changes in Net Merit (measured in dollars) due to increases in marbling were computed and are reported in Tables 12 and 13. Under the 2006 API index, the 40% increase in % USDA Choice and higher resulted in a nearly $5.00 change in Net Merit while using the 2007 API revealed a $43.70 increase per progeny. The changes in Net Merit using traits in the selection criteria and weighted by economic weights used in either the 2006 or 2007 API were ($ 3.05) and $ 31.29, respectively. Value changes between the weighting of traits in breeding objective and selection criteria are expected as not all traits in selection criteria are in breeding objective and vice-versa. Economic weights for the selection criteria, which include some traits in breeding objective and some indicator traits, are the regressed contributions to profit for correlated traits in the breeding objective.

The changes in Net Merit observed here reveals that there are typically only small changes in correlated traits even when significant selection pressure is applied to MRB. The small changes in Net Merit and underlying expression of traits in the breeding objective and selection criteria are a result of the small additive genetic correlations between marbling and the other traits (-0.20 ≤ r ≤ 0.20). Minimal changes in correlated traits should be expected when placing heavy selection pressure on marbling. Any potential genetic antagonism should be countered by inclusion of those traits in the breeding objective or selection decisions. Effective multiple trait selection including marbling and other economically important traits should result in improvement Net Merit.

It appears that little negative impact, and in fact, some positive results in additive genetic merit and resulting phenotypic performance can be achieved through selection for significant increases in MARB. However, these additive genetic gains must be weighed against potential compromises in non-additive genetic merit. In many instances improvements in MARB are achieved through selection of subsequent generations of animals of high merit from within a single breed making use of the breed’s superiority. For instance, one might harvest the core strengths of the Angus or Red Angus breeds for MARB by increasing the percentage of one of those breeds in progeny. This process is likely to increase average genetic merit for MARB, but will reduce heterosis or hybrid vigor. Even though heterosis has little impact on MARB it has large positive effects on lowly heritable, but economically important, traits such as cow longevity, reproductive rate, and productivity (Cundiff and Gregory, 1999; Gregory and Cundiff, 1980). Decreases in economic performance due to reduced heterosis must be rationalized against improvements in additive merit. These potential adverse conditions may be partially mitigated through the effective use of a well designed, structured crossbreeding system that optimizes breed complementarity and heterosis to produce cows best suited for their production environment and market targeted progeny.

**Literature Cited:**


Table 1. Percentage of cattle grading USDA Choice or higher quality grade, t distribution truncation point and required pen average marbling score for pen to achieve state percentage USDA Choice and higher quality grade.

<table>
<thead>
<tr>
<th>% Choice and Higher</th>
<th>Truncation Point</th>
<th>Pen Average Marbling Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.000</td>
<td>5.000</td>
</tr>
<tr>
<td>60</td>
<td>-0.253</td>
<td>5.196</td>
</tr>
<tr>
<td>70</td>
<td>-0.524</td>
<td>5.406</td>
</tr>
<tr>
<td>80</td>
<td>-0.842</td>
<td>5.652</td>
</tr>
<tr>
<td>90</td>
<td>-1.282</td>
<td>5.992</td>
</tr>
</tbody>
</table>

4.00 = Slight 00, 5.00 = Small 00 degrees of marbling

Table 2. Percentage of cattle grading USDA Choice and higher, the required pen average marbling score to achieve stated percentage of choice and higher, the needed increase in genetic merit to achieve percentage choice and higher from a base of 5.00 (50% Choice and higher), the number of genetic standard deviations required to reach each grade level from a base of 50%, the incremental genetic standard deviations required to move from one grade percentage level to next, and the incremental genetic merit increase needed between grade percentage levels.

<table>
<thead>
<tr>
<th>% Choice and Higher</th>
<th>Pen Average Marbling Score</th>
<th>Needed Increase in Genetic Merit</th>
<th>Genetic Std Dev Required to Achieve Increase</th>
<th>Incremental Genetic Std Dev</th>
<th>Incremental Genetic Merit</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>5.000</td>
<td>--</td>
<td>--</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>60</td>
<td>5.196</td>
<td>0.196</td>
<td>0.378</td>
<td>0.378</td>
<td>0.196</td>
</tr>
<tr>
<td>70</td>
<td>5.406</td>
<td>0.406</td>
<td>0.782</td>
<td>0.404</td>
<td>0.210</td>
</tr>
<tr>
<td>80</td>
<td>5.652</td>
<td>0.652</td>
<td>1.254</td>
<td>0.473</td>
<td>0.246</td>
</tr>
<tr>
<td>90</td>
<td>5.992</td>
<td>0.992</td>
<td>1.910</td>
<td>0.656</td>
<td>0.341</td>
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Table 3. Genetic covariances between traits in the API breeding objective and selection criteria.

<table>
<thead>
<tr>
<th></th>
<th>MWT</th>
<th>WW(m)</th>
<th>FERT</th>
<th>SURV</th>
<th>WW(d)</th>
<th>ADG</th>
<th>FI</th>
<th>DP</th>
<th>YG</th>
<th>MRB</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAY</td>
<td>-278.50</td>
<td>-22.10</td>
<td>290.170</td>
<td>53.700</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.550</td>
<td>-1.470</td>
</tr>
<tr>
<td>BWT</td>
<td>290.80</td>
<td>-21.53</td>
<td>-12.400</td>
<td>-22.968</td>
<td>96.549</td>
<td>0.325</td>
<td>3.275</td>
<td>-0.864</td>
<td>-0.118</td>
<td>0.000</td>
</tr>
<tr>
<td>CE(d)</td>
<td>-245.78</td>
<td>-55.50</td>
<td>64.000</td>
<td>88.814</td>
<td>-76.192</td>
<td>-0.524</td>
<td>-1.299</td>
<td>0.000</td>
<td>-0.305</td>
<td>0.405</td>
</tr>
<tr>
<td>CE(m)</td>
<td>248.93</td>
<td>-18.74</td>
<td>129.700</td>
<td>77.959</td>
<td>128.615</td>
<td>0.531</td>
<td>1.316</td>
<td>0.000</td>
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<td>-0.410</td>
</tr>
<tr>
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<td>1667.29</td>
<td>-247.16</td>
<td>0.000</td>
<td>0.000</td>
<td>1060.200</td>
<td>2.789</td>
<td>18.166</td>
<td>6.816</td>
<td>-2.547</td>
<td>-2.538</td>
</tr>
<tr>
<td>WW(m)</td>
<td>-186.87</td>
<td>562.70</td>
<td>-48.700</td>
<td>0.000</td>
<td>-247.162</td>
<td>-0.080</td>
<td>1.975</td>
<td>0.000</td>
<td>0.000</td>
<td>1.233</td>
</tr>
<tr>
<td>YW</td>
<td>2648.38</td>
<td>-257.64</td>
<td>0.000</td>
<td>0.000</td>
<td>1498.807</td>
<td>7.296</td>
<td>33.593</td>
<td>8.859</td>
<td>-5.058</td>
<td>-5.380</td>
</tr>
<tr>
<td>YG</td>
<td>-7.70</td>
<td>0.00</td>
<td>-0.800</td>
<td>0.000</td>
<td>-2.547</td>
<td>-0.007</td>
<td>-0.080</td>
<td>0.037</td>
<td>0.153</td>
<td>0.041</td>
</tr>
<tr>
<td>MRB</td>
<td>-10.24</td>
<td>1.230</td>
<td>-2.130</td>
<td>0.000</td>
<td>-2.537</td>
<td>0.009</td>
<td>0.043</td>
<td>0.079</td>
<td>0.041</td>
<td>0.270</td>
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</table>
Table 4. Genetic variances and covariances among traits in the API selection criteria.

<table>
<thead>
<tr>
<th>Trait</th>
<th>STAY</th>
<th>BWT</th>
<th>CE(d)</th>
<th>CE(m)</th>
<th>WW(d)</th>
<th>WW(m)</th>
<th>YW</th>
<th>YG</th>
<th>MRB</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAY</td>
<td>200.00</td>
<td>-8.60</td>
<td>44.10</td>
<td>89.40</td>
<td>0.00</td>
<td>-22.10</td>
<td>0.00</td>
<td>-0.55</td>
<td>-1.47</td>
</tr>
<tr>
<td>BWT</td>
<td>-8.60</td>
<td>36.62</td>
<td>-38.70</td>
<td>13.38</td>
<td>96.54</td>
<td>-21.53</td>
<td>147.10</td>
<td>-0.11</td>
<td>0.00</td>
</tr>
<tr>
<td>CE(d)</td>
<td>44.10</td>
<td>-38.70</td>
<td>243.36</td>
<td>86.26</td>
<td>-76.19</td>
<td>-55.08</td>
<td>-80.68</td>
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<td>0.40</td>
</tr>
<tr>
<td>CE(m)</td>
<td>89.40</td>
<td>13.38</td>
<td>86.26</td>
<td>249.64</td>
<td>128.61</td>
<td>-18.74</td>
<td>245.15</td>
<td>-0.30</td>
<td>-0.41</td>
</tr>
<tr>
<td>WW(d)</td>
<td>0.00</td>
<td>96.54</td>
<td>-76.19</td>
<td>128.61</td>
<td>1060.20</td>
<td>-247.16</td>
<td>1498.80</td>
<td>-2.54</td>
<td>-2.53</td>
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<tr>
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<td>-22.10</td>
<td>-21.53</td>
<td>55.50</td>
<td>-18.74</td>
<td>-247.16</td>
<td>562.70</td>
<td>-257.64</td>
<td>0.00</td>
<td>1.23</td>
</tr>
<tr>
<td>YW</td>
<td>0.00</td>
<td>147.10</td>
<td>-80.68</td>
<td>245.15</td>
<td>1498.80</td>
<td>-257.64</td>
<td>2675.00</td>
<td>-5.05</td>
<td>-5.37</td>
</tr>
<tr>
<td>YG</td>
<td>-0.55</td>
<td>-0.11</td>
<td>0.406</td>
<td>-0.11</td>
<td>-0.30</td>
<td>-2.54</td>
<td>0.00</td>
<td>-0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>MRB</td>
<td>-1.47</td>
<td>0.00</td>
<td>-0.41</td>
<td>1.233</td>
<td>-5.37</td>
<td>0.041</td>
<td>0.270</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Description of trait abbreviations listed in Table 1 and 2.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG</td>
<td>Average Daily Gain</td>
</tr>
<tr>
<td>BWT</td>
<td>Birth Weight</td>
</tr>
<tr>
<td>CE(d)</td>
<td>Calving Ease - Direct</td>
</tr>
<tr>
<td>CE(m)</td>
<td>Calving Ease - Maternal</td>
</tr>
<tr>
<td>DP</td>
<td>Dressing Percentage</td>
</tr>
<tr>
<td>FERT</td>
<td>Fertility</td>
</tr>
<tr>
<td>FI</td>
<td>Feed Intake</td>
</tr>
<tr>
<td>MRB</td>
<td>Marbling Score</td>
</tr>
<tr>
<td>MWT</td>
<td>Mature Cow Weight</td>
</tr>
<tr>
<td>STAY</td>
<td>Stayability</td>
</tr>
<tr>
<td>SURV</td>
<td>Survival at Birth</td>
</tr>
<tr>
<td>WW(d)</td>
<td>Weaning Weight - Direct</td>
</tr>
<tr>
<td>WW(m)</td>
<td>Weaning Weight - Maternal</td>
</tr>
<tr>
<td>YG</td>
<td>Yield Grade</td>
</tr>
<tr>
<td>YW</td>
<td>Yearling Weight</td>
</tr>
</tbody>
</table>

Table 6. Additive genetic correlations between traits in API breeding objective and selection criteria.

<table>
<thead>
<tr>
<th>Trait</th>
<th>MWT</th>
<th>WW(m)</th>
<th>FERT</th>
<th>SURV</th>
<th>WW(d)</th>
<th>ADG</th>
<th>FI</th>
<th>DP</th>
<th>YG</th>
<th>MRB</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAY</td>
<td>0.25</td>
<td>-0.10</td>
<td>1.00</td>
<td>0.50</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.20</td>
</tr>
<tr>
<td>BWT</td>
<td>0.61</td>
<td>-0.15</td>
<td>-0.10</td>
<td>-0.50</td>
<td>0.49</td>
<td>0.32</td>
<td>0.65</td>
<td>-0.15</td>
<td>-0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>CE(d)</td>
<td>-0.20</td>
<td>-0.15</td>
<td>0.20</td>
<td>0.75</td>
<td>-0.15</td>
<td>-0.20</td>
<td>-0.10</td>
<td>0.00</td>
<td>-0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>CE(m)</td>
<td>0.20</td>
<td>-0.05</td>
<td>0.40</td>
<td>0.65</td>
<td>0.25</td>
<td>0.20</td>
<td>0.10</td>
<td>0.00</td>
<td>-0.05</td>
<td>-0.05</td>
</tr>
<tr>
<td>WW(d)</td>
<td>0.65</td>
<td>-0.32</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.51</td>
<td>0.67</td>
<td>0.22</td>
<td>-0.20</td>
<td>-0.15</td>
</tr>
<tr>
<td>WW(m)</td>
<td>-0.10</td>
<td>1.00</td>
<td>-0.10</td>
<td>0.00</td>
<td>-0.30</td>
<td>-0.02</td>
<td>0.10</td>
<td>0.00</td>
<td>0.00</td>
<td>0.10</td>
</tr>
<tr>
<td>YW</td>
<td>0.65</td>
<td>-0.21</td>
<td>0.00</td>
<td>0.00</td>
<td>0.90</td>
<td>0.84</td>
<td>0.78</td>
<td>0.18</td>
<td>-0.25</td>
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</tr>
<tr>
<td>YG</td>
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<td>0.00</td>
<td>-0.15</td>
<td>0.00</td>
<td>-0.20</td>
<td>-0.10</td>
<td>0.25</td>
<td>0.10</td>
<td>1.00</td>
<td>0.20</td>
</tr>
<tr>
<td>MRB</td>
<td>-0.25</td>
<td>0.10</td>
<td>-0.20</td>
<td>0.00</td>
<td>-0.15</td>
<td>0.10</td>
<td>0.10</td>
<td>0.16</td>
<td>0.20</td>
<td>1.00</td>
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</table>
Table 7. Additive genetic correlations between traits in API selection criteria.

<table>
<thead>
<tr>
<th></th>
<th>STAY</th>
<th>BWT</th>
<th>CE(d)</th>
<th>CE(m)</th>
<th>WW(d)</th>
<th>WW(m)</th>
<th>YW</th>
<th>YG</th>
<th>MRB</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAY</td>
<td>1</td>
<td>-0.10</td>
<td>0.20</td>
<td>0.40</td>
<td>0.00</td>
<td>-0.10</td>
<td>0.00</td>
<td>-0.10</td>
<td>-0.20</td>
</tr>
<tr>
<td>BWT</td>
<td>1</td>
<td>-0.41</td>
<td>0.14</td>
<td>0.50</td>
<td>-0.15</td>
<td>0.47</td>
<td>-0.05</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>CE(d)</td>
<td>1</td>
<td>0.35</td>
<td>-0.15</td>
<td>-0.15</td>
<td>-0.10</td>
<td>-0.05</td>
<td>-0.05</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>CE(m)</td>
<td>1</td>
<td>0.25</td>
<td>-0.05</td>
<td>0.30</td>
<td>-0.05</td>
<td>-0.05</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>WW(d)</td>
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<td>-0.32</td>
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<td>-0.20</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>WW(m)</td>
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<td>0.00</td>
<td>0.10</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>YW</td>
<td>1</td>
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<td>-0.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YG</td>
<td>1</td>
<td></td>
<td></td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Coefficients for genetic regression of traits in API breeding objective on traits in API selection criteria.

<table>
<thead>
<tr>
<th></th>
<th>MWT</th>
<th>WW(m)</th>
<th>FERT</th>
<th>SURV</th>
<th>WW(d)</th>
<th>ADG</th>
<th>FI</th>
<th>DP</th>
<th>YG</th>
<th>MRB</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAY</td>
<td>-1.834500</td>
<td>-0.000099</td>
<td>1.446400</td>
<td>0.115030</td>
<td>0.000000</td>
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<td>0.012278</td>
<td>0.003941</td>
<td>0.000000</td>
<td>-0.000003</td>
</tr>
<tr>
<td>BWT</td>
<td>5.047000</td>
<td>0.000157</td>
<td>-0.022796</td>
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<td>0.000000</td>
<td>-0.004221</td>
<td>0.075473</td>
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<td>-0.000005</td>
</tr>
<tr>
<td>CE(d)</td>
<td>0.281410</td>
<td>0.000666</td>
<td>-0.019023</td>
<td>0.205890</td>
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<td>-0.003102</td>
<td>0.017828</td>
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<td>CE(m)</td>
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<td>1.000000</td>
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<td>-0.000846</td>
<td>0.011349</td>
<td>0.000000</td>
<td>0.000008</td>
</tr>
<tr>
<td>WW(m)</td>
<td>0.332320</td>
<td>1.000000</td>
<td>-0.037740</td>
<td>0.036363</td>
<td>0.000000</td>
<td>-0.000591</td>
<td>0.012739</td>
<td>0.002234</td>
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</tr>
<tr>
<td>YW</td>
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<td>-0.000048</td>
<td>0.006538</td>
<td>-0.024068</td>
<td>0.000000</td>
<td>0.006856</td>
<td>0.013061</td>
<td>0.002258</td>
<td>0.000000</td>
<td>-0.000008</td>
</tr>
<tr>
<td>YG</td>
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<td>0.002428</td>
<td>-0.208800</td>
<td>1.317300</td>
<td>0.000000</td>
<td>0.037554</td>
<td>-0.110130</td>
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<tr>
<td>MRB</td>
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<td>0.623540</td>
<td>0.000000</td>
<td>0.115850</td>
<td>0.380140</td>
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Table 9. Coefficients for genetic regression among traits in API selection criteria.

<table>
<thead>
<tr>
<th></th>
<th>STAY</th>
<th>BWT</th>
<th>CE(d)</th>
<th>CE(m)</th>
<th>WW(d)</th>
<th>WW(m)</th>
<th>YW</th>
<th>YG</th>
<th>MRB</th>
</tr>
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<tbody>
<tr>
<td>STAY</td>
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<td>-0.234840</td>
<td>0.181210</td>
<td>0.358120</td>
<td>0.000000</td>
<td>-0.039275</td>
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</tr>
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<td>BWT</td>
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<td>0.053621</td>
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<td>0.054991</td>
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</tr>
<tr>
<td>CE(d)</td>
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<td>-0.071866</td>
<td>-0.098646</td>
<td>-0.030162</td>
<td>-1.993500</td>
<td>1.503700</td>
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<tr>
<td>CE(m)</td>
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<td>0.121310</td>
<td>-0.033304</td>
<td>0.091647</td>
<td>-2.019600</td>
<td>-1.522200</td>
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<tr>
<td>WW(d)</td>
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<td>-0.439240</td>
<td>0.560300</td>
<td>-16.647000</td>
<td>-9.396300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WW(m)</td>
<td>1</td>
<td>-0.096316</td>
<td>0.000000</td>
<td>4.566700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YW</td>
<td>1</td>
<td>-33.059000</td>
<td>-19.907000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YG</td>
<td>1</td>
<td>0.151850</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRB</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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Table 10. Predicted genetic response via multiple genetic regression for traits included in API breeding objective when marbling genetic merit is increased through selection.

<table>
<thead>
<tr>
<th></th>
<th>MWT</th>
<th>WW(m)</th>
<th>FERT</th>
<th>SURV</th>
<th>WW(d)</th>
<th>ADG</th>
<th>FL</th>
<th>DP</th>
<th>YG</th>
<th>MRB</th>
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<tr>
<td>-54.019</td>
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<td>2.006</td>
<td>1.000</td>
<td>0.147</td>
<td>0.380</td>
<td>0.701</td>
<td>1.000</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>-55.398</td>
<td>0.989</td>
<td>1.352</td>
<td>2.030</td>
<td>1.000</td>
<td>0.152</td>
<td>0.395</td>
<td>0.717</td>
<td>1.000</td>
<td>1.039</td>
<td></td>
</tr>
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<td>-56.876</td>
<td>0.989</td>
<td>1.360</td>
<td>2.057</td>
<td>1.000</td>
<td>0.156</td>
<td>0.411</td>
<td>0.734</td>
<td>1.000</td>
<td>1.081</td>
<td></td>
</tr>
<tr>
<td>-58.603</td>
<td>0.988</td>
<td>1.369</td>
<td>2.087</td>
<td>1.000</td>
<td>0.162</td>
<td>0.430</td>
<td>0.754</td>
<td>1.000</td>
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</tr>
<tr>
<td>-61.003</td>
<td>0.987</td>
<td>1.382</td>
<td>2.130</td>
<td>1.000</td>
<td>0.170</td>
<td>0.456</td>
<td>0.782</td>
<td>1.000</td>
<td>1.198</td>
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</table>

Table 11. Predicted genetic response via multiple genetic regression for traits included in API selection criteria when marbling genetic merit is increased through selection.

<table>
<thead>
<tr>
<th></th>
<th>STAY</th>
<th>BWT</th>
<th>CE(d)</th>
<th>CE(m)</th>
<th>WW(d)</th>
<th>WW(m)</th>
<th>YW</th>
<th>YG</th>
<th>MRB</th>
</tr>
</thead>
<tbody>
<tr>
<td>-7.774</td>
<td>0.231</td>
<td>0.655</td>
<td>-2.362</td>
<td>-24.922</td>
<td>5.470</td>
<td>-51.966</td>
<td>1.152</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>-7.987</td>
<td>0.231</td>
<td>0.714</td>
<td>-2.422</td>
<td>-25.291</td>
<td>5.649</td>
<td>-52.747</td>
<td>1.158</td>
<td>1.039</td>
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<tr>
<td>-8.216</td>
<td>0.231</td>
<td>0.777</td>
<td>-2.486</td>
<td>-25.685</td>
<td>5.841</td>
<td>-53.583</td>
<td>1.164</td>
<td>1.081</td>
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<tr>
<td>-8.483</td>
<td>0.231</td>
<td>0.851</td>
<td>-2.561</td>
<td>-26.147</td>
<td>6.065</td>
<td>-54.560</td>
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</tr>
<tr>
<td>-8.855</td>
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<td>6.377</td>
<td>-55.918</td>
<td>1.182</td>
<td>1.199</td>
<td></td>
</tr>
</tbody>
</table>

Table 12. Changes in Net Merit ($) for traits in API breeding objective associated with increases in marbling score to achieve varying levels of cattle grading % Choice and higher when two different selection indexes are considered.

<table>
<thead>
<tr>
<th>% Choice and Higher</th>
<th>Increase in Marbling Level</th>
<th>Change in Net Merit API 2006</th>
<th>Change in Net Merit API 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.000</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>60</td>
<td>0.196</td>
<td>$ 0.98</td>
<td>$ 8.63</td>
</tr>
<tr>
<td>70</td>
<td>0.406</td>
<td>$ 1.05</td>
<td>$ 9.25</td>
</tr>
<tr>
<td>80</td>
<td>0.652</td>
<td>$ 1.23</td>
<td>$ 10.81</td>
</tr>
<tr>
<td>90</td>
<td>0.992</td>
<td>$ 1.71</td>
<td>$ 15.01</td>
</tr>
<tr>
<td>40</td>
<td>0.992</td>
<td>$ 4.98</td>
<td>$ 43.70</td>
</tr>
</tbody>
</table>

Table 13. Changes in Net Merit ($) for traits in API selection criteria associated with increases in marbling score to achieve varying levels of cattle grading % Choice and higher when two different selection indexes are considered.

<table>
<thead>
<tr>
<th>% Choice and Higher</th>
<th>Increase in Marbling Level</th>
<th>Change in Net Merit API 2006</th>
<th>Change in Net Merit API 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.000</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>60</td>
<td>0.196</td>
<td>$ (0.60)</td>
<td>$ 6.18</td>
</tr>
<tr>
<td>70</td>
<td>0.406</td>
<td>$ (0.65)</td>
<td>$ 6.62</td>
</tr>
<tr>
<td>80</td>
<td>0.652</td>
<td>$ (0.75)</td>
<td>$ 7.74</td>
</tr>
<tr>
<td>90</td>
<td>0.992</td>
<td>$ (1.05)</td>
<td>$ 10.75</td>
</tr>
<tr>
<td>40</td>
<td>0.992</td>
<td>$ (3.05)</td>
<td>$ 31.29</td>
</tr>
</tbody>
</table>
Live Animal, Carcass, and End Product Committee

Robert Williams, Chair

BIF Guidelines for Teat and Udder Scoring in Beef Cattle
Lauren Hyde, North American Limousin Foundation

Ultrasound Then and Now
John Crouch, American Angus Association

The Value of Phenotypes
Dorian Garrick, Colorado State University
The Value of Phenotypes

Dorian Garrick
Department of Animal Sciences, Colorado State University, Fort Collins, CO 80523

Introduction

Most livestock breeders gain satisfaction from breeding, performance recording and selling seedstock animals. Not all livestock breeders rely on profits from the operation to support their lifestyle—for some it is a form of recreation. Such breeders may collect phenotypes simply for enjoyment and interest. However, the framework for this paper is limited to the business viewpoint of investing financial resources in the collection of phenotypes in order to achieve cost-effective genetic improvement. The approach that will be described applies to measurement of economically-relevant traits (e.g., carcass attributes), indicator traits (e.g., live animal ultrasound measures), on individuals of interest (e.g., potential sale bulls) or relatives (e.g., offspring in a progeny). In this context, characterization of DNA (or RNA) can mostly be considered in the same manner as a conventional phenotype.

Increasing Accuracy

In theory, collection of additional information cannot reduce the accuracy of evaluation. In this paper, accuracy is defined as the correlation between true and estimated genetic merit, rather than the related definition of accuracy used by BIF and routinely published on sire summaries. Some performance information will not contribute to an increase in accuracy. For example, information on characteristics that are not correlated to the trait or objective targeted for selection is of no value as is information collected in the absence of meaningful contemporaries. This can occur in several circumstances: when an animal has no contemporaries; or in the case of sires, when a contemporary group contains no offspring of other sires; or in threshold traits, when an entire contemporary group has the same observed score. Apart from these exceptions, collection of additional phenotypes provides an opportunity to purchase an increase in accuracy.

Increasing accuracy usually exhibits the phenomenon of diminishing returns—the higher the accuracy, the more expensive it is to achieve further increases. For example, in a progeny test, each additional progeny has a lesser impact on increasing accuracy, with accuracy approaching an asymptote of one.

Genetic Progress

Increasing accuracy does not in itself guarantee an increase in genetic progress. First, accuracy in relation to selection age must be considered. This will be further considered in following paragraphs. Provided selection is not delayed in order to collect more information and increase accuracy, gain will be increased if an objective basis is used for selection, whereby animals with highest index or EPD values are chosen as parents. It is important in practice that additional information is only used in the prediction of overall merit, and not also considered separately, as that practice can lead to reduced selection advance.

It must be recognized that a unit increase in accuracy will not, in livestock, typically lead to a unit increase in genetic gain per generation. This occurs because genetic gain is the result of more than just one pathway of selection. In the simplest selection scheme, gain depends upon the sum of genetic advance from selection of males to be sires and the selection advance of
females to be dams. In more realistic selection schemes, different strategies are used to select sires of sires than are used to select sires of dams and different strategies are used to select dams of sires compared to dams of dams. The influence on genetic gain of an increase in accuracy in one of these four pathways will be diluted by selection on the other three pathways. Furthermore, the benefit in terms of selection advance from an increase in accuracy will also depend upon the intensity of selection. It is the selection intensity in product with the accuracy that dictates the advance in any one pathway. Increasing accuracy will be more beneficial in paths with intense selection (e.g., sire pathways) than in paths with low selection intensity (e.g., dams to breed dams).

Accuracy can often be increased by delaying selection until more information on the individual of interest or its relatives is available. However, any increase in the average age of parents when offspring are born will erode the annual rate of genetic gain, unless the genetic advance per generation increases proportionately more than the generation intervals. For example, progeny testing can always be used to increase accuracy. The delay in waiting for progeny to be produced and measured is usually only beneficial in traits that have low heritability, are sex-limited, or can be measured with little impact on generation intervals.

Industry Structure

Increasing accuracy is seldom free, but may or may not be expensive. If increased accuracy results in faster genetic progress, then this should generate increased benefit. The value of benefit from genetic gain depends enormously on industry structure. In an unstructured industry, the benefit of genetic improvement might be limited to the increased performance of the herd subjected to selection. In the simplest two-tiered industry, the seedstock herd would incur the costs of collecting information, and the so-called commercial herd(s) that use sires from the seedstock sector would represent the major beneficiary. The relative size, in terms of breeding females, of the commercial vs. seedstock sector dictates the number of phenotypic expressions that enjoy improved performance in relation to the number of individuals that incur measurement costs. An industry with 1% breeding females in the seedstock sector will get much greater relative benefit from gain than an industry with 10% breeding females in the seedstock sector.

Livestock industries often have more than two tiers. More commonly, a multiplier tier makes up most of the seedstock sector, the nucleus that drives genetic gain being a small component. This adds further complexity as the value of increased information is quite different in nucleus compared to multiplier herds. Nucleus herds include those that produce sires of sires, whereas multiplier herds use outside sires bred in other herds. This further complicates the formal consideration of valuing the collection of phenotypic information.

An appropriately-structured industry can afford to pay more to increase accuracy than a poorly-structured industry. However, industry structure is not easy to quantify, nor does it usually come about by design, except in some vertically-integrated industries. The structure of the beef industry is the collective result of selection decisions in every seedstock and commercial herd.

Example Calculation

The above principles can be quantified by considering some scenario and evaluating the costs and benefits from different levels of information collection. However, creating such an example is problematic because so many assumptions must be made. Accordingly, the interested reader really needs to seek professional help in such analysis in their own circumstances. Factors that will alter the
outcome include: aspects of the breeding scheme (current selection accuracy, generation intervals, selection pathways and annual genetic gain), the industry structure (seedstock, multiplier, commercial), and economic factors (costs of measurement, value of benefits, transfer of benefits). The following scenario concerning selection for increased marbling is therefore designed for illustrative purposes, rather than attempting to represent a definitive analysis.

**Assumptions.** The goal is to increase carcass marbling in a vertically-integrated beef production system. The seedstock tier consists of a closed nucleus of 1,000 breeding females. Bulls are made available to the commercial sector as yearlings, where they are used as terminal sires in an extensive ranching system for an average of 3 years at a mating ratio of 1:20. Suppose the calving percentage in product with survival to sale is 90%. Each bull therefore sires $3 \times 20 \times 0.9 = 54$ harvested offspring over its lifetime. Note that this number is very sensitive to the number of offspring produced by each sire over its lifetime. In an intensive natural mating situation, each bull might easily produce 200 rather than 60 conceptions.

Suppose a unit change in marbling score increases carcass value by $10/cwt. If average carcass weights were 700 lb, the value of a one unit change in bull marbling EPD would be $54 \times 7 \times 10 = \$3,780$. Note this figure would be different in self-replacing herds for two reasons. First, less offspring would be harvested as some heifers would be retained as replacements. Second, the cow herd would annually increase in merit for marbling such that harvested offspring would exhibit twice the rate of improvement that would occur in a terminal sire system.

The seedstock herd of 1,000 cows might produce 450 bull calves at weaning each year. Suppose 200 of these are used as sires in the commercial sector. On average one sire produces $3,780 in additional carcass value (through a unit increase in marbling score) over its lifetime, therefore 200 bulls would generate $200 \times \$3,780 = \$756,000$ additional income per unit marbling. Assume these rewards are to be equally partitioned between the seedstock sector, cow-calf sector and feedlot/packer. This would generate added revenue of around $250,000 per unit marbling score for increased seedstock margin plus costs of phenotypic collection.

Suppose it costs $7 to measure carcass marbling and $20 to obtain parentage information in an outcross progeny test through a co-operating herd. It costs $25 to measure ultrasound IMF% in the seedstock herd as an indicator trait.

Suppose the bull breeding herd uses a team of 40 sires with just two pathways of selection. Bulls are used in the seedstock herd an average of two breeding seasons, with the best 20 bulls being selected each year from 450 available. This gives a selection proportion of $20/450 = 0.044$ with corresponding selection intensity of 2.1. The cows in the seedstock herd have an average generation interval of 5 years from a replacement rate of 20%, equivalent to a standardized selection differential of around 1.4. The bull generation interval will depend upon the selection strategy. In the case of ultrasound measures or genotypes, we will assume this could be achieved prior to mating the bulls as yearlings, so their first offspring would be born when the bulls are two yr old. If the bulls are used for two breeding seasons to provide good linkage across years, the average bull generation interval would be 2½ years. In the case of an outcross progeny test, yearling bulls would be used in an outside population, with offspring born when the bulls were two yr old. The bulls would be 3 yr old when the progeny test offspring were yearlings, and four yr old when the progeny test offspring had been harvested and the bulls ranked. The selected elite bulls would be five yr old when their first progeny were born in the bull breeding herd. If these
bulls are also used for two breeding seasons, the bull generation interval would be 5½ years.

Some possible selection scenarios are:

1. Measure carcass marbling on progeny test offspring of young bulls bred in the nucleus, prior to their selection in the bull breeding herd.
2. Measure ultrasound IMF% in all yearling males in the bull breeding herd.
3. Measure ultrasound IMF% in all offspring bred in the nucleus herd.
4. Genotype all young males in the bull breeding herd.
5. Genotype and measure IMF% on males in the bull breeding herd.

Many other possible scenarios are available, most notably two-stage options. For example, the first-stage might use ultrasound scanning on all bull calves and the second stage involve genotyping a subset of the bulls with the best EPDs predicted from the ultrasound data. Such two-stage scenarios will not be considered in this illustrative context.

Assume the heritability of carcass marbling is 0.54 and phenotypic and genetic s.d. are 0.88 and 0.65, respectively. The heritability of ultrasound IMF% is 0.50 and the genetic correlation with carcass marbling is 0.72.

**Genetic Gain in the Various Scenarios.** The annual rate of genetic gain can be computed from the following formula

\[ \Delta G = \frac{(r_{TI})_M + (r_{TI})_F}{L_M + L_F} \sigma_g, \]

where \( i \) are selection intensities, \( r_{TI} \) are selection accuracies, \( L \) are generation intervals, \( M \) and \( F \) subscripts refer to male and female selection, and \( \sigma_g \) is the genetic standard deviation of the objective.

**Scenario 1.** The rates of gain with progeny testing of five offspring from every young bull for carcass marbling are

\[ \Delta G = \frac{(2.1 \times 0.66)_M}{5.5 + 5} 0.65 = 0.09 \] marbling scores per year.

This gain increases to 0.11 or 0.13 scores per year when 20 or 100 offspring are measured per sire, demonstrating the diminishing returns from measuring additional offspring in a progeny test.

**Scenario 2.** The rates of gain using ultrasound measures on males alone are given by

\[ \Delta G = \frac{(2.1 \times 0.5)_M}{2.5 + 5} 0.65 = 0.09 \] marbling scores per year. Although the selection accuracy is reduced, the reduction in generation interval results in the same response as can be achieved by progeny testing with five offspring per bull.

**Scenario 3.** Faster gain can be achieved by scanning bulls and heifers.

\[ \Delta G = \frac{(2.1 \times 0.5)_M + (1.4 \times 0.5)_F}{2.5 + 5} 0.65 = 0.15 \] marbling scores per year.

**Scenario 4.** Genetic gain from DNA genotyping is sensitive to the proportion of genetic variation in marbling that can be accounted for by the markers. Given 10% variation accounted for by markers, the gains from bull selection alone would be

\[ \Delta G = \frac{(2.1 \times \sqrt{0.1})_M}{2.5 + 5} 0.65 = 0.06 \] marbling scores per year. The gain increases to 0.08, 0.13 or 0.18 for 20%, 50% or 100% variation accounted for by markers.

**Scenario 5.** Markers that account for less than 100% genetic variation provide opportunities to increase accuracy by collecting phenotypic as well as genotypic information. Either ultrasound IMF% or carcass marbling phenotypes would improve accuracy. Using
ultrasound and DNA on bulls with 10, 20 or 50% variation accounted for by markers gives gains of 0.11, 0.12 or 0.14 marbling scores per year.

The benefits of genetic change for a single crop of bulls can be assessed by multiplying the industry improvement from one year of selection by the number of sale bulls times the number of harvested offspring per bull. For example, a one-third share of the benefits from the lifetime use of one crop of bulls given a gain of 0.1 marbling scores is worth some $25,000. However, genetic gain is permanent, so one round of selection would result in all successive crops of bulls being better by an average of 0.1 marbling scores. In practice, discounting procedures should be used to discount a stream of future returns and derive the net present value of a particular selection scenario. Suppose we only value the benefit of say 5 successive crops of bulls, and ignore the discounting, the one-third share would be worth $125,000.

Now consider the costs of these selection strategies.

1. Progeny testing 450 bulls with \( n \) progeny per bull would cost \( 450 \times n \times (7 + 20) = 12,150n \).

2. Ultrasound scanning 450 bulls would cost \( 450 \times 25 = 11,250 \).


We can therefore summarize the consequences of the above selection scenarios in the following table (Table 1).

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Genetic gain</th>
<th>Share of revenue</th>
<th>Costs</th>
<th>Net²</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT ( n=5 )</td>
<td>0.09</td>
<td>$112,500</td>
<td>$60,750</td>
<td>$51,750</td>
</tr>
<tr>
<td>PT ( n=20 )</td>
<td>0.11</td>
<td>$137,500</td>
<td>$243,000</td>
<td>Loss</td>
</tr>
<tr>
<td>PT ( n=100 )</td>
<td>0.13</td>
<td>$162,500</td>
<td>$1,215,000</td>
<td>Loss</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Scenario 2</th>
<th>Genetic gain</th>
<th>Share of revenue</th>
<th>Costs</th>
<th>Net²</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMF% males</td>
<td>0.09</td>
<td>$112,500</td>
<td>$11,250</td>
<td>$101,250</td>
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</table>

<table>
<thead>
<tr>
<th>Scenario 3</th>
<th>Genetic gain</th>
<th>Share of revenue</th>
<th>Costs</th>
<th>Net²</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMF% both sexes</td>
<td>0.15</td>
<td>$187,500</td>
<td>$22,500</td>
<td>$165,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 4</th>
<th>Genetic gain</th>
<th>Share of revenue</th>
<th>Costs</th>
<th>Net²</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA 10</td>
<td>0.06</td>
<td>$75,000</td>
<td>Note³ ¹</td>
<td>Note 1</td>
</tr>
<tr>
<td>DNA 20</td>
<td>0.08</td>
<td>$100,000</td>
<td>Note 2</td>
<td>Note 2</td>
</tr>
<tr>
<td>DNA 50</td>
<td>0.13</td>
<td>$162,500</td>
<td>Note 3</td>
<td>Note 3</td>
</tr>
<tr>
<td>DNA 100</td>
<td>0.18</td>
<td>$225,000</td>
<td>Note 4</td>
<td>Note 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 5</th>
<th>Genetic gain</th>
<th>Share of revenue</th>
<th>Costs</th>
<th>Net²</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA 10 &amp; IMF%</td>
<td>0.11</td>
<td>$137,500</td>
<td>+$11,250</td>
<td>+$51,250²</td>
</tr>
<tr>
<td>DNA 20 &amp; IMF%</td>
<td>0.12</td>
<td>$150,000</td>
<td>+$11,250</td>
<td>+$38,750</td>
</tr>
<tr>
<td>DNA 50 &amp; IMF%</td>
<td>0.14</td>
<td>$175,000</td>
<td>+$11,250</td>
<td>+$1,250</td>
</tr>
</tbody>
</table>

¹Scenario 1 = Progeny testing \( n \) offspring of young bulls.

²Net = Revenue DNA & IMF% – Revenue DNA – IMF% Costs (e.g., +$51,250 = 137,500 – 75,000 – 11,250).

³See comments in text below.
Given these various (often unrealistic) assumptions, progeny testing is not worthwhile unless sire parentage is already known or being collected for other purposes and not a cost to the improvement program. Ultrasound scanning of both sexes is well worthwhile.

Note 1. Genotyping using markers that account for 10% variation in marbling, without any phenotypic measurement is less profitable than ultrasound scanning. Measuring IMF% as well as markers would cost an additional $11,250 but bring in an additional $51,250 net of scanning costs. In order for DNA 10 and IMF% to be more profitable than IMF% on bulls alone, the genotyping could not cost more than $25,000 for the 450 bulls or $55 per bull.

Note 2. If DNA accounted for 20% variation in marbling, the test would have to be free to compete with the gains achievable from ultrasound scanning. Nevertheless, measuring ultrasound IMF% would still increase the value of gain, less scanning costs by almost $40,000.

Note 3. A DNA test with 50% variation accounted for was not more profitable than measuring IMF% in both sexes.

Note 4. Genotyping procedures that accounted for 100% variation and only involved measuring bulls could earn $60,000 more than measuring IMF% in both sexes if there were no genotyping costs. The breakeven DNA genotyping cost would be $133 per test, at which point the benefits were the same as ultrasound scanning.

Conclusion

The valuation of alternative scenarios in terms of phenotypes requires a number of assumptions. Investment in the collection of additional phenotypes typically increases accuracy of evaluation and resulting genetic gain. However, the impact on net returns and therefore the role of each scenario must be considered analytically. In general, measurements on the individual are preferable to measurements on progeny because of the time delay associated with progeny testing. Furthermore, conventional phenotypes are typically cost-effective for nucleus breeders even in the presence of good DNA-based tests.
Selection Decisions Committee

Darrh Bullock, Chair

Feed Efficiency
Merlyn Nielsen, University of Nebraska

IGF-1 as an Indicator for Feed Efficiency
Gordon Carstens, Texas A&M University

Bull Marketing
Frank Padilla, North American Limousin Foundation

Temperament
Robert Weaber, University of Missouri
The Use of Insulin-like Growth Factor I (IGF-I) as an Indicator Trait in a Genetic Evaluation for Feed Efficiency

Gordon Carstens, Rod Hill, Tom Welsh, Mike Davis, John Pollak and Darrh Bullock

The objective of this paper is to provide an expert scientific recommendation to the U.S. Beef Industry, on the value of IGF-I as an indicator trait for residual feed intake (RFI) based upon current knowledge of the relationships between IGF-I and RFI in Bos taurus, Bos indicus and crossbred cattle.

It is recognized that feed intake and the efficiency of nutrient utilization are of great importance to the beef cattle industry and the development of a genetic evaluation for these traits is critical. The ratio of feed intake to gain (feed conversion ratio) has traditionally been used as a trait to evaluate feed efficiency in growing cattle, however, ratios are not suitable for use in selection programs. Residual feed intake has been proposed as a more desirable trait to use in breeding programs focused on improving feed efficiency. The rationale is that RFI addresses the biological efficiency of animals and that selection for RFI, growth and compositional traits can occur independently and simultaneously. Residual feed intake is defined as an animal’s actual feed intake minus its expected feed intake. Efficient animals are those that consume less feed than expected based on their size and growth rate.

We recognize that the cost of measuring feed intake continues to limit wide-spread implementation of selection programs that target feed efficiency. However, the accumulation of accurate feed intake phenotypic data in large numbers will be essential for successful implementation of objective breeding programs that focus on either feed consumption or efficiency. The concurrent use of genetic markers or physiological indicator traits that are predictive of RFI will help to reduce the cost of developing RFI as a useful feed efficiency trait. It has been proposed that the hormone IGF-I can be a useful indicator trait for RFI. Additionally, there is a commercially available test for measuring IGF-I levels in cattle.

Blood or serum insulin-like growth factor I (IGF-I) has been shown to be genetically correlated with RFI, in Bos taurus cattle, suggesting that this hormone may be a useful indicator trait for RFI. Moreover, the genetic evaluation program for beef cattle in Australia currently uses IGF-I measurements, along with RFI phenotypic data, to generate estimated breeding values for RFI. However, studies involving Bos indicus and crossbred cattle both in the U.S. and Australia have shown that the relationship between RFI and IGF-I observed in Bos taurus cattle is not always consistent across breedtypes. It is important to note that even in Bos taurus cattle, IGF-I accounts for about 35% of the genetic variation in RFI. Thus, 65% of the variation in RFI appears to be unrelated to IGF-I. Recent work in Australia has also shown lower correlations between IGF-1 and RFI than reported earlier and there seems to be indications of an age of calf fed by test result interaction. Additionally, research has indicated there are possible unfavorable relationships between IGF-I and other economically relevant traits (e.g., marbling, reproduction traits) and further research is warranted to fully understand possible genetic antagonisms to the use of IGF-I as an indicator trait for RFI.

Based on our current assessment of available information, it is our opinion that circulating IGF-I should not be used as an indicator trait for RFI in genetic evaluation programs at this time. However, we do recommend that additional research be conducted.

1 The authors would like to acknowledge and thank Bovigen for sponsoring the Feed Efficiency Symposium and Merial for hosting the workshop that led to the development of this position paper.
to further evaluate genetic and phenotypic relationships between circulating IGF-I (and IGF-I binding proteins) and RFI in diverse breedtypes, and that genetic relationships between IGF-I and growth, product quality and reproductive traits in beef cattle be fully evaluated.
Genetic Prediction Committee

Mark Thallman, Chair

Report of the Subcommittee on Standardization of EPDs for Carcass Traits
Dan Moser, Kansas State University

Genetic Evaluation of Beef Carcass Data Using Different Endpoint Adjustments
Janice Rumph, Montana State University

Standardization of Reporting DNA Test Results
John Pollak, Cornell University

Update on a Prototype Multi-Breed National Cattle Evaluation
Keith Bertrand, University of Georgia

Across-Breed EPD Tables for the Year 2007 Adjusted to Breed Differences for Birth Year of 2005
Larry Kuehn, USDA MARC
GENETIC EVALUATION OF BEEF CARCASS DATA USING DIFFERENT ENDPOINT ADJUSTMENTS


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INTRODUCTION

Estimation of EPD for carcass traits provides cattle breeders with a selection tool for improving carcass traits in breeding animals and their commercial offspring. However, accurate estimation of these values is necessary to make them a useful tool. Currently in the U.S. national cattle evaluation system, carcass trait EPD are calculated at a constant age endpoint; but timing of harvest is usually based on endpoints other than age, such as backfat thickness, marbling score, or carcass weight, or combinations thereof, in an attempt to maximize profitability by minimizing discounts and increasing premiums. Therefore, age may not be the most appropriate adjustment when calculating carcass EPD.

When alternative endpoints are chosen for EPD, reranking of sires is of particular concern because reranking may be indicative of the trait evaluated being changed when the endpoint is changed. Previous studies have suggested that endpoint may affect ranking of sires (i.e., Koch et al., 1995; Shanks et al., 2001; Ríos-Utrera, 2005), which suggests that if the industry does not harvest animals at a constant age, sires are potentially being ranked incorrectly using current industry standard age adjusted endpoints. Therefore, the objective of the current study was to determine if sire reranking occurs when alternate end points are used.

MATERIALS AND METHODS

Data for this project were made available by the American Simmental Association. Summary statistics are provided in Table 1. Traits measured included 12th rib backfat thickness (FAT, n = 6,546), hot carcass weight (HCW, n = 6,795), marbling score (MRB, n = 6,368), longissimus muscle area (LMA, n = 6,728), and percent retail cuts (PRC, n = 5,983). All measurements were collected via USDA graders with PRC being calculated from the component traits of HCW, LMA, and FAT. Percent kidney, pelvic, and heart fat (KPH) measurements were not recorded in this data set and were assumed to be 2.5% for all carcasses. These values were used to calculate PRC = 51.34 – (2.276 x FAT, cm) – (0.0205 x HCW, kg) – (0.462 x KPH, %) + (0.1147 x LMA, cm²) (Boggs et al., 1998).
Data for each trait were adjusted to each of four endpoints: age (EPA), backfat (EPF), hot carcass weight (EPC), or marbling (EPM). Adjustments were made by fitting a linear and quadratic covariate for the chosen endpoint. For HCW, MRB, and FAT, heritability estimates were not undertaken when the adjustment was the trait itself. For instance, heritability of HCW was not estimated in a model adjusting for HCW endpoint.

RESULTS AND DISCUSSION

Estimates of heritability for each trait adjusted to each endpoint are shown in Table 2. With the exception of PRC, estimates of heritability within a trait were similar regardless of endpoint chosen, which is in agreement with results from Bergen et al. (2006a, 2006b) and with the review of carcass analyses by Utrera and Van Vleck (2004). However, estimates were smaller than those typically found for carcass traits using field data (i.e., Wilson et al., 1993; Hirooka et al., 1996; Pariacote et al., 1998). Estimates were 0.12 to 0.14, 0.32 to 0.34, 0.26 to 0.27, and 0.27 for FAT, HCW, LMA, and MRB, respectively. For PRC, the heritability estimate of 0.32 using EPF was significantly larger than heritabilities estimated using the other three endpoints (0.20 to 0.23).

For FAT, HCW, and MRB, there was little difference in ranking of sires when the endpoints were changed. There were moderate differences in ranking for LMA, however, particularly when comparing EPA to EPC as shown in Figure 1. The lower correlation between EPA and EPC is likely due to the fact that these are positively correlated traits (Crews and Kemp, 2001) and adjusting LMA for HCW decreases the genetic variability in LMA, which is in agreement with results shown by Lee et al. (2000). It appears that this adjustment results in an altered definition of LMA EPD that likely does not reflect industry practices.

Table 2. Estimates of heritability for five carcass traits\(^1\) adjusted to four different endpoints\(^2\)

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>FAT (\pm)</th>
<th>HCW (\pm)</th>
<th>MRB (\pm)</th>
<th>LMA (\pm)</th>
<th>PRC (\pm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA</td>
<td>0.13 ± 0.03</td>
<td>0.33 ± 0.05</td>
<td>0.27 ± 0.04</td>
<td>0.26 ± 0.05</td>
<td>0.23 ± 0.05</td>
</tr>
<tr>
<td>EPF</td>
<td>0.14 ± 0.04</td>
<td>0.34 ± 0.05</td>
<td>0.27 ± 0.04</td>
<td>0.26 ± 0.05</td>
<td>0.32 ± 0.05</td>
</tr>
<tr>
<td>EPC</td>
<td>0.12 ± 0.03</td>
<td>0.32 ± 0.05</td>
<td>0.27 ± 0.04</td>
<td>0.27 ± 0.05</td>
<td>0.21 ± 0.05</td>
</tr>
<tr>
<td>EPM</td>
<td>0.14 ± 0.04</td>
<td>0.34 ± 0.05</td>
<td>0.27 ± 0.04</td>
<td>0.26 ± 0.05</td>
<td>0.20 ± 0.04</td>
</tr>
</tbody>
</table>

\(^1\) FAT = fat thickness; HCW = hot carcass weight; MRB = marbling; LMA = longissimus muscle area; PRC = percent retail cuts

\(^2\) EPA = age endpoint; EPF = fat thickness endpoint; EPC = carcass weight endpoint; EPM = marbling endpoint
Figure 1. Rank of high accuracy bulls for longissimus muscle area at an age endpoint (EPA) compared to alternative endpoints. (a) Backfat thickness (EPF), (b) hot carcass weight (EPC), and (c) marling score (EPM) endpoints.

In Figure 1a, the ranking of the 100 highest accuracy sires for LMA using EPA and EPF is shown. Ranking is very similar between these two endpoints. However, as shown in Figure 1b, there is a greater amount of reranking when comparing EPA and EPC. As discussed previously, EPC does result in more reranking than other endpoints and likely should not be used for calculation of national cattle evaluations. In Figure 1c, the comparison of EPA and EPM is shown to result in little reranking among these high accuracy sires.

Although there was reranking for LMA, it was not as extreme as what was found in PRC. Because FAT, HCW, and LMA are all component traits of PRC, adjusting for FAT essentially eliminated the effect of that trait in the PRC calculation. This adjustment, in turn, changes the PRC from a trait partially influenced by backfat to a trait solely dependent on HCW and LMA and whose meaning is different than the original concept of PRC. This is supported by the fact that the estimate of heritability was similar to those obtained for HCW at all endpoints.

Unlike the other traits, PRC was sensitive to endpoint adjustment. Compared to EPA, estimates of genetic variance were 65%, 84%, and 82% for EPF, EPC, and EPM, respectively. Although all adjustments relative to EPA resulted in reduced genetic variance, the adjustment for EPF was of most concern with the adjustment removing more than one third of the genetic variation. This is similar, but more extreme than the reduction by 16% found by Devitt and Wilton (2001). The reduction is partially due to FAT being a component trait of PRC. The reduction in genetic variation using EPC is also due to the fact that HCW is a component trait of PRC, although the reduction seen using this adjustment is not as extreme as for EPF.

Spearman rank correlations were 0.73 (P < 0.01), 0.93 (P < 0.01), and 0.95 (P < 0.01) for
EPF, EPC, and EPM, respectively. Although all three endpoints result in decreased genetic variance relative to EPA, rankings were similar for EPC and EPM. The much lower correlation of 0.73 indicates that adjustment for FAT produces a change in the defined trait likely due to the fact that FAT is a component trait for PRC and the EPF is altering the trait so that it can no longer be considered PRC. Although both HCW and FAT are component traits of PRC, the difference when adjusting to EPC is not as extreme as when adjusting to EPF, compared with the traditional EPA. This difference may be explained by the increased coefficient of variation seen in the FAT vs. HCW phenotypes used to calculate PRC. The coefficient of variation for FAT is 41.3% and for HCW is 11.6%. Therefore there is greater chance of change in FAT than in HCW within the PRC equation.

Figure 2 depicts the ranking of high accuracy sires for PRC using EPA compared to EPF, EPC, and EPM. Reranking among these high accuracy sires is the greatest in PRC, particularly using EPF in support of the Spearman rank correlations calculated using all animals in the pedigree.

For FAT, HCW, LMA, and MRB, endpoint does not appear to influence sire rank, so EPD calculated to EPA, EPF, EPC, and EPM should essentially result in similar outcomes regardless of the endpoint used to decide harvest date. Choice of endpoint would be a concern for PRC as the EPF significantly reranks sires relative to the current EPA adjustment. Further investigation is necessary to determine which adjustment is most predictive of PRC based on the way cattle are currently slaughtered in the United States.

**Implications**

For most traits, there is little reranking of sires when evaluated at alternate endpoints.
However, endpoint has a large effect on the ranking of sires for percent retail cuts and longissimus muscle area. Adjusting percent retail cuts for backfat and longissimus muscle for carcass weight appears to change the definition of these traits. It has been shown that the these traits rerank sires across varying endpoints, but it is unclear as to which endpoint is the most predictive of future progeny performance. Further investigation is needed to determine whether these alternative endpoints result in a more predictive estimate of expected progeny differences than the traditional age endpoint.

**Literature Cited**


Introduction

This report is the year 2007 update of estimates of sire breed means from data of the Germplasm Evaluation (GPE) project at the U.S. Meat Animal Research Center (USMARC) adjusted to a year 2005 base using EPD from the most recent national cattle evaluations. Factors to adjust EPD of 16 breeds to a common birth year of 2005 were calculated and are reported in Tables 1-3 for birth weight (BWT), weaning weight (WWT), and yearling weight (YWT) and in Table 4 for the maternal milk (MILK) component of maternal weaning weight (MWWT).

There were a few data changes and one important procedural change from the 2006 update (Van Vleck and Cundiff, 2006):

Records from USMARC for birth, weaning, and yearling weight were added for seven breeds (Hereford, Angus, Simmental, Limousin, Charolais, Gelbvieh, and Red Angus) from repeated use of sires from GPE Cycle VII in 2006. These additional records caused some small changes in the breed of sire solutions for these breeds relative to the other breeds in the analysis. Maine-Anjou EPD were derived in a multi-breed analysis with Simmental causing the EPD of the sires used at USMARC to shift slightly.

Maternal records continued to be added this year for Hereford and Angus (about 135 records); Simmental, Limousin, Charolais, Gelbvieh, and Red Angus (about 80 records); and for Brangus and Beefmaster (about 40 records). Numbers for Brangus and Beefmaster reflect an increase in records of about 40%.

One procedural change was incorporated into the adjustment factor derivation this year. In past across breed analyses for growth traits, the breed of sire solution (Mi) adjusted for base year has been calculated by scaling the difference between the average EPD of sires used at USMARC (EPD(i)USMARC) and the breed average EPD for the base year (EPD(i)YY) by the regression coefficient of progeny performance on EPD of sire (b) and then adding the USMARC breed of sire solution (USMARC(i)):

$$M_i = \frac{USMARC(i)}{b} + [EPD(i)_{YY} - EPD(i)_{USMARC}]$$

This solution can be thought of as the breed of sire solution adjusted to year YY on a USMARC scale. In the past, it had been added to a function of the breed average EPD to derive the across breed adjustment factor. However, these breed average EPD are on an industry scale. Therefore, this year, the breed of sire solution was divided by the regression coefficient (b) to put it on an industry, rather than a USMARC scale. By dividing the equation by b, the breed of sire solution (M_i) is now:

$$M_i = \frac{USMARC(i)}{b} + [EPD(i)_{YY} - EPD(i)_{USMARC}]$$

This methodology change does cause all of the adjustment factors and breed of sire solutions...
adjusted for year to change more this year than they have in the past from year to year. However, we feel this procedure more closely represents the breed differences on an industry basis. A similar change was also made for deriving the MILK adjustment factors. These scaling adjustments are similar to those used to adjust USMARC carcass differences to a common base in Van Vleck et al. (2007).

The across-breed table adjustments apply only to EPDs for most recent (in most cases; spring, 2007) national cattle evaluations. Serious biases can occur if the table adjustments are used with earlier EPDs which may have been calculated with a different within-breed base.

Materials and Methods

Adjustment for heterosis

The philosophy underlying the calculations has been that bulls compared using the across-breed adjustment factors will be used in a crossbreeding situation. Thus, calves and cows would generally exhibit 100% of both direct and maternal heterosis for the MILK analysis and 100% of direct heterosis for the BWT, WWT, and YWT analyses. The use of the MARC III composite (1/4 each of Pinzgauer, Red Poll, Hereford, and Angus) as a dam breed for Angus, Brangus, Hereford and Red Angus sires requires a small adjustment for level of heterozygosity for analyses of calves for BWT, WWT, and YWT and for cows for maternal weaning weight. Some sires (all multiple sire pasture mated) mated to the F1 cows are also crossbred so that adjustment for direct heterosis for the maternal analysis is required. Two approaches for accounting for differences in breed heterozygosity have been tried which resulted in similar final table adjustments. One approach was to include level of heterozygosity in the statistical models which essentially adjust to a basis of no heterozygosity. The other approach was based on the original logic that bulls will be mated to another breed or line of dam so that progeny will exhibit 100% heterozygosity. Most of the lack of heterozygosity in the data results from homozygosity of Hereford or Angus genes from pure Hereford or Angus matings and also from Red Angus by Angus and from Hereford, Angus or Red Angus sires mated with MARC III composite dams. Consequently, the second approach was followed with estimates of heterosis obtained from analyses of BWT, WWT, YWT, and MWWT using only records from the imbedded diallel experiments with Hereford and Angus. Red Angus by Angus matings were assumed not to result in heterosis. With Brangus representing 5/8 and 3/8 inheritance from Angus and Brahman genes, records of Brangus sired calves were also adjusted to a full F1 basis when dams were Angus cows and MARC III cows (1/4 Angus). The adjustment for calves with Beefmaster (1/2 Brahman, 1/4 Shorthorn, 1/4 Hereford) sires was only when dams were MARC III cows (1/4 Hereford) as Beefmaster sires were not mated to Hereford cows.

The steps were:

1) Analyze records from Hereford-Angus (H-A) diallel experiments to estimate direct heterosis effects for BWT, WWT, YWT (1,326, 1,279, and 1,249 records for BWT, WWT, and YWT, respectively, representing 152 sires). The H-A diallel experiments were conducted as part of Cycle I (1970-1972 calf crops), Cycle II (1973-1974), Cycle IV (1986-1990) and Cycle VII (1999-2001) of the GPE program at USMARC.

2) Adjust maternal weaning weight (MWWT) records of calves of the Hereford and Angus cows from the diallel for estimates of direct heterosis from Step 1) and then estimate maternal heterosis effects from 2,448 weaning weight records of 532 daughters representing 128 Hereford and Angus maternal grandsires.

3) Adjust all records used for analyses of BWT, WWT, and YWT for lack of direct
heterozygosity using estimates from Step 1), and
4) Adjust all records used for analysis of MWWT for lack of both direct and maternal heterozygosity using estimates from Steps 1) and 2).

Models for the analyses to estimate heterosis were the same as for the across-breed analyses with the obvious changes in breed of sire and breed of dam effects. Estimates of direct heterosis were 3.01, 14.70, and 30.39 lb for BWT, WWT, and YWT, respectively. The estimate of maternal heterosis was 23.37 lb for MWWT. As an example of step 3), birth weight of a Hereford by Hereford calf would have 3.01 added. A Red Angus by MARC III calf would have \( \frac{1}{4} \) (3.01) added to its birth weight. A Red Poll sired calf of an Angus by MARC III dam would have \( \frac{1}{8} \) (14.70) plus \( \frac{1}{4} \) (23.37) added to its weaning weight record to adjust to 100% heterozygosity for both direct and maternal components of weaning weight.

After these adjustments, all calculations were as outlined in the 1996 BIF Guidelines. The basic steps were given by Notter and Cundiff (1991) with refinements by Núñez-Dominguez et al. (1993), Cundiff (1993, 1994), Barkhouse et al. (1994, 1995), and Van Vleck and Cundiff (1997–2006). All calculations were done with programs written in Fortran language with estimates of variance components, regression coefficients, and breed effects obtained using the MTDFREML package (Boldman et al., 1995). All breed solutions are reported as differences from Angus. The table values of adjustment factors to add to within-breed EPD are relative to Angus.

**Models for Analysis of USMARC Records**

Fixed effects in the models for BWT, WWT (205-d), and YWT (365-d) were: breed of sire (17 including Pinzgauer); dam line (Hereford, Angus, selection lines of Herefords, MARC III composite) by sex (female, male) by age of dam (2, 3, 4, 5-9, ≥10 yr) combination (49), year of birth by GPE cycle (25), year of dam by damline combination (109), and a separate covariate for day of year at birth of calf for each of the three breeds of dam. Cows from the Hereford selection lines (Koch et al., 1994) were used in Cycle IV of GPE. To account for differences from the original Hereford cows, Hereford dams were subdivided into the selection lines and others. That refinement of the model had little effect on breed of sire solutions. Dam of calf was included as a random effect to account for correlated maternal effects for cows with more than one calf (4,902 dams for BWT, 4,656 for WWT, 4,488 for YWT). For estimation of variance components and to estimate breed of sire effects, sire of calf was also used as a random effect (650).

Variance components were estimated with a derivative-free REML algorithm. At convergence, the breed of sire solutions were obtained as were the sampling variances of the estimates to use in constructing prediction error variances for pairs of bulls of different breeds.

For estimation of coefficients of regression of progeny performance on EPD of sire the random sire effect was dropped from the model. Pooled regression coefficients, and regression coefficients by sire breed, by dam line, and by sex of calf were obtained. These regression coefficients are monitored as accuracy checks and for possible genetic by environment interactions. The pooled regression coefficients were used as described in the next section to adjust for genetic trend and bulls used at USMARC.

The fixed effects for the analysis of maternal effects included breed of maternal grandsire (17 including Pinzgauer), maternal grand dam line (Hereford, Angus, MARC III), breed of natural service mating sire (28), sex of calf (2), birth year-GPE cycle-age of dam subclass (93), and mating sire breed by GPE cycle by age of dam subclass (80) with a covariate for day of year of
birth. The subclasses are used to account for confounding of years, mating sire breeds, and ages of dams. Age of dam classes were 2, 3, 4, 5-9, ≥10 yr. For estimation of variance components and estimation of breed of maternal grandsire effects, random effects were maternal grandsire (620) and dam (3,257 daughters of the maternal grandsires). Due to multiple sire pastures, mating sires were unknown within breed. For estimation of regression coefficients of grand progeny weaning weight on maternal grandsire EPD for weaning weight and milk, random effects of both maternal grandsire and dam (daughter of MGS) were dropped from the model.

Adjustment of USMARC Solutions

The calculations of across-breed adjustment factors rely on solutions for breed of sire or breed of maternal grandsire from records at USMARC and on averages of within-breed EPD from the breed associations. The records from USMARC are not used in calculation of within-breed EPD by the breed associations. The basic calculations for BWT, WWT, and YWT are as follows:

USMARC breed of sire solution for breed i (USMARC (i)) converted to an industry scale (divided by b—new this year) and adjusted for genetic trend (as if bulls born in the base year had been used rather than the bulls actually used):

\[ M_i = \frac{\text{USMARC}(i)}{b} + \left[ \text{EPD}(i)_{YY} - \text{EPD}(i)_{\text{USMARC}} \right]. \]

Breed Table Factor (A_i) to add to the EPD for a bull of breed i:

\[ A_i = (M_i - M_x) - (\text{EPD}(i)_{YY} - \text{EPD}(x)_{YY}). \]

For weaning weight, the breed of sire solution for breed i adjusted for genetic trend on a USMARC scale is also calculated for use in MILK factor derivation:

\[ M_{\text{USMARC}i} = \text{USMARC}(i) + b[\text{EPD}(i)_{YY} - \text{EPD}(i)_{\text{USMARC}}]. \]

where,

USMARC(i) is solution for sire breed i from mixed model equations with USMARC data,

EPD(i)_{YY} is the average within-breed EPD for breed i for animals born in the base year (YY, which is two years before the update; e.g., YY = 2005 for the 2007 update),

EPD(i)_{USMARC} is the weighted (by number of progeny at USMARC) average of EPD of bulls of breed i having progeny with records at USMARC,

b is the pooled coefficient of regression of progeny performance at USMARC on EPD of sire (for 2007: 1.04, 0.87, and 1.14 for BWT, WWT, YWT),

i denotes sire breed i, and

x denotes the base breed, which is Angus in this report.

The calculations to arrive at the Breed Table Factor for MILK are more complicated because of the need to separate the direct effect of the maternal grandsire breed from the maternal effect of the breed.

USMARC breed of maternal grandsire solution for WWT adjusted for genetic trend:

\[ \text{MWWT}(i) = \text{USMARC}(i)_{\text{MGS}} + b_{\text{WWT}}[\text{EPD}(i)_{YYWWT} - \text{EPD}(i)_{\text{USMARCWWT}}] + b_{\text{MLK}}[\text{EPD}(i)_{YYMLK} - \text{EPD}(i)_{\text{USMARCMLK}}] \]

USMARC breed of maternal grandsire solution (MWWT(i)) adjusted for genetic trend and direct genetic effect and converted
to an industry scale for milk EPD (divided by $b_{MLK}$—new this year):

$$\text{MILK}(i) = \left\{ \left[ \frac{\text{MWWT}(i) - 0.5 \ M(i)}{b_{MLK}} \right] - \left[ \frac{\text{MWWT}}{0.5 \ M} \right] \right\} / b_{MLK}$$

Breed Table Factor to add to EPD for MILK for bull of breed $i$:

$$A_i = [\text{MILK}(i) - \text{MILK}(x)] - [\text{EPD}(i)_{YYMLK} - \text{EPD}(i)_{USMARCMLK}]$$

where,

USMARC(i)$_{MGS}$ is solution for MGS breed $i$ for WWT from mixed model equations with USMARC data,

EPD(i)$_{YYWWT}$ is the average within-breed EPD for WWT for breed $i$ for animals born in base year (YY),

EPD(i)$_{USMARCWWT}$ is the weighted (by number of grand progeny at USMARC) average of EPD for WWT of MGS of breed $i$ having grand progeny with records at USMARC,

EPD(i)$_{YYMLK}$ is the average within-breed EPD for MILK for breed $i$ for animals born in base year (YY),

EPD(i)$_{USMARCMLK}$ is the weighted (by number of grand progeny at USMARC) average of EPD for MILK of MGS of breed $i$ having grand progeny with records at USMARC,

$b_{WWT}, b_{MLK}$ are the coefficients of regression of performance of USMARC grand progeny on MGS EPD for WWT and MILK (for 2007: 0.58 and 1.09),

$M(i) = M_{USMARC}$ is the USMARC breed of sire solution from the first analysis of direct breed of sire effects for WWT adjusted for genetic trend and to a USMARC scale,

MWWT and $M$ are constants corresponding to un-weighted averages of $\text{MWWT}(i)$ and $M(i)$ for $i = 1, \ldots, n$, the number of sire (maternal grandsire) breeds included in the analysis.

### Results

Tables 1, 2, and 3 (for BWT, WWT, and YWT) summarize the data from, and results of, USMARC analyses to estimate breed of sire differences and the adjustments to the breed of sire effects to a year 2005 base. The last column of each table corresponds to the Breed Table Factor for that trait.

The general result shown in Tables 1-4 is that for weaning weight many breeds are continuing to become more similar to the arbitrary base breed, Angus. For yearling weight, however, Angus is becoming heavier in comparison to differences in the 2005 report. Most of the other breeds have not changed much relative to each other. Column 7 of Tables 1 and 3, column 8 of Table 2, and column 10 of Table 4 represent the best estimates of breed differences for calves born in 2005 on an industry scale. These pairs of differences minus the corresponding differences in average EPD for animals born in 2005 result in the last column of the tables to be used as adjustment factors for pairs of sires having within-breed EPD.

### Birth Weight

The range in estimated breed of sire differences for BWT relative to Angus is large: from 0.6 lb for Red Angus to 8.6 lb for Charolais and 11.6 lb for Brahman. The relatively heavy birth weights of Brahman sired progeny would be expected to be completely offset by favorable maternal effects reducing birth weight if progeny were from Brahman or Brahman cross dams which would be an important consideration in crossbreeding programs involving Brahman cross females. Even after adjusting to put breed of sire differences on an industry scale, breed
differences from Angus were only slightly changed from the 2006 update (Van Vleck and Cundiff, 2006). The most noticeable changes occurred in Maine-Anjou and Braunvieh differences from Angus due to EPD changes in both of these breeds.

Suppose the EPD for birth weight for a Charolais bull is +2.0 (which is above the year 2005 average of 1.3 for Charolais) and for a Hereford bull is also +2.0 (which is below the year 2005 average of 3.7 for Herefords). The across-breed adjustment factors in the last column of Table 1 are 2.7 for Hereford and 9.6 for Charolais. Then the adjusted EPD for the Charolais bull is 9.6 + 2.0 = 11.6 and for the Hereford bull is 2.7 + 2.0 = 4.7. The expected birth weight difference when both are mated to another breed of cow, e.g., Angus, would be 11.6 – 4.7 = 6.9 lb.

**Weaning Weight**

Weaning weights remained fairly similar to Angus for most breeds—12 of the 15 sire breed differences were less than a 10 lb deviation from Angus. With new data added and the new adjustment to put sire breed differences on an EPD scale, these breed differences changed slightly more than usual, but they were still within 4 lb of the estimates reported in 2006 (Van Vleck and Cundiff, 2006) for all but one breed (Braunvieh).

**Yearling Weight**

Yearling weight was the trait most affected by the addition of new weight records for 7 breeds and the new adjustment for breed of sire differences to year 2005. However, most changes were within 5 lb of last year’s estimated difference relative to Angus (adjusted to year 2004). Angus-sired calves were predicted to have heavier yearling weights than 13 other breeds.

**Maternal Milk**

The changes from last year for milk for the current base year (Table 4, column 10) were generally small. The largest changes were for Brangus (-4.5 lb) and Limousin (+3.1 lb), both of which had new maternal records this year. Changes for other breeds were all less than 2 lb.

**Accuracies and Variance Components**

Table 5 summarizes the average Beef Improvement Federation (BIF) accuracy for bulls with progeny at USMARC weighted appropriately by number of progeny or grand progeny. South Devon bulls had relatively small accuracy for all traits as did Hereford, Brahman, and Shorthorn bulls. Charolais bulls had low accuracy for yearling weight and milk. Table 6 reports the estimates of variance components from the records that were used in the mixed model equations to obtain breed of sire and breed of MGS solutions. Neither Table 5 nor Table 6 changed much from the 2004 report.

**Regression Coefficients**

Table 7 updates the coefficients of regression of records of USMARC progeny on sire EPDs for BWT, WWT, and YWT which have theoretical expected values of 1.00. The standard errors of the specific breed regression coefficients are large relative to the regression coefficients. Large differences from the theoretical regressions, however, may indicate problems with genetic evaluations, identification, or sampling. The pooled (overall) regression coefficients of 1.04 for BWT, 0.87 for WWT, and 1.14 for YWT were used to adjust breed of sire solutions to the base year of 2005. These regression coefficients are reasonably close to expected values of 1.0. Deviations from 1.00 are believed to be due to scaling differences between performance of progeny in the USMARC herd and of progeny in herds contributing to the national genetic evaluations of the 16 breeds.
The regression coefficient for female progeny on sire EPDs for YWT was 1.00 compared to 1.28 for steers. These differences might be expected because post weaning average daily gains for heifers at USMARC have been significantly less than those for steers. The heifers were fed relatively high roughage diets to support average daily gains of 1.6 lb per day while the steers were fed relatively high energy growing and finishing diets supporting average daily gains of about 3.4 lb per day. This result may imply that heifers at USMARC are treated in a similar fashion to bulls and heifers in herds contributing to the national genetic evaluations.

The coefficients of regression of records of grand progeny on MGS EPDs for WWT and MILK are shown in Table 8. Several sire (MGS) breeds have regression coefficients considerably different from the theoretical expected values of 0.50 for WWT and 1.00 for MILK. Standard errors, however, for the regression coefficients by breed are large except for Angus and Hereford. The pooled regression coefficients of 0.58 for MWWT and 1.09 for MILK are reasonably close to the expected regression coefficients of 0.50 and 1.00.

**Prediction Error Variances of Across-Breed EPD**

The standard errors of differences in the solutions for breed of sire and breed of MGS differences from the USMARC records can be adjusted by theoretical approximations to obtain variances of adjusted breed differences (Van Vleck, 1994; Van Vleck and Cundiff, 1994). These variances of estimated breed differences can be added to prediction error variances of within-breed EPDs to obtain prediction error variances (PEV) or equivalently standard errors of prediction (SEP) for across-breed EPDs (Van Vleck and Cundiff, 1994, 1995). The variances of adjusted breed differences are given in the upper triangular part of Table 9 for BWT, lower triangular part of Table 9 for YWT, upper triangular part of Table 10 for direct WWT, and lower triangular part of Table 10 for MILK. Use of these tables to calculate standard errors of prediction for expected progeny differences of pairs of bulls of the same or different breeds was discussed in the 1995 BIF proceedings (Van Vleck and Cundiff, 1995).

Even though the variances of estimates of adjusted breed differences look large, especially for YWT and MILK, they generally contribute a relatively small amount to standard errors of predicted differences. For example, suppose for WWT, a Salers bull has an EPD of 15.0 with prediction error variance of 75 (SEP = 8.7) and a Hereford bull has an EPD of 30.0 with PEV of 50 (SEP = 7.1). The difference in predicted progeny performance is (Salers adjustment + Salers bull's EPD) - (Hereford adjustment + Hereford bull's EPD):

\[(30.7 + 15.0) - (-3.1 + 30.0) = 45.7 - 26.9 = 18.8.\]

The prediction error variance for this difference is (use the 18.0 in the upper part of Table 10 at intersection of row for HE and column for SA):

\[V(Salers breed - Hereford breed) + PEV(Salers bull) + PEV(Hereford bull):\]

\[18 + 75 + 50 = 143\]

with

standard error of prediction, SEP = \(\sqrt{143} = 12.\)

If the difference between the Salers and Hereford breeds in the year 2005 could be estimated perfectly, the variance of the estimate of the breed difference would be 0 and the standard error of prediction between the two bulls would be:

\[SEP(difference) = \sqrt{(0 + 75 + 50)} = 11.2\] which is only slightly smaller than 12.0.

**Implications**
Bulls of different breeds can be compared on a common EPD scale by adding the appropriate table factor to EPDs produced in the most recent genetic evaluations for each of the 16 breeds. The across-breed EPDs are most useful to commercial producers purchasing bulls of two or more breeds to use in systematic crossbreeding programs. Uniformity in across-breed EPDs should be emphasized for rotational crossing. Divergence in across-breed EPDs for direct weaning weight and yearling weight should be emphasized in selection of bulls for terminal crossing. Divergence favoring lighter birth weight may be helpful in selection of bulls for use on first calf heifers. Accuracy of across-breed EPDs depends primarily upon the accuracy of the within-breed EPDs of individual bulls being compared.

References


Van Vleck, L. D., and L. V. Cundiff. 1997. The across-breed EPD tables adjusted to a


Table 1. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2005 base and factors to adjust within breed EPD to an Angus equivalent – BIRTH WEIGHT (lb)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Number Sires</th>
<th>Progeny</th>
<th>Raw USMARC Mean (1)</th>
<th>Ave. Base EPD Breed 2005 (2)</th>
<th>USMARC Bulls (3)</th>
<th>Breed Soln at USMARC + Ang vs Ang (4)</th>
<th>Adjust to 2005 Base + Ang vs Ang (6)</th>
<th>Factor to adjust EPD To Angus (8)</th>
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<tr>
<td>Hereford</td>
<td>113</td>
<td>1903</td>
<td>87</td>
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<td>1.7</td>
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<td>90</td>
<td>88</td>
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Calculations:
(4) = (5) + (1, Angus)
(6) = (4) / b + [(2) – (3)] with b = 1.04
(7) = (6) – (6, Angus)
(8) = (7) – (7, Angus) – [(2) – (2, Angus)]
Table 2. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2005 base and factors to adjust within breed EPD to an Angus equivalent – WEANING WEIGHT (lb)

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<tr>
<th>Breed</th>
<th>Number</th>
<th>Progeny</th>
<th>Raw USMARC Mean (1)</th>
<th>Ave. Breed Bull EPD 2005 USMARC (2)</th>
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<th>USMARC Scale (6)</th>
<th>Adjust to 2005 Base + Ang vs Ang EPD (7)</th>
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Calculations:
(4) = (5) + (1, Angus)
(6) = (4) + b[(2) – (3)] with b = 0.87 (used in MILK calculation; Table 4)
(7) = (4) / b + [(2) – (3)] with b = 0.87
(8) = (7) – (7, Angus)
(9) = (8) – (8, Angus) – [(2) – (2, Angus)]
Table 3. Breed of sire solutions from USMARC, mean breed and USMARC EPD used to adjust for genetic trend to the year 2005 base and factors to adjust within breed EPD to an Angus equivalent – YEARLING WEIGHT (lb)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Number</th>
<th>Sires</th>
<th>Progeny</th>
<th>Raw USMARC Mean</th>
<th>Ave. Base Breed 2005</th>
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<th>Adjust to 2005 Base + Ang vs Ang (6) (7)</th>
<th>Factor to adjust EPD To Angus (8)</th>
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<td>77.6</td>
<td>87.7</td>
<td>887 12.0</td>
<td>768 -28.3</td>
<td>-31.9</td>
</tr>
<tr>
<td>Gelbvieh</td>
<td>48</td>
<td>617</td>
<td>863</td>
<td>74.0</td>
<td>58.9</td>
<td>867 -8.5</td>
<td>775 -21.2</td>
<td>-21.2</td>
</tr>
<tr>
<td>Tarentaise</td>
<td>7</td>
<td>189</td>
<td>807</td>
<td>11.0</td>
<td>-3.9</td>
<td>840 -35.1</td>
<td>752 -44.7</td>
<td>18.3</td>
</tr>
<tr>
<td>Salers</td>
<td>27</td>
<td>173</td>
<td>898</td>
<td>27.4</td>
<td>8.8</td>
<td>883 8.0</td>
<td>793 -3.1</td>
<td>43.5</td>
</tr>
<tr>
<td>Red Angus</td>
<td>21</td>
<td>240</td>
<td>924</td>
<td>52.4</td>
<td>46.1</td>
<td>875 0.2</td>
<td>774 -22.3</td>
<td>-0.7</td>
</tr>
<tr>
<td>Braunvieh</td>
<td>7</td>
<td>182</td>
<td>737</td>
<td>5.9</td>
<td>13.0</td>
<td>858 -16.8</td>
<td>746 -50.7</td>
<td>17.4</td>
</tr>
<tr>
<td>Brangus</td>
<td>21</td>
<td>152</td>
<td>977</td>
<td>39.1</td>
<td>42.6</td>
<td>902 27.2</td>
<td>788 -8.4</td>
<td>26.5</td>
</tr>
<tr>
<td>Beefmaster</td>
<td>22</td>
<td>157</td>
<td>991</td>
<td>12.0</td>
<td>22.4</td>
<td>899 23.7</td>
<td>778 -18.3</td>
<td>43.7</td>
</tr>
</tbody>
</table>

Calculations:
(4) = (5) + (1, Angus)
(6) = (4)/b + [(2) – (3)] with b = 1.14
(7) = (6) – (6, Angus)
(8) = (7) – (7, Angus) – [(2) – (2, Angus)]
<table>
<thead>
<tr>
<th>Breed</th>
<th>MGS</th>
<th>Gpr Daughters</th>
<th>Raw MGS Mean WWT</th>
<th>Mean EPD Breed MILK WWT</th>
<th>Mean EPD USMARC MILK</th>
<th>Breed Soln at USMARC MWWT</th>
<th>Adjust to 2005 Base MWWT</th>
<th>MILK EPD to Angus vs Ang vs Ang vs Ang to Angus</th>
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</thead>
<tbody>
<tr>
<td>Hereford</td>
<td>108</td>
<td>3024</td>
<td>721</td>
<td>487</td>
<td>39.0</td>
<td>15.0</td>
<td>23.3</td>
<td>7.9</td>
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<tr>
<td>Angus</td>
<td>104</td>
<td>2307</td>
<td>550</td>
<td>508</td>
<td>40.0</td>
<td>20.0</td>
<td>21.4</td>
<td>10.3</td>
</tr>
<tr>
<td>Shorthorn</td>
<td>22</td>
<td>251</td>
<td>69</td>
<td>527</td>
<td>14.0</td>
<td>2.0</td>
<td>7.7</td>
<td>6.1</td>
</tr>
<tr>
<td>South Devon</td>
<td>14</td>
<td>347</td>
<td>69</td>
<td>488</td>
<td>19.6</td>
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<td>-0.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Brahman</td>
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<td>880</td>
<td>216</td>
<td>522</td>
<td>14.0</td>
<td>6.3</td>
<td>4.3</td>
<td>2.6</td>
</tr>
<tr>
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<td>1217</td>
<td>244</td>
<td>528</td>
<td>32.9</td>
<td>4.9</td>
<td>23.1</td>
<td>8.6</td>
</tr>
<tr>
<td>Limousin</td>
<td>40</td>
<td>1193</td>
<td>242</td>
<td>496</td>
<td>37.6</td>
<td>19.4</td>
<td>20.6</td>
<td>16.8</td>
</tr>
<tr>
<td>Charolais</td>
<td>68</td>
<td>1108</td>
<td>239</td>
<td>515</td>
<td>20.9</td>
<td>6.3</td>
<td>8.3</td>
<td>4.2</td>
</tr>
<tr>
<td>Maine-Anjou</td>
<td>17</td>
<td>485</td>
<td>86</td>
<td>533</td>
<td>39.1</td>
<td>19.3</td>
<td>43.2</td>
<td>23.2</td>
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<tr>
<td>Gelbvieh</td>
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<td>1086</td>
<td>240</td>
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<td>18.0</td>
<td>32.4</td>
<td>17.0</td>
</tr>
<tr>
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<td>78</td>
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<td>1.0</td>
<td>-5.9</td>
<td>4.6</td>
</tr>
<tr>
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<td>87</td>
<td>534</td>
<td>16.3</td>
<td>8.4</td>
<td>5.5</td>
<td>11.9</td>
</tr>
<tr>
<td>Red Angus</td>
<td>21</td>
<td>423</td>
<td>97</td>
<td>519</td>
<td>30.1</td>
<td>15.5</td>
<td>27.3</td>
<td>13.5</td>
</tr>
<tr>
<td>Braunvieh</td>
<td>7</td>
<td>502</td>
<td>92</td>
<td>542</td>
<td>3.3</td>
<td>0.0</td>
<td>8.0</td>
<td>-0.4</td>
</tr>
<tr>
<td>Brangus</td>
<td>19</td>
<td>136</td>
<td>43</td>
<td>549</td>
<td>23.6</td>
<td>7.7</td>
<td>24.3</td>
<td>2.6</td>
</tr>
<tr>
<td>Beefmaster</td>
<td>20</td>
<td>152</td>
<td>51</td>
<td>551</td>
<td>7.0</td>
<td>2.0</td>
<td>15.8</td>
<td>-1.7</td>
</tr>
</tbody>
</table>

Calculations:

\[(6) = (7) + (1, \text{Angus}); (8) = (6) + b_{\text{WWT}}[(2) – (4)] + b_{\text{MLK}} [(3) – (5)] \] with \[b_{\text{WWT}} = 0.58 \text{ and } b_{\text{MLK}} = 1.09; (9) = (8) – (8, \text{Angus}); (10) = (((9) – Average (9)) – 0.5[(6, \text{Table 2}) – Average (6, \text{Table 2})]) / b_{\text{MLK}}; (11) = ([10] – (10, \text{Angus})] – [(3) – (3, \text{Angus})].\]
Table 5. Mean weighted\textsuperscript{a} accuracies for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), maternal weaning weight (MWWT) and milk (MILK) for bulls used at USMARC

<table>
<thead>
<tr>
<th>Breed</th>
<th>BWT</th>
<th>WWT</th>
<th>YWT</th>
<th>MWWT</th>
<th>MILK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hereford</td>
<td>0.59</td>
<td>0.56</td>
<td>0.55</td>
<td>0.53</td>
<td>0.48</td>
</tr>
<tr>
<td>Angus</td>
<td>0.73</td>
<td>0.75</td>
<td>0.70</td>
<td>0.73</td>
<td>0.66</td>
</tr>
<tr>
<td>Shorthorn</td>
<td>0.65</td>
<td>0.59</td>
<td>0.58</td>
<td>0.61</td>
<td>0.48</td>
</tr>
<tr>
<td>South Devon</td>
<td>0.37</td>
<td>0.39</td>
<td>0.37</td>
<td>0.41</td>
<td>0.42</td>
</tr>
<tr>
<td>Brahman</td>
<td>0.50</td>
<td>0.55</td>
<td>0.38</td>
<td>0.55</td>
<td>0.42</td>
</tr>
<tr>
<td>Simmental</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
<td>0.94</td>
<td>0.93</td>
</tr>
<tr>
<td>Limousin</td>
<td>0.92</td>
<td>0.89</td>
<td>0.83</td>
<td>0.89</td>
<td>0.84</td>
</tr>
<tr>
<td>Charolais</td>
<td>0.73</td>
<td>0.67</td>
<td>0.58</td>
<td>0.66</td>
<td>0.57</td>
</tr>
<tr>
<td>Maine-Anjou</td>
<td>0.72</td>
<td>0.71</td>
<td>0.71</td>
<td>0.71</td>
<td>0.71</td>
</tr>
<tr>
<td>Gelbvieh</td>
<td>0.74</td>
<td>0.68</td>
<td>0.54</td>
<td>0.72</td>
<td>0.59</td>
</tr>
<tr>
<td>Tarentaise</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Salers</td>
<td>0.83</td>
<td>0.83</td>
<td>0.77</td>
<td>0.82</td>
<td>0.83</td>
</tr>
<tr>
<td>Red Angus</td>
<td>0.89</td>
<td>0.87</td>
<td>0.87</td>
<td>0.85</td>
<td>0.82</td>
</tr>
<tr>
<td>Braunvieh</td>
<td>0.85</td>
<td>0.86</td>
<td>0.84</td>
<td>0.86</td>
<td>0.79</td>
</tr>
<tr>
<td>Brangus</td>
<td>0.81</td>
<td>0.79</td>
<td>0.67</td>
<td>0.82</td>
<td>0.68</td>
</tr>
<tr>
<td>Beefmaster</td>
<td>0.72</td>
<td>0.78</td>
<td>0.64</td>
<td>0.79</td>
<td>0.68</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Weighted by number of progeny at USMARC for BWT, WWT, and YWT and by number of grand progeny for MWWT and MILK.
Table 6. REML estimates of variance components (lb²) for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), and maternal weaning weight (MWWT) from mixed model analyses

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Direct</th>
<th>Maternal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BWT</td>
<td>WWT</td>
</tr>
<tr>
<td>Directa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sires (650) within breed (17)</td>
<td>11.67</td>
<td>155.16</td>
</tr>
<tr>
<td>Dams (4656) within breed (3)</td>
<td>26.19</td>
<td>880.58</td>
</tr>
<tr>
<td>Residual</td>
<td>68.62</td>
<td>1550.32</td>
</tr>
<tr>
<td>Maternal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MGS (620) within MGS breed (17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daughters within MGS (3257)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aNumbers for weaning weight.*
Table 7. Pooled regression coefficients (lb/lb) for weights at birth (BWT), 205 days (WWT), and 365 days (YWT) of F1 progeny on sire expected progeny difference and by sire breed, dam breed, and sex of calf

<table>
<thead>
<tr>
<th></th>
<th>BWT</th>
<th>WWT</th>
<th>YWT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pooled</strong></td>
<td>1.04 ± 0.05</td>
<td>0.87 ± 0.05</td>
<td>1.14 ± 0.05</td>
</tr>
<tr>
<td><strong>Sire breed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hereford</td>
<td>1.20 ± 0.08</td>
<td>0.82 ± 0.07</td>
<td>1.16 ± 0.07</td>
</tr>
<tr>
<td>Angus</td>
<td>0.85 ± 0.10</td>
<td>0.80 ± 0.09</td>
<td>1.16 ± 0.08</td>
</tr>
<tr>
<td>Shorthorn</td>
<td>0.51 ± 0.52</td>
<td>0.66 ± 0.46</td>
<td>1.28 ± 0.37</td>
</tr>
<tr>
<td>South Devon</td>
<td>0.97 ± 0.56</td>
<td>-0.17 ± 0.35</td>
<td>-0.07 ± 0.40</td>
</tr>
<tr>
<td>Brahman</td>
<td>1.79 ± 0.27</td>
<td>1.13 ± 0.27</td>
<td>0.70 ± 0.24</td>
</tr>
<tr>
<td>Simmental</td>
<td>1.05 ± 0.19</td>
<td>1.35 ± 0.17</td>
<td>1.33 ± 0.15</td>
</tr>
<tr>
<td>Limousin</td>
<td>0.72 ± 0.14</td>
<td>0.54 ± 0.15</td>
<td>0.98 ± 0.14</td>
</tr>
<tr>
<td>Charolais</td>
<td>1.09 ± 0.13</td>
<td>0.98 ± 0.13</td>
<td>0.93 ± 0.12</td>
</tr>
<tr>
<td>Maine-Anjou</td>
<td>0.81 ± 0.38</td>
<td>0.32 ± 0.49</td>
<td>0.08 ± 0.50</td>
</tr>
<tr>
<td>Gelbvieh</td>
<td>1.01 ± 0.15</td>
<td>1.13 ± 0.25</td>
<td>1.27 ± 0.20</td>
</tr>
<tr>
<td>Tarentaise</td>
<td>0.59 ± 0.85</td>
<td>0.74 ± 0.56</td>
<td>1.32 ± 0.59</td>
</tr>
<tr>
<td>Salers</td>
<td>1.20 ± 0.38</td>
<td>1.04 ± 0.45</td>
<td>0.81 ± 0.45</td>
</tr>
<tr>
<td>Red Angus</td>
<td>0.69 ± 0.19</td>
<td>0.76 ± 0.33</td>
<td>0.89 ± 0.30</td>
</tr>
<tr>
<td>Braunvieh</td>
<td>0.53 ± 0.39</td>
<td>0.67 ± 0.65</td>
<td>1.94 ± 0.53</td>
</tr>
<tr>
<td>Brangus</td>
<td>1.62 ± 0.35</td>
<td>0.63 ± 0.43</td>
<td>0.45 ± 0.40</td>
</tr>
<tr>
<td>Beefmaster</td>
<td>1.18 ± 0.53</td>
<td>1.59 ± 0.38</td>
<td>1.49 ± 0.42</td>
</tr>
<tr>
<td><strong>Dam breed</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hereford</td>
<td>0.95 ± 0.08</td>
<td>0.84 ± 0.08</td>
<td>1.02 ± 0.07</td>
</tr>
<tr>
<td>Angus</td>
<td>1.12 ± 0.06</td>
<td>0.85 ± 0.06</td>
<td>1.17 ± 0.06</td>
</tr>
<tr>
<td>MARC III</td>
<td>0.99 ± 0.08</td>
<td>0.92 ± 0.09</td>
<td>1.22 ± 0.08</td>
</tr>
<tr>
<td><strong>Sex of calf</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heifers</td>
<td>1.01 ± 0.06</td>
<td>0.95 ± 0.06</td>
<td>1.00 ± 0.06</td>
</tr>
<tr>
<td>Steers</td>
<td>1.06 ± 0.06</td>
<td>0.78 ± 0.06</td>
<td>1.27 ± 0.06</td>
</tr>
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</table>
Table 8. Pooled regression coefficients (lb/lb) for progeny performance on maternal grandsire EPD for weaning weight (MWWT) and milk (MILK) and by breed of maternal grandsire, breed of maternal grand dam, and sex of calf

<table>
<thead>
<tr>
<th>Type of regression</th>
<th>MWWT</th>
<th>MILK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pooled</td>
<td>0.58 ± 0.04</td>
<td>1.09 ± 0.06</td>
</tr>
</tbody>
</table>

**Breed of maternal grandsire**

<table>
<thead>
<tr>
<th>Breed</th>
<th>MWWT</th>
<th>MILK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hereford</td>
<td>0.50 ± 0.06</td>
<td>1.20 ± 0.12</td>
</tr>
<tr>
<td>Angus</td>
<td>0.53 ± 0.08</td>
<td>1.02 ± 0.12</td>
</tr>
<tr>
<td>Shorthorn</td>
<td>0.72 ± 0.39</td>
<td>0.14 ± 0.60</td>
</tr>
<tr>
<td>South Devon</td>
<td>0.31 ± 0.24</td>
<td>-1.21 ± 0.86</td>
</tr>
<tr>
<td>Brahman</td>
<td>0.40 ± 0.22</td>
<td>0.49 ± 0.35</td>
</tr>
<tr>
<td>Simmental</td>
<td>0.91 ± 0.17</td>
<td>0.82 ± 0.37</td>
</tr>
<tr>
<td>Limousin</td>
<td>1.19 ± 0.12</td>
<td>1.83 ± 0.21</td>
</tr>
<tr>
<td>Charolais</td>
<td>0.41 ± 0.10</td>
<td>1.08 ± 0.19</td>
</tr>
<tr>
<td>Maine-Anjou</td>
<td>0.04 ± 0.35</td>
<td>0.39 ± 0.47</td>
</tr>
<tr>
<td>Gelbvieh</td>
<td>0.97 ± 0.21</td>
<td>1.50 ± 0.33</td>
</tr>
<tr>
<td>Tarentaise</td>
<td>0.27 ± 0.71</td>
<td>0.88 ± 0.86</td>
</tr>
<tr>
<td>Salers</td>
<td>0.89 ± 0.33</td>
<td>2.26 ± 0.37</td>
</tr>
<tr>
<td>Red Angus</td>
<td>0.88 ± 0.25</td>
<td>1.80 ± 0.28</td>
</tr>
<tr>
<td>Braunvieh</td>
<td>3.24 ± 0.98</td>
<td>-2.08 ± 1.67</td>
</tr>
<tr>
<td>Brangus</td>
<td>0.07 ± 0.61</td>
<td>0.81 ± 0.57</td>
</tr>
<tr>
<td>Beefmaster</td>
<td>1.22 ± 0.46</td>
<td>3.74 ± 0.46</td>
</tr>
</tbody>
</table>

**Breed of maternal grand dam**

<table>
<thead>
<tr>
<th>Breed</th>
<th>MWWT</th>
<th>MILK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hereford</td>
<td>0.54 ± 0.06</td>
<td>1.44 ± 0.10</td>
</tr>
<tr>
<td>Angus</td>
<td>0.56 ± 0.05</td>
<td>1.03 ± 0.09</td>
</tr>
<tr>
<td>MARC III</td>
<td>0.63 ± 0.07</td>
<td>0.91 ± 0.10</td>
</tr>
</tbody>
</table>

**Sex of calf**

<table>
<thead>
<tr>
<th>Sex</th>
<th>MWWT</th>
<th>MILK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifers</td>
<td>0.56 ± 0.05</td>
<td>1.09 ± 0.08</td>
</tr>
<tr>
<td>Steers</td>
<td>0.59 ± 0.05</td>
<td>1.10 ± 0.08</td>
</tr>
</tbody>
</table>
Table 9. Variances (lb$^2$) of adjusted breed differences to add to sum of within breed prediction error variances to obtain variance of differences of across breed EPD for bulls of two different breeds$^a$. Birth weight above the diagonal and yearling weight below the diagonal.

<table>
<thead>
<tr>
<th>Breed</th>
<th>HE</th>
<th>AN</th>
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$^a$For example, a Hereford bull has within breed PEV of 300 for YWT and that for a Shorthorn bull is 200. Then the PEV for the difference in EPDs for the two bulls is 55 + 300 + 200 = 555 with SEP = $\sqrt{555} = 23.6$. 

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Table 10. Variances (lb$^2$) of adjusted breed differences to add to sum of within breed prediction error variances to obtain variance of difference of across breed EPDs for bulls of two different breeds. Weaning weight direct above the diagonal and MILK below the diagonal

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Expected progeny differences (EPDs) have been the primary tool for genetic improvement of beef cattle for over 30 years beginning with evaluations of growth traits. Since that time EPDs have been added for several other production traits such as calving ease, stayability, and carcass merit and conformation. Most recently, several breed associations have derived economic indices from their EPDs to increase profit under different management and breeding systems.

It is useful for producers to compare the EPDs of potential breeding animals with their breed average. The current EPDs from the most recent genetic evaluations of 17 breeds are presented in this report. Mean EPDs for growth traits are shown in Table 1 (17 breeds), for other production traits in Table 2 (13 breeds), and for carcass and composition traits in Table 3. Several breeds also have EPDs that are unique to their breed; these EPDs are presented in Table 4.

Average EPDs should only be used to determine the genetic merit of an animal relative to its breed average. To compare animals of different breeds, across breed adjustment factors should be added to animals’ EPDs for their respective breeds (see Across-breed EPD Tables reported by Kuehn et al. in these proceedings).
### Table 1. Birth year 2005 average EPDs from 2007 evaluations for growth traits

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### Table 2. Birth year 2005 average EPDs for other production traits

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<td>Charolais</td>
<td>2.0</td>
<td>5.2</td>
<td>104</td>
<td>13.9</td>
<td>16.8</td>
</tr>
<tr>
<td>Gelbvieh</td>
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<td>104</td>
<td>0.4</td>
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<tr>
<td>Limousin</td>
<td>6.7</td>
<td>2.7</td>
<td>0.3</td>
<td>7.6</td>
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<tr>
<td>Salers</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simmental</td>
<td>5.8</td>
<td>2.1</td>
<td></td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>Tarentaise</td>
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<td>1</td>
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</table>
Table 3. Birth year 2005 average EPDs for carcass and composition traits

<table>
<thead>
<tr>
<th>Breed</th>
<th>Carcass Wt (lb)</th>
<th>Retail Product (%)</th>
<th>Yield Grade</th>
<th>Marbling Score</th>
<th>Ribeye Area (in²)</th>
<th>Fat Thickness (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angus</td>
<td>5.7</td>
<td>0.21(^a)</td>
<td>0.20(^a)</td>
<td>-0.003(^a)</td>
<td>0.14</td>
<td>0.23</td>
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<tr>
<td>Hereford</td>
<td>-</td>
<td>0.00(^b)</td>
<td>0.13(^b)</td>
<td>0.003(^b)</td>
<td>0.00</td>
<td>0.13</td>
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<tr>
<td>Red Angus</td>
<td>-2</td>
<td>0.06</td>
<td>0.03</td>
<td>-0.001(^a)</td>
<td>0.4</td>
<td>0.24</td>
</tr>
<tr>
<td>Shorthorn</td>
<td>-0.01</td>
<td>-0.02(^a)</td>
<td>-0.04(^a)</td>
<td>0.0(^a)</td>
<td>0.4</td>
<td>0.24</td>
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<tr>
<td>South Devon</td>
<td>16.8</td>
<td>0.06</td>
<td>0.01</td>
<td>0.12</td>
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<td>Brangus</td>
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<td></td>
<td>16.8</td>
<td>0.12</td>
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<tr>
<td>Charolais</td>
<td>13.07</td>
<td>0.00</td>
<td>0.18</td>
<td>-0.003</td>
<td>0.27</td>
<td>0.22</td>
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<tr>
<td>Gelbvieh</td>
<td>-0.19</td>
<td>-0.04(^a)</td>
<td>0.07(^a)</td>
<td>0.0(^a)</td>
<td>0.27</td>
<td>0.22</td>
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<tr>
<td>Limousin</td>
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<td>0.03</td>
<td>0.01</td>
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<td>Maine-Anjou</td>
<td>8.2</td>
<td>0.27</td>
<td>0.22</td>
<td>0.26</td>
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<tr>
<td>Salers</td>
<td>19.2</td>
<td>0.1</td>
<td>0.0</td>
<td>0.01</td>
<td>19.2</td>
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<tr>
<td>Simmental</td>
<td>-1.12</td>
<td>0.002</td>
<td>0.09</td>
<td>0.04</td>
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</table>

\(^a\)Calculated using only actual carcass data (no ultrasound data)

\(^b\)Calculated using ultrasound and carcass data in a multi-trait model
<table>
<thead>
<tr>
<th>Breed</th>
<th>Mature Weight (lb)</th>
<th>Mature Height (in)</th>
<th>Cow Energy Value ($)</th>
<th>Weaned Calf Value ($)</th>
<th>Feedlot Value ($)</th>
<th>Grid Value ($)</th>
<th>Beef Value ($)</th>
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<tbody>
<tr>
<td>Angus</td>
<td>32.3</td>
<td>0.5</td>
<td>6.18</td>
<td>23.44</td>
<td>18.79</td>
<td>14.77</td>
<td>32.38</td>
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<tr>
<td>Hereford</td>
<td>Maternal Index ($)</td>
<td>Brahman Influence Index ($)</td>
<td>Certified Hereford Beef Index ($)</td>
<td>Calving Ease Index ($)</td>
<td>14.7</td>
<td>14.2</td>
<td>16.45</td>
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<tr>
<td>Red Angus</td>
<td>Heifer Pregnancy (%)</td>
<td>Mature Cow Maintenance (Mcal/mo)</td>
<td>8.5</td>
<td>4.4</td>
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<tr>
<td>Gelbvieh</td>
<td>Feedlot Merit ($)</td>
<td>Grid Merit ($)</td>
<td>Gestation Length (d)</td>
<td>14.32</td>
<td>11.66</td>
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<td>Limousin</td>
<td>Mainstream Terminal Index ($)</td>
<td>42.2</td>
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<tr>
<td>Simmental</td>
<td>All Purpose Index ($)</td>
<td>Terminal Index ($)</td>
<td>90.4</td>
<td>61.4</td>
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</tbody>
</table>
Cow Herd Efficiency and Adaptability Committee

Mark Enns, Chair

Development of Guidelines for Individual Feed Intake Data Collection – Current Status and Future Direction
D.H. “Denny” Crews, Jr., National Study Leader, Agriculture and Agri-Food Canada

New Methods for Evaluating Susceptibility to High Altitude Disease in Angus Cattle
Konni Shirley and Dorian Garrick, Colorado State University

Genetic Evaluation of Feed Intake, Efficiency, and Maintenance Energy in the Cow – What Do We Need to Learn?
D.H. “Denny” Crews, Jr., National Study Leader, Agriculture and Agri-Food Canada
Producer Applications Committee

Bob Weaber, Chair

What are verification programs and why do we need them? International and domestic marketing perspectives
Keith Belk, Colorado State University

Feed Yard Perspectives on Implementation and Value Capture Associated with QSA-PVP Programs
Dick Carlson, Producers Livestock Marketing Association Feedlot, Greeley, CO
Steve Gabel, Magnum Feedyard LLC, Wiggins, CO

Adding Value, Serving Customers and Capturing Data through Breed Sponsored Verifications Programs.
Short Presentations by representatives from The American Angus Association, American Hereford Association, American Simmental Association and The Red Angus Association of America
Emerging Technology Committee

Bill Bowman, Chair

Whole Genome Scanning for the Beef Industry
Jerry Taylor, University of Missouri

Establishing Guidelines for Incorporation of Genomic Information into Selection Tools
Mike Tess, Montana State University

Investigating Opportunities Available in Genetic Selection for Healthy Beef
J.R. Tait, Iowa State University
FRANK H. BAKER

Born: May 2, 1923, Stroud, Oklahoma
Died: February 15, 1993, Little Rock, Arkansas

Dr. Frank Baker is widely recognized as the “Founding Father” of the Beef Improvement Federation (BIF). Frank played a key leadership role in helping establish BIF in 1968, while he was Animal Science Department Chairman at the University of Nebraska, Lincoln, 1966-74. The Frank Baker Memorial Scholarship Award Essay competition for graduate students provides an opportunity to recognize outstanding student research and competitive writing in honor of Dr. Baker.

Frank H. Baker was born May 2, 1923, at Stroud, Oklahoma, and was reared on a farm in northeastern Oklahoma. He received his B.S. degree, with distinction, in Animal Husbandry from Oklahoma State University (OSU) in 1947, after 2½ years of military service with the US Army as a paratrooper in Europe, for which he was awarded the Purple Heart. After serving three years as county extension agent and veterans agriculture instructor in Oklahoma, Frank returned to OSU to complete his M.S. and Ph.D. degrees in Animal Nutrition.

Frank’s professional positions included teaching and research positions at Kansas State University, 1953-55; the University of Kentucky, 1955-58; Extension Livestock Specialist at OSU, 1958-62; and Extension Animal Science Programs Coordinator, USDA, Washington, D.C., 1962-66. Frank left Nebraska in 1974 to become Dean of Agriculture at Oklahoma State University, a position he held until 1979, when he began service as International Agricultural Programs Officer and Professor of Animal Science at OSU. Frank joined Winrock International, Morrilton, Arkansas, in 1981, as Senior Program Officer and Director of the International Stockmen’s School, where he remained until his retirement.

Frank served on advisory committees for Angus, Hereford, and Polled Hereford beef breed associations, the National Cattlemen’s Association, Performance Registry International, and the Livestock Conservation, Inc. His service and leadership to the American Society of Animal Science (ASAS) included many committees, election as vice-president and as president, 1973-74. Frank was elected an ASAS Honorary Fellow in 1977, he was a Fellow of the American Association for the Advancement of Science, and served the Council for Agricultural Science and Technology (CAST) as president in 1979.

Frank Baker received many awards in his career, crowned by having his portrait hung in the Saddle and Sirloin Club Gallery at the International Livestock Exposition, Louisville, Kentucky, on November 16, 1986. His ability as a statesman and diplomat for the livestock industry was to use his vision to call forth the collective best from all those around him. Frank was a “mover and shaker” who was skillful in turning “Ideas into Action” in the beef cattle performance movement. His unique leadership abilities earned him great respect among breeders and scientists alike. Frank died February 15, 1993, in Little Rock, Arkansas.
Recipients of the Frank Baker Memorial Scholarship Award

Kelly W. Bruns .......................Michigan State University .....1994
William Herring .......................University of Georgia ..........1994
D. H. "Denny" Crews, Jr.............Louisiana State University .....1995
Dan Moser ................................University of Georgia ..........1995
D. H. "Denny" Crews, Jr.............Louisiana State University .....1996
Lowell S. Gould .......................University of Nebraska ..........1996
Rebecca K. Splan ......................University of Nebraska ..........1997
Robert Williams .................University of Georgia ..........1997
Patrick Doyle .......................Colorado State University .....1998
Shannon M. Schafer ..............Cornell University ..............1998
Janice M. Rumph .................University of Nebraska ..........1999
Bruce C. Shanks .......................Montana State University .....1999
Paul L. Charteris ................Colorado State University .........2000
Katherine A. Donoghue ..........University of Georgia ..................2000
Khathutshelo A. Nephawe .........University of Nebraska ............2001
Janice M. Rumph .................University of Nebraska ..........2001
Katherine A. Donoghue ..........University of Georgia ..................2002
Khathutshelo A. Nephawe .........University of Nebraska ............2002
Fernando F. Cardoso ...............Michigan State University ......2003
Charles Andrew McPeake .......Michigan State University ......2003
Reynold Bergen .................University of Guelph ...............2004
Angel Rios-Utrera ..................University of Nebraska ..........2004
Matthew A. Cleveland ..........Colorado State University ......2005
David P. Kirschten ..............Cornell University ..................2005
Amy Kelley .........................Montana State University ......2006
Jamie L. Williams ...............Colorado State University ......2006
Gabriela C. Márquez Betz ......Colorado State University ......2007
Yuri Regis Montanholi ...........University of Guelph ...............2007
2006 Frank Baker Memorial Scholarship Recipients

The Beef Improvement Federation honored Amy Kelley (right), Montana State University, with the Frank Baker Memorial Scholarship during an awards luncheon April 19 at the 2006 BIF Annual Meeting and Research Symposium in Choctaw, Miss. Presenting the award is 2005 BIF President Lynn Pelton. Kelley won the scholarship with her essay, "The Relationship of Genetics and Nutrition and Their Influence on Animal Performance."

The Beef Improvement Federation honored Jamie Williams (left), Colorado State University, with the Frank Baker Memorial Scholarship during an awards luncheon April 19 at the 2006 BIF Annual Meeting and Research Symposium in Choctaw, Miss. Presenting the award is Larry Cundiff of the Roman L. Hruska U.S. Meat Animal Research Center. Williams won the scholarship with her essay, "Selection to Improve Performance of Cattle in Subtropical Regions Using Heat Tolerant EPD."
Using the Rate of Genetic Change and the Population Structure of Cattle to Better Target Genetic Progress

Gabriela C. Márquez Betz
Department of Animal Sciences
Colorado State University
Fort Collins, CO 80523

Introduction

Understanding the structure of the beef cattle industry is important for driving genetic improvement. Knowledge of the dynamics of the pedigreed population is the first step toward making genetic improvement recommendations (Koots and Crow, 1989). In beef cattle populations, not all herds contribute the same amount of genetics to the breed. There are two different kinds of herds: pedigreed or seedstock herds and herds that sell their product commercially for slaughter (Baker and Davey, 1960; Lush, 1946). The pedigreed portion of the beef cattle industry is made up of more than one type of breeder. This sector includes the “nucleus” herds that supply genetics to the rest of the “multiplier” herds. These multiplier herds in turn supply genetic material to commercial producers (Lush, 1946). There is overlap between the two, as many of the nucleus herds also sell animals to the commercial herds.

In an analysis of the American Red Angus Association Pedigree from 1985 to 1989, currently under way at Colorado State University, 3,829 herds (81.75% of the total) did not appear in the pedigree as having bred sires of sires, and 3,087 herds (66.63% of the total) did not contribute to any sires of dams in the pedigree. These herds are most likely multiplier herds that pass their animal’s genetics, obtained from the nucleus herds, further down to commercial producers. On the other hand, in the same analysis of the Red Angus pedigree, 4 herds were found to be responsible for producing 20.6% of the parental grandsires and 13.4% of the maternal grandsires in the pedigree, this indicates that these four herds are nucleus herds. Genetic change is passed on to commercial producers after the nucleus breeders make the changes (Smith and Banos, 1991). The Red Angus model is similar to what has been reported in other breeds (Gutiérrez et al., 2003; McGuirk, 2000; Robertson, 1953). There is great potential for genetic improvement in beef cattle, by better analyzing and understanding the structure of the pedigrees and targeting genetic improvement programs to the true drivers of genetic change.

Knowing the rate and direction of genetic change in a breed can influence our ultimate decision regarding genetic improvement. The main factors contributing to the rate of genetic change are the selection intensity, generation interval, genetic variation, and accuracy of selection (Bourdon, 2001). We can make the rate of genetic change faster by intensifying selection, shortening generation intervals, improving accuracy or having more genetic variation. These factors contribute to genetic change in different ways. Some, like the intensity of selection or generation interval can be manipulated relatively easily by beef cattle breeders. On the other hand, genetic variation and accuracy of selection are difficult to manipulate. There are interactions between all these factors that have to be taken into account when making selection decisions. The nucleus breeders are the ones that make the greatest impact in the rate of genetic change of a breed,
because their animals have the greatest representation in the pedigrees of the breeds.

Review of Literature

Rate of genetic change. In cattle populations, the rate of genetic change is driven by accuracy of selection, selection intensity, genetic variation and generation interval (Bourdon, 2000):

\[ \Delta BV / t = \frac{rBV \cdot BVi \cdot \sigma BV}{L} \]

Where \( \Delta BV / t \) is the change in breeding values over time, or rate of genetic change over time. \( r_{av} \) is the accuracy of selection, \( i \) is the selection intensity, \( \sigma BV \) is the genetic variation, and \( L \) is the generation interval (Bourdon, 2000). From this equation we see that the rate of genetic change can be increased by reducing the generation interval, or by increasing selection intensity, accuracy of selection, or genetic variation.

In populations like the beef cattle population of the United States, where matings are not random, genetic change occurs, or should occur, constantly from generation to generation, but it can be positive or negative. The key to achieving genetic improvement is that the value of all the positive changes outweigh the value of all the negative changes (Garrick, 2006). This involves identifying the animals with the best breeding values, and selecting them to become the parents for the next generation (Bichard, 2002). On an individual basis genetic improvement requires that the net benefit per animal be greater than the total cost of achieving the improvement (Garrick, 2006). In any situation, the goal of the breeder should be to produce future generations that are more profitable than the last (Bichard, 2002).

Accuracy. The accuracy of selection is defined as “the correlation between true breeding values and their predictions for a trait under selection” (Bourdon, 2000). Increasing accuracy can enhance the rate of genetic change, by having more appropriate estimates of true breeding values. Harris and Newman (1994) reason that, if we have accurate estimations of genetic parameters, response to selection can be maximized because we know more about the animals used for breeding.

Statistics is a very important tool for animal breeders, and techniques that have been developed over the years, such as best linear unbiased prediction, among others, have improved the accuracy of reported breeding values for cattle (Harris and Newman, 1994). Accuracy has also been improved though progeny testing, which commonly takes place in the dairy industry. Individual animals, with large numbers of offspring, have more accurate records than animals where only the individuals are tested (Harris and Newman, 1994). Nicholas and Smith (1983) propose that reproductive technologies, such as embryo splitting and cloning, act as a way to increase accuracy because records on genetically identical individuals are available, therefore improving the animal’s accuracy. Accuracy is important for making mating decisions and genetic improvement, but Harris and Newman (1994) suggest that the influence of selection intensity and generation interval on genetic improvement is greater.

Selection intensity. Bourdon (2001), defines selection intensity as the “difference between the mean selection criterion of the individuals selected to be parents (\( S_C \)) and the average selection criterion of all potential parents (\( \overline{SC} \)), expressed in standard deviations from the mean” or, \( i = \frac{S_C - \overline{SC}}{\sigma c} \). Selection is a function of reproduction, replacement rate, and recognizing genetically superior animals in time for breeding (Bichard, 2002). In the beef industry, the selection that drives genetic improvement is usually performed at the level of the nucleus herds, and this genetic improvement is passed down to other herds through the multiplier herds.
Reproductive physiology places limits on the amount of selection intensity that can be achieved (Harris and Newman, 1994). Selection has intensified with progress in reproductive technologies, which results in fewer parents contributing to the next generation of offspring (McParland et al., 2007). As mentioned above, in beef cattle herds, selection intensity is usually higher in males because of their reproductive physiology, and technologies like artificial insemination, that make it possible for reproductive rates of one animal to be artificially high (Smith and Banos, 1991). This makes it more feasible to select a few popular sires out of the population, driving up selection intensity. More intensive selection of females also improves the rate of genetic change, and can be achieved by technologies like embryo transfer and in vitro fertilization, but these technologies are so far limited to animals that have proven their genetic superiority and does not take place in the majority of beef herds (Smith and Banos, 1991). One negative aspect of more intense selection is the loss of genetic diversity, which will be discussed later (Cleveland et al., 2005).

**Generation Intervals.** Generation interval also affects the rate of genetic change, it is desirable to have a lower generation interval for a greater rate of change (Comstock et al., 1998). The generation interval is the time required to replace one generation with the next, and is measured as the average age of the parents at the birth of their offspring (Bourdon, 2000). The generation interval is calculated by taking the age of each of the parents at the birth of its offspring and averaging it over all the parents (Baker and Davey, 1960).

Three recent studies report generation intervals in different breeds. Gutiérrez et al. (2003) found, that in some breeds of Spanish beef cattle generation intervals were longer in larger populations, but there was a trend towards shorter generation intervals due to improvements in reproductive management and the use of genetic evaluations for replacement decisions. McParland et al. (2007), in an analysis of Irish Charolais, Limousin, Hereford, Angus and Simmental and Holstein-Fresian cattle populations found that generation intervals were increasing, but at decreasing rates. Bozzi et al. (2006) studied Chianina, Marchigiana and Romagnola cattle pedigrees and found that sire-offspring pathways had shorter generation intervals, they proposed that this was due to early replacement of sires, especially when artificial insemination was used. In these papers we see a trend toward shorter generation intervals, which could result in a faster rate of genetic change in the breeds, by using younger parents to produce new generations.

**Genetic Variation and Inbreeding.** It is important to maintain genetic variation and diversity in a population. Inbreeding lowers genetic diversity (Bourdon, 2000), it increases homozygosity in a population and has deleterious effects towards traits such as weight and fertility (Wright, 1923). Burrow (1993) in a review of the effects of inbreeding in cattle found that inbreeding caused a decrease in performance in traits such as male and female reproduction, feed intake, conformation, and also in growth and maternal traits. The effects were minor at low levels of inbreeding, and increased at high levels of inbreeding. One of the biggest consequences of inbreeding is the loss of hybrid vigor, which causes declines in the traits mentioned above (Wright, 1922). Heterozygosity can be recovered though outbreeding or crossbreeding, thus recovering
hybrid vigor (Wright, 1923). Cleveland et al. (2005) found inbreeding to be decreasing and then increasing in the population of USA Herefords. In other studies inbreeding has also been found to be increasing slightly, but at a manageable rate (McParland et al. 2007; Bozzi et al. 2006; Gutiérrez et al. 2003). Keeping inbreeding at low levels is important so that performance ability is not lost in the animals. In reported populations inbreeding is being kept sufficiently low to avoid most of its negative consequences.

In the 1920’s Wright developed a coefficient of relationship that describes the probability that an individual’s genes are identical by descent to the genes of another individual. Comstock et al. (1998) describe it as the relationship of an animal to itself. Wright’s coefficient of relationship measures how closely an animal is related to the population being studied (Comstock et al., 1998). Comstock et al. (1998) list Wright’s coefficients, along with inbreeding coefficients and the coefficient of direct relationship, for some of the most influential sires of the American Red Angus Association pedigree in an article for the American Red Angus trade publication.

Another reason why genetic variation is important is because cattle need to be adaptable to differing beef production trends. Adaptation can be achieved by maintaining access to genetics that provide the potential for adaptation in individual breeds (Notter, 1999). In this paper, Notter states that in order to maintain a potential for adaptation, allelic diversity, or the range of potentially adaptive alleles present in a species, must be maintained. It is important to maintain adaptive capabilities in beef cattle populations because they are catering to a consumer oriented market and the final product needs to be able to change with changes in consumer preferences in order to be more profitable.

Knowledge of genetic diversity is important in managing beef cattle populations in both small and large populations where only a few sires are used (Nomura et al., 2001), and in populations where there is not much exchange of breeding animals (Bozzi et al., 2006). Modifying breeding programs to include more sires can lead to an increase in genetic diversity and increased adaptation potential (Bozzi et al., 2006). Nomura et al. (2001) analyzed the effects of inbreeding in Japanese beef cattle breeds and recommended that there be an upper limit on the use of artificial insemination in order to keep diversity and inbreeding at appropriate levels, so the genetic improvement achieved in the Japanese breeds would not be lost. Koots and Crow (1989) found that, in the Canadian Hereford population, there is little variation among herds due to the high level of transfer of breeding animals from one herd to the next. This limits the adaptive potential of this population, and does not take advantage of possible hybrid vigor.

**Dissemination of Genetics.** We can achieve genetic progress if we know how genetics are disseminated in a breed. When accurate pedigree information is available, the genetic structure of a population can be inferred, we can know which animals and which herds have made the greatest contribution of genetics to the whole breed (Cole et al., 2004). Lush (1946) was one of the first to describe that there are two types of herds in breeds of beef cattle. One type are the registered herds that appear in the breed association’s pedigrees, and the second type are the commercial herds, where cattle are sold for slaughter (Baker and Davey, 1960). Registered herds can be further broken down into two categories: nucleus herds that provide the core genetics for the breed, and multiplier herds that act as an intermediate between the nucleus herds and the commercial producers (Baker and Davey, 1960; Lush, 1946). Robertson (1953) described that the genetics of a breed as a whole depend on a relatively small group of nucleus herds that dominate the breed. The multipliers herds’ role is to multiply the genes from the nucleus herds and pass them on to other herds.
The remaining commercial herds that do not always appear in the pedigree receive their genetics from the multiplier herds. There is some direct exchange of animals between the nucleus herds and the commercial herds, but the nucleus-multiplier-commercial model applies widely to many breeds. Lush (1946) suggested that the distribution of genetic quality from one herd to another is approximately continuous, so that the drivers of genetic progress are the nucleus herds and the rest of the breed is being changed to reflect the composition of the nucleus herds. Beef cattle breeding is part of a dynamic system where all of the components interact, but the structure described above can be taken as a rough description of what happens (Robertson, 1953). This line of thinking has been corroborated in other studies where a small number of herds behave as selection nucleus which supply sires for the rest of the population. The rate of genetic change in the rest of the herds should mimic the rate achieved in the nucleus herds, since the nucleus genetics are ultimately being passed down (Gutiérrez et al., 2003; McGuirk, 2000).

Robertson and Asker (1951), in an analysis of British Friesian cattle, found that over 80% of the sires used in a herd were bred in outside herds. They found that 80% of the grandsires of females born in 1945 were bred in what they classified as nucleus herds. As a result of this breed structure, the rest of the herds are behind the nucleus group in terms of genetic progress, and the nucleus group needs to continue improving in order to stay on top. Koots and Crow (1989) found that in Canadian Herefords, over two thirds of the sires used and one third of dams used were bred in outside herds. Because genetics are being transferred from the nucleus herds to the rest, the genetic superiority of the nucleus herds is constantly being eroded by the use of its animals in the other groups (Robertson and Asker, 1951). Koots and Crow (1989) suggest that herds adopt positions in the breed hierarchy as a result of the popularity of their breeding animals, the breeding methods they use and other market forces. They found that, in the Canadian population of Herefords, the more popular herds had higher calving ease scores, lower pre-weaning gain and higher gain from birth to yearling age. Bichard (1971) suggests that in order to have the most productive commercial herds available, the lag in genetic progress between the top herds and the rest of the herds must be minimized. It is clear that there is a structure in beef cattle breeding, and we can take advantage of it to improve genetics faster by targeting the herds that are actually making the genetic changes, and minimizing the lag between them and the rest of the breed.

**Reproductive Technologies.** An additional factor has to be taken into account when talking about genetic improvement. Advances in reproductive technologies such as artificial insemination, embryo transfer and splitting, cloning, etc., have changed many aspects of animal agriculture including beef cattle breeding and genetics. By making reproductive rates artificially high we can select the best animals more intensively and get more offspring out of them. The same well-proven Mendelian inheritance principles are involved with these technologies so results on genetic improvement can be predicted (Nicholas and Smith, 1983). Nicholas and Smith (1983) suggest that with well designed selection experiments, the rate of genetic improvement can be increased and theoretically even doubled with the use of embryo transfer and splitting. When a superior bull is identified, artificial insemination allows for rapid transfer of genetic material and leads to rapid genetic progress (Bichard, 2001). Vozzi et al., 2006 found in the Nelore breed in Brazil, that artificial insemination lead to a high genetic contribution of just a few sires, presumably genetically superior. By identifying the best animals and using them for breeding at higher rates than the rest of the population, we are making genetic progress much faster than would be permissible without these reproductive technologies.
Conclusion and Implications To Genetic Improvement Of Beef Cattle

A point has been made in the literature that there are, within breeds, nucleus herds that act as drivers of genetic change (Baker and Davey, 1960; Robertson, 1953; Lush, 1946). Subsequent studies in different breeds have suggested that this is in fact still the case (McParland et al., 2007; Gutiérrez et al., 2003; Bozzi et al., 2006; Bichard, 2001). These nucleus herds supply much of the genetic material that is passed down to the rest of the herds, and are responsible for much of the genetic change in beef cattle breeds. Identifying these herds in different beef cattle breeds would be beneficial to hasten genetic improvement in the breed as a whole, thus making producers of all different levels more profitable. As Harris (1998) points out, in an industry where a producer is rewarded for a high relative quality of their product, everyone is better off concentrating genetic improvement efforts with the superior breeders, who will pass this improvement on to other producers. The nucleus breeders can make changes faster than many small breeders working toward different goals.

None of the components that affect the rate of genetic change: the accuracy, intensity of selection, genetic variation and genetic interval, are isolated from one another. More often than not tradeoffs have to be made in practical situations. A higher intensity can be achieved if we use older and fewer animals, which will have a negative impact on generation intervals. Accuracy can also be improved if we use fewer, proven, individuals as parents, but this would result in a loss of genetic diversity, because we are using fewer parents for the next generation, and therefore fewer genes. Every breeder must make choices that will affect the rate of genetic change in his or her herd, and not all breeders will have the same goals, because of differences in the markets they cater to, environmental limitations, etc. Recommendations on practical issues must be made on the basis of achieving genetic improvement. Making genetic improvement is a never ending process and the result will be cattle that are better adapted to their environment and more profitable for all kinds of producers.

In order to keep up with consumer demands and market pressures, constant genetic improvement in beef cattle is needed. A lot can be learned about the movement of genetics in a breed by analyzing pedigreed populations. If we identify superior nucleus breeders and target them with scientific recommendations on traits to select for, we will be targeting the breed as a whole and everyone will benefit, especially if the lag of genetic transfer between one group and the other is low. One of the main challenges facing the beef industry is to have producers that are more economically efficient. If positive genetic change can be made at a higher rate, this goal can be achieved. Studying pedigrees and understanding the dissemination of genes and the rate of genetic change within breeds is a way to make genetic improvement faster.

References


Genetic Improvement in Beef Cattle for Feed Efficiency: Increasing our Understanding of the Biological Basis

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Introduction

The basis of feed utilization has been instigating the curiosity of researchers for many years. In 1859, Charles Darwin pointed out initial insights about the variation of animals under domestication. He mentioned that ‘the nature of the organism’ and ‘the nature of conditions’ account for utilization of food by the organism, such as colour from the nature of the food or size from the amount of food. For almost one and a half centuries, geneticists; physiologists; nutritionists and researchers from other disciplines have been working hard in this broad topic: feed efficiency in farm animals; and a number of important advances were made. Crop scientists developed efficient varieties of diverse grains and forages, which are adapted to the different environments around the world that can be economically used to feed farm animals. On the other hand, animal scientists developed breeds and strains, which produce goods that are essential to meet the demand of humankind for animal products. For all livestock production systems feed is a major expense, ranging from 60 to 80% of the total costs across the most common farm animals species. There are also environmental issues associated with livestock production (e.g. greenhouse gases emission, land degradation, loss of biodiversity, water shortage and pollution), which are related to the type of husbandry system, to the compounds of the diet and to the quantity of feed necessary to supply the animals’ needs for growing and production. To date, the livestock sector generates more greenhouse gases than transport activities, being responsible for 18% of total greenhouse gases emissions from human activity (FAO, 2006). Therefore, improvements in the efficiency of feed utilization by farm animals could bring economical benefits for the livestock industry and also could be more environmentally sustainable.

Some of the feed efficiency measurements have their theoretical roots on feed evaluation systems. The conceptual framework and initial determinations of the variables used in the two most popular models for representation of nutrient utilization by animals (metabolic - ME and net energy systems – NE) were suggested early in the 20\textsuperscript{th} century (e.g. Armbysy, 1917). Based on these models, multiple approaches to measuring and reporting feed efficiency utilization where developed in the last 50 years, such as: maintenance efficiency (Ferrell & Jenkins, 1985), partial efficiency of growth (Archer et al. 1999), Kleiber ratio (Arthur at al. 2001), and residual feed intake (RFI) (Koch et al. 1963). Among these, RFI is the only measure independent from production traits. As a result, RFI probably reflects more variation in basic metabolic processes (maintenance requirements) (Nkrumah et al. 2006) than variation due to differences in level of production. Moreover, there is a known genetic variation in RFI in all livestock species (Pitchford, 2004), making the selection for RFI possible. However, the biological basis associated with this variation has not been completely elucidated either in
small animals (e.g. poultry, mice) or in large animals such as beef cattle. A better understanding of the biological basis associated with RFI might result in the following benefits: prediction of correlated response to selection; identification of traits that are less expensive to measure than feed intake and efficiency and; it might suggest alternative, non-genetic methods, which might be used to manipulate metabolism in beef cattle.

The biological basis associated with RFI in beef cattle have been intensively investigated in the last few years (Johnston et al. 2002; Richardson et al. 2004; Herd et al. 2004; Richardson & Herd, 2004, Kolath et al. 2006a,b, Nkrumah et al. 2006, Hegarty et al. 2007). It is recognised that progress is being made in this area. Some plausible explanations for variation in RFI and identification of physiological markers as predictors for RFI have been developed. As well, technologies such as infrared thermography (Schaefer et al. 2005, Montanholi et al. 2006) and indirect calorimetry (Nkrumah et al. 2006, Castro Bulle et al. 2006) has been applied as a predictive tool for the animal’s RFI. There is no shortage of approaches that, singularly or in combination, might contribute to genetic variation in energy utilization in ruminants. Therefore, a challenge for the future is to unravel the mechanisms responsible for the remaining unexplained variation in RFI and to validate the proportional contribution of the already known mechanisms, which might result in new predictors for RFI that could be applied as selection criteria for feed efficiency in beef cattle. The objectives of this paper include: i) to contextualize and define the concept of RFI and to present some of its genetic parameters; ii) to review some of the studies conducted to evaluate the biological basis of RFI and to suggest possible ‘new-candidates’ for RFI biomarkers; and iii) to highlight some of the potential implications and opportunities for beef cattle breeding on the biological basis of feed efficiency.

Review of literature

Like in other livestock production sectors, the beef sector aims for high productivity and profit to be a successful enterprise. A significant portion of this success is due to the objectives of the breeding program applied. An objective of breeding programs is to increase the efficiency of production, and irrespective of how efficiency is defined, the efficiency of nutrient utilization will form a major component of the breeding program objective (Pitchford, 2004). Feed costs are the main portion of total expenses in cattle feeding operations. The cost of feeding beef cows may account for 60–65% of the total cost of production in a cow-calf operation (Kaliel & Kotowich, 2002). In the feedlot operation these costs may represent more than 70% of the total expenses of production (Taylor & Field, 1999). Thompson & Barlow (1986) modelled the effect of changes in feeding and growth parameters on the efficiency of the cow-calf unit and they concluded that one of the most promising avenues for increasing the biological efficiency of the total production system would be to decrease the maintenance feed costs of breeding cows. To date, approximately 24 million metric tonnes of feed dry matter are fed to an estimated 6.5 million growing calves destined for slaughter in Canada. An improvement in feed utilization of only 1% would result in an estimated savings of over $31 million annually in feed costs to the beef industry alone. It also could result in a reduction of over 242,000 metric tonnes of manure dry matter per year and minimize the greenhouse gases emissions which could have a large impact on reducing the environmental impact of cattle feeding operations. Therefore, improvements in the efficiency of feed utilization will go a long way in reducing the cost of production and will also result in important environmental benefits.

Feed efficiency traits have been incorporated in selection objectives and selection criteria in poultry (Fairfull & Chambers, 1984) and pig
breeding programs (De Vries & Kanis 1992). In dairy (Persaud et al. 1991) and beef cattle (Barwick et al. 1994) breeding programs, selection objectives have generally focused on outputs (e.g. fertility and carcass traits), which have not included feed efficiency traits. This approach has been used in cattle due to the difficulty in recording feed inputs. Indeed, the establishment of nucleus breeding herds in dairy and beef presents the opportunity to include feed efficiency traits in the selection objectives and also the opportunity to identify biological predictors of the feed efficiency traits. Besides the myriad of feed efficiency measures described in the literature herein special emphasis will be given to RFI, which has emerged as one of the key parameters for assessing feed efficiency in all livestock species in the last two decades. Especially in the case of beef cattle, there has been increased interest in using RFI as a selection criterion in animal breeding programs. Actually, the Australian beef genetic improvement scheme, BREEDPLAN, started providing estimated breeding values for RFI on animals from 2002 (Arthur & Herd, 2005).

The concept of RFI was first described in 1963 by Koch et al. These authors examined various indices for calculating feed efficiency and suggested that feed intake could be adjusted for liveweight and weight gain, effectively partitioning feed intake into two components: (1) the feed intake expected for the given level of production; and (2) a residual portion. The residual portion (RFI) can be used to identify those animals that deviate from their expected level of feed intake, and they can be classified as high efficiency (negative residual intake) or low efficiency (positive residual intake). The units of RFI are in amount of feed eaten adjusted to mean production rather than feed per unit production, which is common for other efficiency measures. The residual portion is related to true metabolic efficiency which would be comparable across beef industry segments. This feature not only overcomes the limited insight into efficiency of the entire production system, which occurs when using others measures of feed efficiency, but also overcomes the problem of the high correlation with production traits that is characteristic of other feed efficiency traits.

The computation of RFI requires the estimation of expected feed intake. This can be predicted from production data by using feeding standards formulae (e.g. National Research Council, 1996), by using individual feed intake prediction models (e.g. Cornell Value Discovery System, 2004) or by phenotypic or genetic regression using actual feed test data (Kennedy et al. 1993). Calculation of RFI, as reported in several recent studies which used the phenotypic regression approach (Archer et al. 1997; Arthur et al. 2001a,b; Crews et al. 2003), can generally be summarized as:

\[
y = \beta_0 + \beta_1(ADG) + \beta_2(WT) + RFI
\]

Where \(y\) is daily feed intake, \(\beta_0\) is the regression intercept, \(\beta_1\) is the partial regression of daily intake on average daily gain (ADG), and \(\beta_2\) is the partial regression of daily intake on body weight (WT). Note that the above equation was designed for young and growing cattle; although the concept of RFI is not so limited, it is possible to adapt equations for other beef cattle categories as well such as pregnant beef cows (Montanholi et al. 2006).

All reviews (e.g. Kelley, 2006) and major studies highlight the existence of genetic variation in feed efficiency and the fact that most feed efficiency traits are moderately heritable, hence the potential for genetic improvement (Arthur & Herd, 2005). Pitchford (2004) calculated the mean heritability of 0.25 for RFI from 35 estimates across seven species/types. Specific heritability estimates of RFI in beef cattle include 0.39 to 0.43 (Arthur et al. 2001a); 0.26 to 0.30 (Crews et al. 2003) and 0.38 (Schenkel et al. 2004). There are no estimates for heterosis associated with RFI in
cattle but, negligible values (around 3%) were found in Japanese quail (Pitchford, 2004). From the genetic point of view, RFI owns an extra advantage in comparison to other traits of feed efficiency. It presents a high genetic correlation between the trait measured in the young animal and that measured in the adult, while for other feed efficiency traits, such as feed conversion ratio, this correlation is low (Archer et al. 2002). This indicates that RFI probably reflects more variation in basic metabolic processes (maintenance requirements) than variation due to differences in level of production or growth rate.

Although RFI offers the possibility to select on the proportion of feed intake, which is due to the metabolic processes, in some respects quantitative genetics has been based on a ‘black box’ approach. This philosophy has been useful, and during the past few decades the discipline of Genetics has been very successful in delivering tools and outcomes to improve animal production (Arthur & Herd, 2005). However, this approach does not make use of the knowledge of physiological processes of animal production. The better understanding and application of the biological basis involved in RFI differences can be very useful for a number of disciplines. The biological basis associated with RFI might work as a tool in Animal Breeding, as well as a bridge between Nutrition, Physiology and Genetics research. Especially in the case of Genetics, a comprehensive understanding of the biological basis of RFI might be helpful for prediction or assessment of correlated responses to selection, supporting quantitative geneticists and also by giving some hints to molecular geneticists about possible metabolic pathways, which might be controlled by certain major genes.

Some studies have been conducted on the biological basis of RFI in beef cattle, mainly by Australian, American and Canadian researchers (Johnston et al. 2002; Richardson et al. 2002 and 2004; Herd et al. 2004a; Richardson & Herd, 2004, Kolath et al. 2006a,b, Nkrumah et al. 2006, Hegarty et al. 2007). Richardson et al. (2002), by looking at the blood cell profiles in animals selected for and against RFI, concluded that it is doubtful that blood cells parameters could be used as predictors for RFI. In a more comprehensive study, Richardson et al. (2004) looked at a number of physiological parameters through key metabolites in beef steers from weaning through to slaughter (Table 1). These researchers found phenotypic correlations between RFI and concentrations of: β-hydroxy butyrate (r = 0.55 at weaning); aspartate aminotransferase (r = 0.34 at weaning; r = 0.43 at feedlot phase); plasma urea (r = 0.26 at weaning); total blood protein (r = 0.26 at weaning); plasma levels of glucose (r = 0.40 at feedlot phase); creatinine (r = -0.45 at feedlot phase); insulin (r = 0.43 over the experiment); blood plasma cortisol (r = -0.40 over the experiment) and leptin (r = 0.31 over the experiment). The concentrations of urea, triglycerides, insulin, and cortisol tended to be correlated with sire estimated breeding values, providing evidence for genetic associations with RFI. Johnston et al. (2002) demonstrated that plasma IGF-1 levels are correlated to RFI (r = 0.56) and its adequacy as a selection criterion for RFI was suggested (Wood et al. 2004). Currently, IGF-1 is used as a marker in a two-stage selection for RFI in Australian breeding programs and since 2004, IGF-1 information was also included in the generation of EBVs for RFI (Arthur & Herd 2005).

Herd et al. (2004) and Richardson & Herd (2004) utilized data from the above studies along with scientific information about feed utilization to estimate the percentage contribution of different physiological events to variation in RFI. Herd et al. (2004) reviewed and summarized five plausible mechanisms by which the variation in the efficiency of nutrient use may occur, Figure 1. Together, these mechanisms may be responsible for about one-third of the variation in RFI, with the remaining two-thirds likely to be associated with heat loss.
due to variation in other processes, such as protein turnover, ion transport and proton leakage. The study conducted by Richardson & Herd (2004) was slightly different from the previously discussed. Herein, the contribution of ‘protein turnover, tissue metabolism and stress’ was computed by using a multi-trait prediction equation, without any direct measurement of actual ‘protein turnover’, Figure 2. The traits selected for this multi-trait equation were: Aspartate amino transferase (AST), beta-hydroxy butyrate (BOH), creatinine (CRE), dry matter digestibility (DMD), leptin (LEP), cortisol (COR), blood viscosity (VIS) and ultrasound measurements (rib (RIB), rump (RUM) and eye-muscle area (EMA). These traits were used to identify differences in body composition (BOH, LEP, CRE, RIB, RUM, EMA); tissue turnover and metabolism (AST and BOH); stress responsiveness (COR) and; any difference in digestibility (DMD). This multiple-trait equation explained 0.52 of the observed variation in RFI.

These two studies discussed above imply that protein turnover might be a meaningful source of variation for RFI. Thus, more specific studies in this area might improve our understanding on the biological basis of RFI. Besides protein turnover, another two physiological processes also have major contributions to the total maintenance energy requirements; these are ion pumping and proton leakage (Rolfe et al. 1999). It is important to be reminded that the basic premise behind the concept of RFI is that the variation in feed efficiency is the result of variation in the basic biological processes, which are mainly represented by these three processes.

Ion pumping is a cellular metabolic process where ions are moved across cell membrane against their concentration gradient. Such transport is highly demanding in energy. In the field of Energy Metabolism one particular kind of ion pumping deserves special emphasis, the Na⁺/K⁺ pump that accounts for 20 to 30% of the total maintenance energy requirements (Baldwin et al. 1980). The electrical and concentration gradient established by the Na⁺/K⁺ pump supports the cell resting potential. The exportation of sodium from the cell provides the driving force for several facilitated transporters, and also the translocation of sodium from one side of an epithelium to the other side creates an osmotic gradient that drives the absorption of water. The function of this pump is controlled by the enzyme Na⁺/K⁺-ATPase, which is located in the cell membrane of every animal cell (Reece & Dukes, 2004). Although it has been suggested that ion pumping is an important source of variation to explain the differences associated with RFI (Richardson & Herd, 2004), there is a lack of studies demonstrating a genetic variation on this physiological event. However, there are some studies that identified a genetic component of ion pumping. For instance, the hyperkalemic periodic paralysis in some lines of Quarter horses is associated with a genetic dysfunction of the Na⁺/K⁺ pump (Pickar et al. 1991). Similarly, in certain human families one of the forms of migraine headaches is associated with mutations in a gene that encodes a subunit of the Na⁺/K⁺-ATPase (Wessman et al. 2004).

The proton leakage (H⁺) across the mitochondrial membrane is partially catalyzed by uncoupling proteins (UCPs). These proteins have an important role in the total heat production in mammals, representing around 20% of the maintenance energy requirements (Rolfe et al. 1999). The respiration chain across the inner membrane of the mitochondria provides an efficient conversion of energy from a membrane gradient to ATP, through the conversion of ADP + ~P using an electrochemical gradient generated by H⁺ concentration (mitochondrial matrix: lower H⁺ concentration, mitochondrial intermembrane space high H⁺ concentration). When this gradient results in the production of ATP, the system is defined as ‘coupled’. However, if the energy is directed away from ATP production toward heat production, due to the activation of
a given uncoupler (e.g.: weak acids or UCPs) that dissipates the $H^+$ electrochemical gradient, less energy is available for ATP production and the system is ‘uncoupled’ (Jezek et al. 1998). In this situation, energy efficiency is decreased because energy is lost as heat rather than used as an energy source by the cells. The UCPs are located in the mitochondrial inner membrane and promote the pumping of protons from the mitochondrial intermembrane space ($H^+$) back to the mitochondrial matrix, avoiding the generation of an electrochemical gradient, and thus impairing the ATP formation (Garlid et al. 2000). Kolath et al. (2006b) observed that high and low-RFI beef steers had similar expression of the two most popular UCPs (2 and 3). However, in a previous study these authors (Kolath et al. 2006a) found out that the mitochondrial function was not different between high and low-RFI steers but rather the rate of mitochondrial respiration is increased in low-RFI compared to high-RFI steers, suggesting a better efficiency of electron transfer in low-RFI steers.

Protein turnover involves the continual synthesis and breakdown of body proteins. These processes greatly exceed those of either protein intake or protein deposition (Reeds & Fuller, 1983). Although protein turnover has an important role in helping to ensure homeothermy in mammals, its role in ‘tissue plasticity’ is also vital (Lobley, 2003). Continual, extensive remodeling of tissue proteins to alter tissue structure, metabolism or activity occurs as part of normal physiological mechanisms. Depending on the physiological condition, increases and decreases in both cell number and size within specific tissues can occur (Lobley, 2003); as well protein synthesis and degradation within cells can be changed (McBride & Kelly, 1990). These changes in metabolism are associated with maintenance energy requirements, which might be reflected on variation in RFI. Around 20% of the maintenance energy requirements are due solely to whole body protein synthesis (Rolfe et al. 1999). There are some divergent information about relationships between protein turnover and RFI. Tatham et al. (2000) found a positive relationship between RFI and plasma creatinine:urea ratio, which is indicative of higher turnover of creatine phosphate in the muscle of high-RFI bulls. Conversely, Castro Bulle et al. (2006) did not find any difference between high and low-RFI beef steers in terms of myofibrillar protein metabolism. These two studies looked at metabolites derived from muscle metabolism which represents 50% of the whole body protein but accounts for only 15-20% of the whole body protein synthesis. However, there has been no investigation done in the protein turnover of more metabolic active organs such as gut, which accounts for only 5-7% of the body mass and represents 32-45% of the whole body protein synthesis. Protein turnover, ion pumping and proton leakage account for around 60 to 70% of the total energy requirements for maintenance, which basically represent the animals’ energetic inefficiency. Therefore, not only are investigations on these individual physiological events desirable, but also studies looking at the total ‘heat’ output are needed and sometimes easier to conduct than punctual investigations. Animal calorimetry studies have been carried on beef steers separated in low and high RFI groups. Nkrumah et al. (2005) found that more efficient beef steers (low-RFI) had lower heat production than medium or high RFI groups. Similar results were presented by Castro Bulle et al. (2006). These results indicate that RFI may be negatively correlated with maintenance energy requirements. However, from the practical point of view the assessment of animals’ heat production is too laborious and expensive to be performed on a large scale (e.g. testing a contemporary group of bulls). Thus, more reliable alternatives are required. The principal route for energy loss in ruminants is evaporative heat loss (through heat exchange in the lungs and nasal turbinates) (Blaxter, 1967). However, part of the energy loss happens
through the skin. This tissue is responsible for 11% of the total heat production of the animal’s body (Webster, 1983). Heat is dissipated through the skin by radiation, convection, conduction, or evaporation (Turner, 2001). A possible way to introduce this ‘heat’ information in breeding programs could be through infrared images (IRI). The infrared camera measures and images the emitted infrared radiation from an object. The fact that radiation is a function of object surface temperature makes it possible for the camera to calculate and display its estimated temperature (Turner, 2001).

Infrared thermography has been applied to assess a number of different aspects of animal production. The surface temperature of the animal’s body could be related to several pathological and physiological mechanisms and production aspects. IRI may have potential as a technique for early detection of illness in cattle (Hurnik et al. 1984; Berry et al. 2003; Schaefer et al. 2004). IRI appears to have limited usefulness for routine detection of estrus in dairy cows, but the technique may have potential as a research tool for the study of skin temperature patterns (Hurnik et al. 1985). IRI could be used prior to slaughter to detect poor quality beef and pork (Tong et al. 1995; Schaefer et al, 1989). IRI also may have applications in the field of Animal Nutrition: Caldwell (2007) noticed that bulls fed a high energy diet had higher foot temperatures than bulls fed a low energy diet. Schaefer et al. (2005) demonstrated some preliminary results that IRI may be useful in the assessment of feed efficiency in cattle. Thermal image technology is a potential tool to be applied in large scale animal production systems, because it is a non-invasive, quickly and easily obtained measurement. Moreover, Montanheli et al. (2007) have some preliminary information demonstrating, for the first time, a positive correlation \( r = 0.43 \) between infrared thermography and indirect calorimetry (heat production measured through gas exchange) in cows.

Another approach to look at the maintenance requirements is to consider the individual organs metabolic rate. The gastrointestinal tract (GIT) and liver are the main contributors to the maintenance energy requirements, relative to their contributions to total body mass (less than 10%) in ruminants (Lobley, 2003). Around 50% of the maintenance energy requirements are due to GIT (16 to 29%) and liver (20 to 26%) metabolism (Johnson et al. 1990). Unfortunately, there is limited information in the scientific literature relating RFI and the metabolism of the GIT and liver. However, the literature is rich in information about maintenance energy requirements and visceral tissue changes. There are demonstrated differences in efficiency of energy use for maintenance between animals, within species and at similar physiological states. There is also evidence that the maintenance energy requirement is associated with genetic variation in RFI (Herd et al. 2004).

Liver and GIT weights appear to increase or decrease in direct proportion to dietary intake within and across physiological stages of maintenance, growth, fattening or lactation (Johnson et al. 1990). There are also changes in visceral organ weights according to the plane of nutrition (Sainz & Bentley, 1997; Swanson et al. 1999). Changes in tissue mass are the net result of rates of cellular proliferation, cellular losses, as well as changes in cellular size (Alberts et al. 2002). The intestine has a remarkable capacity to adapt to changing conditions of alimentation. Starvation or protein deficiency results in atrophy (shrinkage of a tissue or organ due to a reduction in the size or number of cells). On the other hand, refeeding or feed intake above the normal levels results in hyperplasia (increment in the size of a tissue or organ due to the increment in the number of cells) (Fawcett, 1994). Compared to other organs that are constantly being renewed, the hepatic parenchyma is a rather stable cell population; cells in division are seldom seen in the normal
liver (Fawcett, 1994). This implies that changes in the liver weight are mainly due to hypertrophy (increment in the size of a tissue or organ due to the enlargement of existing cells).

Measurements of DNA, RNA and protein content in tissue samples can be used as indirect parameters of cell proliferation and cell size (Burrin et al. 1988; Sainz & Bentley, 1997; Swanson et al. 1999; Baldwin et al. 2004). The amount of DNA in the tissue sample is associated with the number of cells, because DNA is one of the components of the cell nucleus. DNA content between cells is quite constant within a specific cell type. The net content of protein and RNA within a cell or tissue is a result of the balance between synthesis and degradation. The relationship between estimates of actual rates of protein synthesis and ratios of cellular constituents is commonly used to indicate protein synthetic capacity of a tissue. Research has been conducted on the quantification of these nucleic acids and its quantitative relationships in liver and intestine of cattle relative to nutritional treatments (Swanson et al. 1999; Baldwin et al. 2004). However, these determinations were not well characterized between animals of different breed types or in animals ranked according to their RFI values. In the same way, direct measurements through tissue morphological studies of the patterns of cell proliferation and cell size changes may display a complementary role to the indirect measurements described above (or vice-versa). As well, patterns of natural cell death (apoptosis) might be observed through light microscopy.

Still related to the source of variation ‘protein turnover, tissue metabolism and stress’ discussed above (Figure 2), the stress component seems to display an important role in the variation of RFI in beef cattle. Stress in beef cattle is a non-specific response of the body to any demand from the environment (Frazer et al. 1975). Cattle in an intensive husbandry system are potentially subjected to an increased abundance of stressors (Fox, 1985). These stressors may end up requiring some extra activation of the animals’ immune system, which might result in a lower performance or a poorer feed efficiency (Klasing & Leshchinsky, 2000). There are some indications that in the main domestic species the high genetic pressure applied for growth has contributed to the development of lines in which nutrients are more directed to the growth of muscle at the expense of the immune system (Rauw et al. 1998). One of the consequences of chronic stress in farm animals is a suppression of the body defense barriers resulting in a lower resistance to pathogens, which certainly will result in an activation of the immune system beyond the basal level. Cortisol, a glucocorticoid hormone, synthesized and released by the adrenal gland, is a key component of the physiological response to stress (Palme et al. 2005). Richardson et al. (2004) noticed that beef steers with a genetic propensity for low-RFI have a lower cortisol concentration in the blood following stress than steers with high-RFI (8.51 vs 19.84 ng/ml) and the correlation between RFI and concentration of plasma cortisol was -0.40. Thus, cortisol levels might be a good candidate as a bio-marker for RFI.

However, there are some concerns associated with the measurement of stress hormone levels, especially in blood samples, as done by Richardson et al. (2004). Because secretion of glucocorticoids occurs in a pulsatile fashion, blood hormone concentration can change by a factor of 10 or more within minutes (Palme et al. 2005). Therefore, interpretation (on the individual level) of most endocrine parameters based on a single (blood) sample might be misleading. In addition, stress experienced during the sampling procedure imposes an important limitation. Fortunately, stressful sample collection can be avoided by using alternative sample matrices such as: saliva (Negrão et al. 2004), urine (Gwinup & Johnson, 1975), feces (Mooring et al. 2006), and hair (Davenport et al. 2006). Like blood samples,
saliva is a ‘point’ sample strongly affected by time of day, food intake, and any environmental disturbance that may have occurred shortly before sampling. On the other hand, cortisol values obtained from urine, feces and hair samples reflect somewhat longer periods of hypothalamic-pituitary-adrenocortical activity, thereby providing a true basal hormonal ‘phenotype’ for each individual subject (Davenport et al. 2006). Palme et al. (2003) found that fecal concentrations of cortisol metabolites in cattle reflected the total amount excreted and therefore reflected cortisol secretory patterns better than did blood concentrations, which changed quickly. In addition, because only the free cortisol fraction from the blood is available for metabolism and excretion, fecal cortisol metabolite concentration may more accurately reflect the biologically active portion of the hormone. Therefore, it might be worthwhile to examine the possible relationship between RFI and cortisol levels in different tissues matrices (e.g. feces) rather than blood plasma.

Conclusions and Implications to Genetic Improvement of Beef Cattle

Feed efficiency measurements constitute one of the key approaches to study animal bioenergetics and metabolism, which represent ‘undiscovered’ niches of potential traits for beef cattle breeding programs. Recently residual feed intake has re-emerged as one of the potential tools to verify the potential differences in feed efficiency among different animals. This trait likely reflects variation in basic metabolic processes more than variation due to differences in the level of production. Therefore, primary research on the most basal energy demanding processes of the organism might result in quite reliable indicators of animals’ performance, which might constitute potential tools for beef breeding.

Research conducted by diverse research groups worldwide have begun to emerge in the last few years. However, reasonable explanations for differences in feed efficiency and accurate predictors are still lacking and there are many of hypotheses yet to be tested. Besides information on increasing our understanding of the biological basis associated with feed efficiency, new bio-markers for feed efficiency will likely be proposed. There is clearly a need for more easily-obtainable indicators of the animals’ residual feed intake than that obtained through the feed record per se.

In this paper, a few potential possibilities of physiological explanations for distinct residual feed intakes were suggested; certainly many other approaches are possible to apply in the searching for biological differences among animals in respect to feed efficiency. For instance, one of the most promising technologies to ‘scan’ the animal’s tissues for potential bio-markers is proteomics; however, the costs associated with this technology are still prohibitive on a large scale. On the other hand, some of the above suggested topics such as cellular studies, infrared thermography and hormonal determinations might be examined using technologies that are more affordable and easily accomplished. Therefore an interesting scenario of testing new traits and looking for key-controlling genes will make the life of Animal Geneticists more fascinating in the near future.

Moreover, the fact that different disciplines are being combined to study feed efficiency, one might expect more biological meaningful models to explore the variation that exists in feed efficiency, as well as a greater interconnection among researchers with different expertise. This interdisciplinary approach is beneficial for ‘Beef Science’ as a whole.

Finally, the economical and environmental benefits associated with selection for more feed efficient animals are strong arguments for a long life of research on this subject. One might suggest that a new era of more and more fine
tuned and comprehensive investigations in feed efficiency has emerged with the ‘re-discovery’ of residual feed intake, which certainly will have important repercussions on Beef Breeding in the next decades.

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<th>Process</th>
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<td>Energy substrates</td>
<td>- Glucose, β-hydroxy butyrate (BOH), triglycerides</td>
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<td>Skeletal muscle mass</td>
<td>- Creatinine (blood and urine), urea</td>
</tr>
<tr>
<td></td>
<td>- Creatine kinase, urea, albumin, total plasma protein</td>
</tr>
<tr>
<td>Protein metabolism</td>
<td>(TPP), 3-methyl histidine (urine, 3MH), aspartate aminotransferase (AST)</td>
</tr>
<tr>
<td>Fat mass and metabolism</td>
<td>- Triglycerides, leptin</td>
</tr>
<tr>
<td>Liver function</td>
<td>- Total bilirubin, γ-glutamyl transferase, AST, alkaline phosphatase</td>
</tr>
<tr>
<td>Stress</td>
<td>- Cortisol</td>
</tr>
<tr>
<td>Oxygen transport efficiency</td>
<td>- Blood viscosity</td>
</tr>
<tr>
<td>Digestion</td>
<td>- Dry matter digestibility (DMD)</td>
</tr>
<tr>
<td>Rumen microbial protein</td>
<td>- Allantoin (urine)</td>
</tr>
<tr>
<td>production</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Estimates of the percentage contribution of different mechanisms contributing to the variation in RFI in beef cattle. Source: Herd et al. 2004.

Figure 2. Estimates of the percentage contribution of different mechanisms contributing to the variation in RFI in beef cattle. Source: Richardson & Herd, 2004
Seedstock Producer Honor Roll of Excellence

Billy L. Easley ....................... KY ... 1972
Dale H. Davis ........................ MT ... 1972
Elliot Humphrey .................... AZ ... 1972
Harold A. Demorest ................. OH ... 1972
James D. Bennett .................... VA ... 1972
Jerry Moore ........................... OH ... 1972
John Crowe ............................ CA ... 1972
Marshall A. Mohler ................... IN ... 1972
Albert West III ........................ TX .... 1973
C. Scott Holden ........................ MT ... 1973
Carlton M. Corbin ..................... OK ... 1973
Clyde Barks ........................... ND ... 1973
Heathman Herefords .................... WA ... 1973
James D. Hemmingsen ................ IA ... 1973
Messersmith Herefords ............... NE ... 1973
Mrs. R. W. Jones, Jr. ............... GA ... 1973
Raymond Meyer ........................ SD ... 1974
Robert Miller ............................ MN ... 1974
William F. Borrow ..................... CA ... 1974
Bert Crame ................................ KS .... 1974
Bert Sackman ............................ ND ... 1974
Dover Sinderlar ........................ MT ... 1974
Burwell M. Bates ....................... OK ... 1974
Charles Descheemacher ............... MT ... 1974
J. David Nichols ........................ IA ... 1974
Jorgensen Brothers ..................... SD ... 1974
Marvin Bohmfort ........................ NE ... 1974
Maurice Mitchell ....................... MN ... 1974
Wilfred Dugan .......................... MO ... 1974
Dale Engler ............................. KS ... 1975
Frank Kubik, Jr. ....................... ND ... 1975
George Chiga ............................ OK ... 1975
Glenn Burrows .......................... NM ... 1975
Howard Collins ........................ MO ... 1975
Jack Cooper ............................. MT ... 1975
Joseph P. Dittmer ..................... IA ... 1975
Leslie J. Holden ........................ MT ... 1975
Licking Angus Ranch ................... NE ... 1975
Louis Chestnut ......................... WA ... 1975
Robert Arthuhton ....................... KS ... 1975
Robert D. Keever ...................... MT ... 1975
Walter S. Markham ..................... CA ... 1975
Ancel Armstrong ....................... VA ... 1976
Gerhard Mittens ........................ KS ... 1976
Healey Brothers ........................ OK ... 1976
Jackie Davis ............................ CA ... 1976
Jay Pearson ............................. ID ... 1976
L. Dale Porter ............................ IA ... 1976
Lovellyn Tewsbury ..................... ND ... 1976
M.D. Shepherd ........................... ND ... 1976
Robert Sallstrom ....................... MN ... 1976
Sam Friend ............................... MO ... 1976
Stan Lund ............................... MT ... 1976
Bill Wolfe ............................... OR ... 1977
Bob Sitz ................................. MT ... 1977
Clair Percel ............................. KS ... 1977
Floyd Hawkins ............................ MO ... 1977
Frank Ramackers, Jr. ................. NE ... 1977
Glen Burrows ........................... NM ... 1977
Henry and Jeanette Chitty ............ NM ... 1977
Hubert R. Freise ....................... ND ... 1977
James Volz ............................. MN ... 1977
Lloyd DeBruycker ....................... ND ... 1977
Loren Schlipf ........................... IL .... 1977
Marshall A. Mohler ..................... IN ... 1977
Robert Brown ........................... TX .... 1977
Tom and Mary Shaw ..................... ID ... 1977
Tom Dashiel ............................... WA ... 1977
Wayne Eshelman ......................... WA ... 1977
Harold Anderson ........................ SD ... 1977
William Boro ............................ CA ... 1977
A.L. Fau ................................. CA ... 1977
Bill Wolfe ............................... OR ... 1978
Bill Womack, Jr. ......................... AL ... 1978
Buddy Cobb ............................. MT ... 1978
Frank Harpster ......................... MO ... 1978
George Becker ........................... ND ... 1978
Healey Brothers ........................ OK ... 1978
Jack Delaney ............................ MN ... 1978
James D. Bennett ....................... VA ... 1978
Larry Berg ............................... IA ... 1979
Roy Hunst ............................... PA ... 1979
Bill Wolfe ............................... OR ... 1979
Del Krumweid ........................... ND ... 1979
Floyd Metter ............................ MO ... 1979
Frank & Jim Wilson ..................... SD ... 1979
Glen & David Gibb ...................... IL .... 1979
Jack Ragsdale .......................... KY ... 1979
Jim Wolf ................................. NE ... 1979
Leo Schuster Family .................... MN ... 1979
Peg Allen ............................... MT ... 1979
Rex & Joann James ...................... IA ... 1979
Bill Wolfe ............................... OR ... 1980
Blythe Gardner ......................... UT ... 1980
Bob Laflin ............................... KS ... 1980
Charlie Richards ....................... IA ... 1980
Donald Barton ........................... UT ... 1980
Floyd Dominy ........................... VA ... 1980
Frank Felton ............................. MO ... 1980
Frank Hay ............................... CAN ... 1980
James Bryan ............................... MN ... 1980
John Masters ............................ KY ... 1980
Mark Keffer ............................. SD ... 1980
Paul Myland .............................. MT ... 1980
Richard McLaughlin .................... IL .... 1980
Richard Tokach ......................... ND ... 1980
Roy and Don Udelhoven ............... WI ... 1980
Bob & Gloria Thomas .................... OR ... 1981
Bob Dickinson ........................... KS ... 1981
Clarence Burch ........................... OK ... 1981
Clayton Canning ....................... CAN ... 1981
Dwight Houff ............................ VA ... 1981
G.W. Crowell ............................ IA ... 1981
Harold Thompson ....................... WA ... 1981
Herman Schaefer ........................ IL ... 1981
J. Morgan Donelson ..................... MO ... 1981
Jack Ragsdale .......................... KY ... 1981
James Leachman ....................... MT ... 1981
Lynn Frey ............................... ND ... 1981
Myron Autfath ........................... MN ... 1981
Roy Beeby ............................... OK ... 1981
Russ Denowh ............................ MT ... 1981
Bob Thomas .............................. OR ... 1982
Clare Geddes ............................ CA ... 1982
David A. Breimer ....................... KS ... 1982
Frankie Flint ............................ NM ... 1982
Garold Parks ........................... IA ... 1982
Gary & Gerald Carlson .................. NS ... 1982
Harlin Hecht ........................... MN ... 1982
Howard Krog ............................. MN ... 1982
Joseph S. Bray ........................... KY ... 1982
Larry Leonhardt ......................... MT ... 1982
Orville Stangl ........................... SD ... 1982
W.B. Williams ........................... IL ... 1982
William Kottwitz ........................ MO ... 1982
Alex Stauffer ........................... WI ... 1983
Bill Boro ................................. CA ... 1983
C. Ancel Armstrong .................... KS ... 1983
Charles E. Boyd ......................... KY ... 1983
D. John & Lebert Schultz .......... ......... MO ... 1983
E.A. Keithley ............................. MO ... 1983
Frank Myatt ............................. IA ... 1983
Harvey Lemmon .......................... GA ... 1983
J. Earl Kindig ............................ MO ... 1983
Jake Larson ............................. ND ... 1983
John Bruner ............................. SD ... 1983
Leness Hall ............................. WA ... 1983
Ric Hoyt ................................. OR ... 1983
Robert H. Schafer ....................... MN ... 1983
Russ Pepper ............................. MT ... 1983
Stanley Nesemeier ..................... IL ... 1983
A. Harvey Lemmon ...................... GA ... 1984
Charles W. Druin ........................ KY ... 1984
Clair K. Parcell ........................... KS ... 1984
Donn & Sylvia Mitchell ............... CA ... 1984
Earl Kindig ............................. VA ... 1984
Floyd Richard ......................... ... 1984
Fred H. Johnson ......................... OH ... 1984
Glen Klippenstein ........................ MO ... 1984
Jack Farmer ............................. CA ... 1984
Jerry Chappell .......................... VA ... 1984
Joe C. Powell ........................... NC ... 1984
John B. Green ........................... LA ... 1984
Lawrence Meyer .......................... IL ... 1984
Lee Nichols ............................. IA ... 1984
Phillip A. Abrahamson ................. MN ... 1984
Ric Hoyt ................................. OR ... 1984
Robert L. Sitz ........................... MT ... 1984
Ron Beiber .............................. SD ... 1984
Arnold Wienk ........................... SD ... 1985
Bernard F. Pedretti ..................... WI ... 1985
David McGehee ......................... KY ... 1985
Don W. Schoene .......................... MO ... 1985
Earl Schaefer ............................ MN ... 1985
Jim & JoAnn Enos ............... IL .... 1997
Juan Reyes .......................... WY ... 1997
Nicholas Wehrmann ............... VA ... 1997
Richard McClung .................. VA ... 1997
Abilgail & Mark Nelson .......... CA ... 1998
Adrian Weaver & Family .......... CO ... 1998
Airy Family .......................... MB ... 1998
Dallis & Tammy Basel .......... SD .... 1998
Dave & Cindy Judd ............... KS .... 1998
Dick & Bonnie Helms .......... NE .... 1998
Duane L. Kruse Family ........ IL .... 1998
Earl & Nedra McKarns .......... OH ... 1998
James D. Bennett Family ........ VA ... 1998
Tom Shaw ............................ ID ... 1998
Wilbur & Melva Stewart ......... AB ... 1998
Duane Schieffer .................. MT ... 1999
John Kluge ........................... VA ... 1999
Kelly & Lori Darr ............... WY ... 1999
Kent Klineman ........................ SD .... 1999
Lynn & Gary Pelton .............. KS .... 1999
Noller & Frank Charolais ....... IA .... 1999
Rausch Herefords ................. SD .... 1999
Steve Munger ......................... SD .... 1999
Terry O'Neil ....................... MT ... 1999
Tony Walden ........................ AL .... 2000
Alan & Deb Vedvei .............. SD .... 2000
Banks & Margo Hernond ........ AL .... 2000
Blane & Cindy Nagel ............. SD .... 2000
Galien, Lori & Megan Fink .... KS .... 2000
Harlin & Susan Hecht ........... MN ... 2000
Jim & Janet Listen ............... WY ... 2000
John & Betty Botert ............. MO ... 2000
John C. Curtin ...................... IL .... 2000
Kend Klineman
& Steve Munger .................. SD .... 2000
Larry & Jean Croissant .......... CO ... 2000
Mike & T.K. McDowell ............ VA ... 2000
Ralph Blalock, Sr. Blalock, Jr. and
David Blalock ...................... NC ... 2000
Vaughn Meyer & Family .......... SD .... 2000
Blane & Cindy Nagel ............ SD .... 2001
Bob & Nedra Funk ................. OK ... 2001
Don, & Mike Spencer .......... NE .... 2001
Don & Priscilla Nielsen ......... CO ... 2001
Eddie L. Sydenstricker ......... MO ... 2001
George W. Lemm .................. VA ... 2001
Ken Stielow & Family .......... KS .... 2001
Kevin, Jessica, & Emily Moore ........ TX ... 2001
Marvin & Katheryn Robertson .... VA ... 2001
McAllen Ranch ..................... TX ... 2001
Steve Hillman & Family ......... IL .... 2001
Tom Lovell ......................... AL .... 2001
DeBruycker Charolais .......... MT ... 2002
Ellis Farms ......................... IL .... 2002
Holly Hill Farm .................... VA ... 2002
Isa Cattle Co., Inc ............... TX ... 2002
Lyons Ranch ....................... KS .... 2002
Noller and Frank Charolais .... IA .... 2002
Rishel Angus ....................... NE .... 2002
Running Creek Ranch .......... CO ... 2002
Shamrock Angus ................... WY ... 2002
Stewart Angus ..................... IN .... 2002
Triple "M" Farm ..................... AL .... 2002
Bedwell Charolais .......... IA .... 2003
Boyd Farm ......................... AL .... 2003
Camp Cooley Ranch .......... TX .... 2003
Hilltop Ranch ..................... TX .... 2003
Moser Ranch ....................... KS .... 2003
Mystic Hill Farms .......... VA .... 2003
Pingetzer’s Six Iron Ranch .... WY .... 2003
San Isabel Ranch .......... CO .... 2003
Shamrock Vale Farms .......... OH .... 2003
Adams Angus Farm .......... AL .... 2004
Byland Polled Shorthorns ..... OH ... 2004
Camp Cooley Ranch .......... TX .... 2004
Eaton Charolais .................. MT ... 2004
Flat Branch Cattle Company ... IL ... 2004
Judd Ranch, Inc. ............... KS ... 2004
Rausch Herefords ............... SD ... 2004
Reynolds Ranch ................. CO ... 2004
Silveira Brothers Angus and
Diversified Farming .......... CA ... 2004
Symens Brothers Limousin .... SD ... 2004
Touchstone Angus ............... WY ... 2004
Triple U Ranch ................... IA .... 2004
Altenburg Super Baldy ........ CO .... 2005
Bar S Ranch ....................... KS ... 2005
Ellis Farms ......................... IL .... 2005
Ingram Cattle Company ......... MS ... 2005
Moore Farms ....................... AL .... 2005
Morrison Stock Farm .......... OH ... 2005
Pangburn Stock Farm ........... IA .... 2005
Rishel Angus ....................... NE .... 2005
Rogers Bar HR ..................... MS ... 2005
Soldiers’ Hill Angus Farm .... VA .... 2005
Sunnyhill Angus Farm .......... IL .... 2005
Waukaru Farms, Inc ............ IN .... 2005
Benoit Angus Ranch .......... KS .... 2006
Champion Hill ................. OH .... 2006
EE Ranches, Inc ............... MS .... 2006
Earhart Farms ................. WY .... 2006
Figure 4 Cattle Company / Volk Ranch
LLLP ......................... CO .... 2006
Lawler Farm ....................... AL .... 2006
Powder Creek Simmentals .... GA .... 2006
Quaker Hill Farm LLC ......... VA .... 2006
Sauk Valley Angus .......... IL .... 2006
Thomas Charolais, Inc .......... TX .... 2006
Vorthmann Limousin ........... IA .... 2006
Waukaru Farms, Inc ............ IN .... 2006
Seedstock Producer of the Year

John Crowe ............................California ...........1972
Mrs. R. W. Jones, Jr. ..............Georgia ................1973
Carlton Corbin .......................Oklahoma ...........1974
Jack Cooper ............................Montana .............1975
Leslie J. Holden .....................Montana .............1975
Jorgenson Brothers .................South Dakota ......1976
Glenn Burrows .......................New Mexico ......1977
James D. Bennett .................Virginia ...............1978
Jim Wolf ..............................Nebraska ...........1979
Bill Wolfe ..............................Oregon .............1980
Bob Dickinson .......................Kansas ................1981
A.F. “Frankie” Flint ...............New Mexico ......1982
Bill Borror ...........................California ..........1983
Lee Nichols ............................Iowa .................1984
Ric Hoyt ..............................Oregon ...............1985
Leonard Lodoen .....................North Dakota ......1986
Henry Gardiner .....................Kansas ................1987
W.T. “Bill” Bennett ...............Washington ......1988
Glynn Debter ..........................Alabama .............1989
Douglas & Molly Hoff ...........South Dakota......1990
Summitcrest Farms .................Ohio .................1991
Leonard Wulf & Sons ..........Minnesota ....1992
J. David Nichols ...................Iowa ..................1993
R.A. “Rob” Brown .................Texas .................1993
Richard Janssen .................Kansas .................1994
Tom & Carolyn Perrier ..........Kansas .................1995
Frank Felton ........................Missouri .............1996
Bob & Gloria Thomas ..........Oregon .................1997
Wehrmann Angus Ranch ........Virginia ...............1997
Flying H Genetics .................Nebraska .............1998
Knoll Crest Farms .................Virginia ...............1998
Morven Farms ......................Virginia ...............1999
Fink Beef Genetics .................Kansas .................2000
Sydenstricker Angus Farms ...Missouri ...............2001
Circle A Ranch .....................Missouri ...............2002
Moser Ranch ........................Kansas .................2003
Camp Cooley Ranch ..............Texas ..................2004
Rishel Angus .......................Nebraska .............2005
Sauk Valley Angus ..............Illinois .................2006
2006 Seedstock Producer of the Year
Sauk Valley Angus – Illinois

The Beef Improvement Federation (BIF) named Sauk Valley Angus its 2006 Seedstock Producer of the Year during the organization’s 38th annual meeting April 18-21 in Choctaw, Miss.

Headquartered southwest of Rock Falls, Ill., in Whiteside County, Sauk Valley Angus is owned by Gary and Kathy Sandrock and managed by Jay King, Ben Sandrock and Matt Sandrock. The family-owned and -operated seedstock and row-crop operation has been at the current location for seven generations. All income is derived from the sale of Angus seedstock and cash crops.

The farming operation consists of more than 10,000 acres of row-crop ground, 75% of which is irrigated. The farm raises corn, soybeans, sweet corn, wheat, peas, rye, lima beans, alfalfa, pasja and native grasses. Conservation practices have allowed the operation to maximize production while minimizing impact on the land.

The cattle operation is composed of 480 registered Angus cattle and 190 commercial Angus females that are used as embryo transfer (ET) recipients. The breeding program is focused on production of functional, balanced-trait cattle that are designed to create value in every segment of the beef industry, while yielding an end product that will exceed consumer expectations. Sauk Valley Angus conducted its 10th annual bull sale this spring, and has its 10th annual production sale scheduled this fall.

The cows are synchronized and artificially inseminated (AIed) to calve within a 45-day window in January and February. In recent years, the inception and growth of their embryo program has enabled them to propagate their most elite cow families, while expediting genetic improvements to provide customers with the cutting-edge genetics they demand.

One of the key elements in the operation is its performance recordkeeping system, composed of the Sesame Database program, which was customized by Sauk Valley Angus to utilize herd information in a more efficient manner. The Sesame Database allows them to rapidly access and utilize Angus Herd Improvement Records (AHIR™) performance data, expected progeny differences (EPDs), production records and ultrasound scan data to assist in making objective culling and selection decisions.

The Sesame Database contains the entire production record for every breeding female in the herd. In addition to individual performance information, the system provides every breeding date, every sire bred
to, every calving date and all the calving information for the life of the dam. Through this system, Sauk Valley Angus can make note of any information pertinent to the cow to help in the analysis of her performance. Custom breeding, calving, health and other reports can be printed. The program makes it easy to get all the information and history on a particular animal in a matter of seconds.

Sauk Valley Angus works with its customer base to ensure the genetics provided improve performance and profitability for their customers. One of the programs developed is the Sauk Valley-sired Feeder Calf Sale at the Walnut Sale Barn. This sale will be held for the fifth year in 2006. It has secured some of the top feeder calf prices in the area. Sauk Valley Angus also cooperates with a commercial company to provide a preconditioning program.

Through the Sauk Valley Herd Builders Program, the Sandrocks partner with new producers to help them develop their herds. The operation also offers a youth incentive program for 4-H and FFA members purchasing females in their sale and then winning at local, state or national shows.

The Sauk Valley Angus Country Store offers Certified Angus Beef® (CAB) product direct from the store or by mail order. To complement the beef, the store offers various cooking utensils and cookbooks to promote the use of high-quality beef. King serves as a director on the American Angus Association Board.

The Seedstock Producer of the Year Award has been presented to outstanding seedstock firms throughout the United States and Canada since 1972. Since then, only 35 firms have been honored with the prestigious award. Sauk Valley Angus is the first purebred firm from Illinois to receive the award.

BIF was formed as a means to standardize programs and methodology and to create greater awareness, acceptance and usage of beef cattle performance concepts. More information can be found on the organization’s web site, www.beefimprovement.org.
5L Red Angus
Owners/Managers: Larry and Lisa Mehlhoff
Montana

5L Ranch is located in the Ruby Valley of SW Montana near Sheridan. It is a family owned and operated Red Angus seedstock operation, consisting of Larry, Lisa and their 5 children: Laramie (20), Larisa (19), Landon (16), Larinda (13), and Logan (10). With the exception of the embryologist, ultrasound technicians, and a night calver, all the cattle work is done exclusively by the family. Three seasonal employees are hired to help with feeding cows, irrigation, haying and fencing. The ranch consists of deeded and leased land which currently encompasses 30,000± acres, of which 3,450 are irrigated. The primary crops grown are wheat, oats, hay and pasture. As well as being lifetime cattle producers, they also do custom farming, haying and combining in the valley.

The 5L cow herd currently consists of 1,250 mother cows and 340 yearling heifers. Artificial insemination and embryo transfer are used extensively, with 1,000 cows A.I.’d and 150-200 embryos transferred into their own recipient cows annually. A spring calving season is used primarily, beginning the first week of February. The bull calves are put on test in the bull development center on the ranch in September and sold in a spring production sale. The steer mates, after being backgrounded at the ranch, are sent back to the Midwest to be finished and subsequently harvested with the resulting carcass data utilized to analyze herd sire’s carcass merit. Females and embryos are sold private treaty, as available.

Ten years ago 5L began introducing superior black Angus bloodlines into their Red Angus program to expand the gene pool and thereby design new Red Angus bloodlines and a black red-carrier line of Red Angus cattle they have logoed Profit Plus. This Profit Plus program has allowed them to develop “outcross genetics” within the Red Angus breed.

5L Red Angus was proudly nominated by the Red Angus Association of America.

Bridle Bit Simmentals
Owner: Errol and Gayle Cook & Sons. Chad, Brent and Brad
Manager: Chad Cool
Colorado

Bridle Bit Simmentals, a family operation, moved from northern Colorado to extreme southeast Colorado in 1986. Walsh, Colorado is home for the Cooks, where they raise purebred and cross bred Simmental and Simmental, Red and Black Angus composites. BBS calve out 100 head of females beginning in February. Bridle Bit has been breeding Simmentals since 1969. They used AI to introduce the Simmental breed and have had an extensive AI program since that date.

Clean up bulls have been used the last 15 years. Bulls are sold by private treaty in the spring. Off-spring not selected for replacement females or bull prospects are placed in their
feedlot and sold on the rail to US Premium Beef. Retaining ownership plus the carcass premiums the Cooks receive by selling on the rail, has proved to be a financial benefit. BBS is a consignor to the Wild Wild West Simmental Sale which is held during the National Western at Adams County Fairgrounds in Brighton, CO. Bridle Bit females have been distributed throughout the United States. Bridle Bit Simmentals is run exclusively with family labor.

The Colorado Cattlemen’s Association is proud to nominate Bridle Bit Simmentals.

Echo Ridge Farm
Owner/Manager: C.W. Pratt
Virginia

The Echo Ridge herd, initiated by C.W. Pratt as an FFA project in 1964, has evolved into one of the elite seedstock operations in Virginia. The registered Angus operation presently consists of 225 cows managed in both fall and spring calving seasons. The farm sells approximately 75 bulls per year primarily through the Virginia BCIA Performance Bull Test Program as well as on-farm private treaty sales.

Echo Ridge maintains a strong commitment to performance principles and satisfying commercial bull buyers’ needs. The foundation of the Echo Ridge herd was built through the 1970’s through performance recording and participation in the Virginia bull test program. In the 1980’s Echo Ridge served as a cooperator herd for the Select Sires Young Sires Program which was instrumental in establishing the base cow families to which their herd traces today. From the beginning, Echo Ridge has been committed to strict performance standards. Their whole-herd artificial insemination program has been complimented by the utilization of superior natural service sires in their breeding program. Rito 8X8 and GAR 6807 Traveler 4144 are two examples of sires which went on to have pronounced impacts in the Angus breed, after first seeing use by natural service at Echo Ridge.

Heartland Cattle Company
Owner/Manager: Tom and Cora Lynch
Iowa

Tom and Cora Lynch are the owners of Heartland Cattle Company which is located near New Hampton, Iowa. The 175 cows in their seedstock breeding herd are primarily Simmental with a few Angus and Charolais. The business started in 1976; the first registered cattle were purchased to raise calves for 4-H projects. The cattle and farm operation has always involved family. As the children became older and shared more responsibility, the registered cow herd grew. The family has expanded its business since their son, Kirk, joined the operation after he graduated from Iowa State University in 2003.

The Lynches work closely with their customers, who are interested in age and source verification for feeder or fed cattle premiums. They also started a buy-back program for calves produced by their bulls, in which they furnish carcass data to the calves’ owners.

The marketing program for the roughly 60 to 70 bulls the Lynches sell each year includes the Iowa Cattlemen Association’s bull test program, private treaty sales and production sales. They are founding members of the Hawkeye Simmental Association, a marketing
and promotion group of 10 breeders. The Lynches recently held their first female production sale in early November 2006. They sold about 130 head of bred heifers and cows, and show heifer prospects. The first bull sale is scheduled for April 28, 2007.

The Iowa Cattlemen’s Association is proud to nominate the Heartland Cattle Company.

**Lindskov-Thiel Ranch**
**Owner:** Les and Marcia Lindskov & Brent and Nancy Thiel  
**Manager:** Brent Thiel  
**South Dakota**

Lindskov-Thiel Ranch is located in western South Dakota 60 miles west of the Missouri River on the Standing Rock and Cheyenne River Sioux Indian reservations. Les and Marcia Lindskov, from ranch families and life-long residents of this area, began raising purebred Charolais cattle in 1979. In 1987 Brent and Nancy Thiel joined the ranch in an ownership role.

Currently, the Charolais herd is 350 females. Added in 1997, the Angus herd numbers 175. Utilizing a 60-day spring-calving program, first-calf heifers begin calving the last half of February and cows start calving around March 1. Over 80 percent of females are artificially inseminated each year with a 75+ percent conception rate. Pasture sires are turned out for 60 days. During years of average moisture, the summer stocking rate is 20 acres per cow/calf pair. The calves are weaned during the first week in October. After the culling process is complete, a group of replacement heifers is retained, and a group of heifer calves is marketed by private treaty. Those heifers primarily are sold sight unseen with a satisfaction guarantee, many going to repeat customers.

The bull calves are developed in hilly, 10- to 40-acre pastures to aid long-term reproductive traits and soundness. Bulls are marketed through the Lindskov-Thiel annual bull sale held the third Saturday in April. 2007 marked the 26th annual sale. Eighty-five percent of the bulls are sold in a 100- to 150-mile radius of Isabel. The other 15 percent sell to regional commercial producers or purebred operations across the country.

The Lindskov-Thiel Ranch is proudly nominated by the American International Charolais Association.

**Pelton Simmental/Red Angus**
**Owner:** Lynn and Gary Pelton Families  
**Manager:** Lynn Pelton  
**Kansas**

Pelton Simmental/Red Angus is a family-owned and operated seedstock business located near Burdett, KS. Gary, Donna and their sons, Jason, Aaron and Burke; and Lynn, Sue and their daughter, Shanna, and son, Dustin, began a partnership in 1976, which later was incorporated into a diversified farm and ranch operation. The Pelton business consists of 4,300 acres of grass, 800 acres in the Conservation Reserve Program (CRP) 4,700 acres of cultivated land and 500 head of registered Red Angus, SimAngus and Simmental cows. About 200 cows calve in the fall and remaining 300 in the spring. Gary’s son, Aaron, and Lynn’s son, Dustin, and new wife, Kendra, have joined the business full time.

The purebred operation began in 1972 with 12 bulls being sold to local cattlemen. During the 13th annual sale, March 22, 2006, 150 Red Angus, SimAngus and Simmental bulls and 120 females were sold into 13 different states. Including private treaty, a total of 180 bulls were sold in 2006.

With the use of an extensive embryo transfer (ET) program and proven, predictable genetics, a strong genetic cowherd has been developed by utilizing every available economic and performance measurement. Along with a strong genetic base, a customer service program was developed and emphasized for the sole purpose of providing “value-added marketing opportunities” for our customers.
In the past three years, the commitment to helping market customers’ calves through various avenues has been especially rewarding. Two alliances with which we are involved provide feedlot and carcass data on animals going through each program. In addition, a Pelton Program Sale, held the first Friday of November, has proven very successful for providing customers an opportunity to market replacement-quality females and performance steers. In 2006, over 1,250 head were sold during the program sale.

Since Lynn’s graduation from Kansas State University in 1975, the program has become very “hands-on” with respect to the entire operation. Whether it be day-to-day care of the cowherd, sire selection and mating decisions, heat detection and AI work, ET preparation, weaning and development of bulls and replacements, putting up and grinding feed, various aspects of sale management and promotion, financial and breed association bookwork, computer time, customer service and marketing options or hosting tour stops and judging workouts – the family works together and utilizes the strengths of each person to better enhance the efficiency of the operation.

The Kansas Livestock Association is proud to nominate Pelton Simmental/Red Angus.

Star Lake Cattle Ranch
Owner: Jim and Randy Blin
Manager: Montie Soules
Oklahoma

Star Lake Cattle Ranch at Skiatook, Okla., is a premier source of Hereford genetics for cattlemen throughout the United States and numerous foreign countries. The ranching operation has been in existence as a unit since 1978, starting in Millbrook, N.Y., and operating in Oklahoma since 1985. The ranch is owned by father and son Jim and Randy Blin and managed by Montie Soules.

Encompassing 3,400 acres of native prairie grass in northeastern Oklahoma, the ranch is home to 1,000 head of registered Hereford cattle including 400-500 mother cows. The ranch uses the latest technologies available to make their cattle more efficient and add to their value. They have used ET since 1979, use sonograms to sex pregnancies and have used sexed semen on all yearling heifers to increase the value of those pairs as replacement prospects. This year will mark the 29th annual spring sale hosted by the operation. Star Lake also markets pairs, show prospects and 18-month old Ranch Ready Bulls in their annual fall sale.

Star Lake has a strong youth market and has awarded more than $150,000 in cash, credits and prizes during the last 13 years in their Junior Futurity. Star Lake has shown numerous National Champion Herefords and Denver Carload Champions, utilizing the cattle shows as other businesses would use a trade show to display their genetics to the public. Star Lake is proud to be a Hereford breeder, and is constantly striving to breed, produce and offer to their customers the best Herefords possible.

Star Lake Cattle Ranch is proudly nominated by the American Hereford Association.

TC Ranch
Owner: Vance, Connie and Dru Uden
Nebraska

TC Ranch, owned by Vance and Connie Uden and son Dru, is a family oriented purebred Angus operation that has been in continuous operation for 58 years beginning in 1949. The ranch is located in the Republican Valley of South Central Nebraska where their 700 registered Angus cows are pastured on both sides of the valley. The ranch consists of 8,000 acres of native grass and irrigated farm land which is in corn, soybeans, alfalfa and hay. TC Ranch understands the value of operating their seedstock business with the commercial industry in mind, and thus their cowherd is managed under the same parameters as many commercial herds in the area. The cows are
pastured in the native grass hills in the summer and grazed on cornstalks in the valley in the winter.

The herd has been on performance records since 1958 – first with the Nebraska Extension Service, then moved to AHIR (Angus Herd Improvement Records) program when the Angus program was initiated. These records have allowed them to identify many outstanding sires, and also to identify and perpetuate numerous outstanding cow families and individuals. They believe that the end result in the beef industry is the consuming public’s acceptance for beef. Because of this philosophy, they have fed out the bottom one-third of their bulls as steers to gain carcass data for the past fifteen years. This tells them how their steers perform in a feedlot situation which is what the real beef world is all about. Because of their efforts they have had one or two sires in the top ten registrations for all Angus cattle for fifteen years. They currently have 33 proven sires and 33 young sires listed in the National Angus Sire Evaluation Summary that were all bred at TC Ranch.

TC Ranch, a known name in the seedstock industry, is known as “The Herd with a Program”. Originally their slogan meant bringing the best genetics possible into their progressive Angus operation. Today the slogan means genetics, service, marketing and working with their customers. For the past 33 years, a yearling bull sale has been held the fourth Wednesday in February and a female sale has been held every third or fourth year in the fall.

TC Ranch was proudly nominated by the Nebraska Cattlemen and the University of Nebraska, Lincoln.

Tinney Farms
Owner: Howard Tinney
Manager: Arlin Taylor
Alabama

Tinney Farms is located in Hanceville, Alabama and has been part of this community for over 20 years. The 300 brood-cow operation is maintained on 2,000 acres owned by Howard Tinney and managed by Arlin Taylor. Tinney Farms is a premier producer of purebred Santa Gertrudis cattle, as well as, Star-5 commercial females.

The goal of Tinney Farms to compete on the rail and in the pasture with any breed of cattle. To accomplish this goal, all performance tools are utilized to produce the traits that the market demands. The Cattle Max performance software is currently used to identify cow and herd sire performance, utilize pasture management, analyze profitability, and to prepare sale catalogs and other marketing tools. Tinney Farms is actively collecting carcass data on all animals by retaining ownership at the King Ranch Feed Lot in Kingsville, TX and participating in the Nolan Ryan Tender Aged Beef program, as well as, utilizing carcass ultrasound. Extensive DNA testing of the entire herd through the Bovigen GeneSTAR program is a standard at Tinney Farms to evaluate for carcass quality.

Fifteen sires from Tinney Farms are currently listed in the Santa Gertrudis Breeder International Sire Summary, with 3 sires that lead the multi-trait summary. The farm has also produced more national champions than anyone else in the Santa Gertrudis breed. Howard Tinney serves as the current president of Santa Gertrudis International and has been very instrumental in the development of the American Breeds Coalition and its vision.

The Alabama Beef Cattle Improvement Association and the Santa Gertrudis Breeders International Alliance is proud to nominate Tinney Farms.

Tomlinson Farms
Owner: George and Deanna Tomlinson
Manager: Tommy Tomlinson
Illinois

Tomlinson Farms is located in southern Illinois two and one-half miles east of West Frankfort in Franklin County. The operation comprises 2,000 acres with approximately 1,000
devoted to corn and soybean production with the remaining 1,000 for hay and pasture.

The purebred Angus herd was started by George’s uncle, T.L. Tomlinson, in 1946. The operation has continued to maintain a purebred Angus to the present. Now the herd comprises 200 brood cows and 40 replacement heifers. Since 1946 the cow numbers have been at a high of 500 cows and as low as 50 cows.

Tomlinson’s breeding program focuses on performance improvement, particularly in association with the Angus Herd Improvement Registry. Working with the University of Illinois Extension since his farm’s establishment, Tomlinson began private performance testing in the 1970’s and still uses this program today.

The first herd bulls were purchased from J. Garrett Toland Farms from Pleasant Plains, Illinois. Presently, Tomlinson’s senior herd sire, Summitcrest Pfred 3B18 0J98, is featured in the Origen AI Stud and is considered the most extreme curve-bender for the EPD traits of light birth weight and high growth (weaning and yearling weight). Many daughters are retained in the Tomlinson herd along with sons used to concentrate this elite sire. Tomlinson uses both artificial insemination and natural service to cover his cows. Emphasis is placed on EPDs for light birth weight that excels in growth and carcass desirability.

Tomlinson feels strongly on the issue of using superior bulls for clean up. The herd has always purchased and used the best performance bulls they can afford with many of these coming from Summitcrest Angus.

Tomlinson makes 90 percent of his sales by private treaty. Annually he merchandizes 75 yearling bulls and 40 bred heifers to Illinois, Missouri, Kentucky and Indiana customers. Along with a visual assessment of the sale animal, Tomlinson offers complete performance information including birth, weaning, yearling, and maternal milk EPDs to his customers. In addition, progeny are scanned for carcass traits and EPDs provided for marbling, ribeye area and percent retail product.

The University of Illinois Extension and Illinois Beef Association are proud to nominate Tomlinson Farms.
Commercial Producer Honor Roll of Excellence

Ralph Neill.............................. IA ..... 1979
Harold & Wesley Arnold ........ SD .... 1979
Dean Haddock ........................ KS .... 1978
John Glaus ............................. SD .... 1979
Alfred B Cobb, Jr. .................... MT ... 1972
Max Kiner ............................... WA .. 1974
Donald Schott .............. MT ... 1973
Stephen Garst ...................... IA .... 1978
J.K. Sexton ............................. CA ... 1973
Elmer Maddox ........................ OK ... 1973
Arnold Wyffels ....................... MN... 1978
Otto Uhrig ............................... NE .... 1978
Ron & Malcom McGregor ...... IA ..... 1978
Clifford Ouse .......................... MN... 1973
Myron Hoeckle ....................... ND ... 1979
Bert Hawkins ........................ OR ... 1979
Dean Haddock ........................ KS .... 1978
Norman, Denton, & ..................
Calvin Thompson ............... SD .... 1979
Jess Kilgore ........................... MT ... 1980
Robert & Lloyd Simon ......... IL .... 1980
Lee Eaton ............................... MT ... 1980
Leo & Eddie Grubl .............. SD .... 1980
Roger Winn, Jr. ................. VA .... 1980
Gordon McLean ....................... ND ... 1980
Ed Disterhaupt ................. MN .... 1980
Thatd Snow ............................. CAN .... 1980
Arnold Wyffels ....................... MN... 1978
Pat Wilson .............................. FL ... 1973
Eugene Duckworth ............... MO .... 1975
Gene Gates ............................. KS .... 1979
V.A. Hills .............................. KS .... 1979
Robert D. Keefer ................. MT .... 1974
Kenneth E. Leistritz .......... NE .... 1976
Ron Baker .............................. OR ... 1976
Dick Boyle .............................. ID ..... 1976
James Hackworth .......... MO .... 1976
John Hiligendorf .......... MN .... 1976
Kahau Ranch ......................... HI .... 1976
Milton Mallery ...................... CA ... 1976
Robert Rawson ........................ IA .... 1976
William A. Stegner .......... NE .... 1976
Maynard Creees ................. KS .... 1977
Ray Franz .............................. MT .... 1977
Forrest H. Ireland .......... SD .... 1977
John A. Jameson ............... IL .... 1977
Leo Knoabla ................................ MN.... 1977
Jack Pierce ............................. ID .... 1977
Mary & Stephen Garst ........ IA .... 1977
Todd Osterross ..................... ND .... 1978
Charles M. Jarecki .............. MT .... 1978
Jimmy G McDonnal .......... NC .... 1978
Victor Arnaud ........................ MO.... 1978
Ron & Malcom McGregor .... IA .... 1978
Otto Uhling ................................ NE .... 1978
Arnold Wyffels ................ MN.... 1978
Bert Hawkins ........................ OR ... 1978
Mose Tucker ........................ AL .... 1978
Dean Haddock ........................ KS .... 1978
Myron Hoeckle ............. ND .... 1979
Harold & Wesley Arnold ...... SD .... 1979
Ralph Neill .............................. IA .... 1979
Morris Kuschel ...................... MN.... 1979
Bert Hawkins ....................... OR .... 1979
Dick Coon .............................. WA .... 1979
Jerry Northcutt ................. MO .... 1979
Steve McDonnell ............. MT .... 1979
Doug Vandermyde .......... II .... 1979
Norman, Denton, & ..................
Calvin Thompson ............... SD .... 1979
Jess Kilgore ........................... MT ... 1980
Robert & Lloyd Simon ......... IL .... 1980
Lee Eaton ............................... MT ... 1980
Leo & Eddie Grubl .............. SD .... 1980
Roger Winn, Jr. ................. VA .... 1980
Gordon McLean ....................... ND ... 1980
Ed Disterhaupt ........ MN .... 1980
Thad Snow ............................. CAN .... 1980
Oren & Jerry Raburn ........ OR .... 1980
Bill Lee ................................. KS .... 1980
Paul Moyer ........................... MO .... 1980
G.W. Campbell ...................... IL .... 1981
J.J. Feldman ........................ IA .... 1981
Henry Gardiner .................... KS .... 1981
Dan L. Weppler ............. MT .... 1981
Harvey P. Wehrli ............... ND .... 1981
Dannie O'Connell .............. SD .... 1981
Wesley & Harold Arnold ...... SD .... 1981
Jim Russell & Rick Turner ..... MO .... 1981
Oren & Jerry Raburn ........ OR .... 1980
Orin Lamport ........................ SD .... 1981
Leonard Wulf ......... MN .... 1981
Wm. H. Romersberiter .......... IL .... 1982
Milton Krueger ................. MO .... 1982
Carl Odegard ................. MT .... 1982
Marvin & Donald Stoker .... IA .... 1982
Sam Hands ............................ KS .... 1982
Larry Campbel ..................... KY .... 1982
Earl Schmidt ....................... MN .... 1982
Raymond Josephson .......... ND .... 1982
Clarence Reutter ............... SD .... 1982
Leonard Berger ................. CAN .... 1982
Kent Brunner ...................... KS .... 1983
Tom Chrystal ....................... IA .... 1983
John Freitag ....................... WI .... 1983
Eddie Hamilton ................. KY .... 1983
Bill Jones .............................. MT .... 1983
Harry & Rick Kline .......... IL .... 1983
Charlie Kopp ....................... OR .... 1983
Duwayne Olson ...................... SD .... 1983
Ralph Pederson ................... SD .... 1983
Ernest & Helen Schaller ......... MO .... 1983
Al Smith .............................. VA .... 1983
John Spencer ....................... CA .... 1983
Bud Wishard ......................... MN.... 1983
Bob & Sharon Beck .......... OR .... 1984
Leonard Fawcett .............. SD .... 1984
Fred & Lee Kummerfeld ........ WY .... 1984
Norman Conver & Sons .... VA .... 1984
Franklyn Esser ................. MO .... 1984
Edgar Lewis ......................... MT .... 1984
Boyd Mahler ....................... CA .... 1984
Neil Moffat .......................... CAN .... 1984
William H. Moss, Jr. .......... GA .... 1984
Dennis P. Solvieve ............. MN .... 1984
Robert P. Stewart ................ KS .... 1984
Charlie Stokes ..................... NC .... 1984
Milton Wendland .............. AL .... 1984
Bob & Sheri Schmidt .......... MN .... 1985
Delmer & Joyce Nelson .......... IL .... 1985
Harley Brockel ...................... SD .... 1985
Kent Brunner ...................... KS .... 1985
Glenn Havery ........................ OR .... 1985
John Maino ............................ CA .... 1985
Ernie Reeves ........................ VA .... 1985
John R. Rouse ........................ WY .... 1985
George & Thelma Boucher ...... CAN .... 1985
Kenneth Bentz ...................... OR .... 1986
Gary Johnson ........................ KS .... 1986
Ralph G. Lovelady ................ AL .... 1986
Ramon H. Oliver ................. KY .... 1986
Kay Richardson ...................... FL .... 1986
Mr. & Mrs. Clyde Watts ....... NV .... 1986
David & Bev Lischka ......... CAN .... 1986
Dennis & Nancy Daly ............ WY .... 1986
Carl & Fran Dobitz .............. SD .... 1986
Charles Fariss ........................ VA .... 1986
David Forster ........................ CA .... 1986
Danny Geersen ...................... SD .... 1986
Oscar Bradford ..................... AL .... 1987
R.J. Mawer ........................... CAN .... 1987
Rodney G. Oliphant .............. KS .... 1987
David Reed ............................ OR .... 1987
Jerry Adamson ...................... NE .... 1987
Gene Adams ........................... GA .... 1987
Hugh & Pauline Maze .......... SD .... 1987
P.T. McIntire & Sons .......... VA .... 1987
Frank Disterhaupt .......... MN .... 1987
Mac, Don, & Joe Griffith ...... GA .... 1988
Jerry Adamson ...................... NE .... 1988
Ken, Wayne, & ...................... Bruce Gardiner ......... CAN .... 1988
C.L. Cook .............................. MO .... 1988
C.J. and D.A. McGee .......... IL .... 1988
William E. White .................. KY .... 1988
Frederick M. Mallory .......... CA .... 1988
Stevenson Family .................. OR .... 1988
Gary Johnson ........................ KS .... 1988
John McDaniel ...................... AL .... 1988
William Stegner ................... ND .... 1988
Lee Eaton .............................. MT .... 1988
Larry D. Cundall ..................... WY .... 1988
Dick & Phyllis Henze .......... MN .... 1988
Mr. & Mrs. Clyde Watts ....... NV .... 1988
John A. Jameson ..................... CA .... 1988
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Mr. & Mrs. Clyde Watts ....... NV .... 1988
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Harry & Rick Kline .......... IL .... 1983
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Lauren & Mel Schuman ......... CA ... 1989
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Joe Thielen .......................... KS ... 1989
Eugene & Ylene Williams ... MO ... 1989
Phillip, Patty, & Greg Bartz ... MO ... 1989
John C. Chrisman................. VA ... 1990
Les Herbst .......................... KY ... 1990
Jon C. Ferguson ..................... KS ... 1990
Mike & Dianna Hooper ...... OR ... 1990
James & Joan McKinlay ... CAN ... 1990
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Ken and Wendy Sweetland .... CAN ... 1990
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Robert A Nixon & Sons ......... VA ... 1991
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James Hauff .......................... ND ... 1991
J.R. Anderson ........................ WI ... 1991
Ed and Rich Blair ........................ SD ... 1991
Reuben & Connee Quinn ........ SD ... 1991
Dave & Sandy Umbarger ........ OR ... 1991
James A. Theeck ........................ TX ... 1991
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Gene Thiry ............................. MB ... 1993
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Tom Woodard ........................... TX ... 1995
Jerry and Linda Bailey .......... ND ... 1996
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David Howard .......................... IL ... 1996
Virgil & Mary Jo Huseman ....... KS ... 1996
Q.S. Leonard ............................ NC ... 1996
Ken & Rosemary Mitchell .......... CAN ... 1996
James Sr., Jerry, & James Petlik .... SD ... 1996
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Merlin Anderson ........................ KS ... 1997
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Rosemary ROUNDS & Marc & Pam Scarborough ........................ SD ... 1997
Morey and Pat Van Hoecke ... MN ... 1997
Randi and Judy Mills ........................ KS ... 1998
Mike and Priscille Kasten .......... MO ... 1998
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Terry and Dianne Crisp ......... AB ... 1998
Jim and Carol Faulstich .......... SD ... 1998
James Gordon Fitzhugh .......... WY ... 1998
John B. Mitchell ....................... VA ... 1998
Holzapfel Family ........................ CA ... 1998
Mike Kiley .............................. IL ... 1998
Wallace & Donald Schilke ......... ND ... 1998
Doug & Ann Deane & Patricia R. Spearman ...... CO ... 1998
Glenn Baumann ........................ ND ... 1999
Bill Boston .............................. IL ... 1999
C-J-R-Christensen Ranches ......... WY ... 1999
1999 Ken Fear, Jr. ...........................
Giles Family ............................. KS ... 1999
Burt Guerrieri ............................ CO ... 1999
Karlen Family ......................... SD ... 1999
Deseret Ranches of Alberta .... CAN ... 1999
Nick and Mary Klintworth ......... ND ... 1999
MW Hereford Ranch ................. NE ... 1999
Mossy Creek Farm ................. VA ... 1999
Irvis, Bill, & Linda Lipscomb .... AL ... 1999
Amana Farms, Inc ........................ IA ... 2000
Toby Boothe .............................. AL ... 2000
Glenn Claibough ....................... WY ... 2000
Connie, John & Terri Griffith Ks ...... 2000
Frank B. Labato ............................ CO ... 2000
Roger & Sharon Lamont & Doug & Shawn Lamont ............. SD ... 2000
Bill and Claudia Tucker .......... VA ... 2000
Wayne and Chip Unsticks ......... IL ... 2000
Billy H. Boldignon ..................... AL ... 2001
Mike and Tom Endress ............. IL ... 2001
Henry and Hank Maxey ......... VA ... 2001
2001 Paul McKee 3-R Ranch ............. CO ... 2002
Ag-Services Division, Oklahoma Department of Corrections .......... OK ... 2002
2002 Alpine Farms
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Griffin Seedstock ........................ KS ... 2002
Indian Knoll Cattle Co. ............. IL ... 2002
Miles Land and Livestock ......... WY ... 2002
Shovel Dot Ranch ........................ NE ... 2002
Torbert Farms ............................. AL ... 2002
White Farms ............................. IA ... 2002
Voiles Farms ............................. IN ... 2002
Clear Creek Cattle Company ....... WY ... 2003
Crider Salers ............................. ND ... 2003
Mike Goldwasser ........................ VA ... 2003
Patterson Ranch ....................... CO ... 2003
W.S. Roberts and Sons ............... IN ... 2003
Shriver Farms ........................... OH ... 2003
Stroud Farms ............................. AL ... 2003
Tailgate Ranch Company .......... KS ... 2003
Burkhalter Cattle ...................... AL ... 2004
Doler Farm ............................. MS ... 2004
LU Ranch ................................. WY ... 2004
Nanminga Angus ........................ SD ... 2004
Nellwood Farms ........................ GA ... 2004
Olsen Ranches, Inc ................. NE ... 2004
Prather Ranch
(Ralphs Ranches Inc.) ......... CA ... 2004
Blair Porteous and Sons .......... OH ... 2004
Rx Ranch ................................. MO ... 2004
Schuette Farms ........................... IL ... 2004
Valdez Ranches .......................... CO ... 2004
Wickstrum Farms, Inc .............. KS ... 2004
CK Ranch ................................. KS ... 2005
Diamond V Ranch ................. ND ... 2005
Dover Ranch ............................. MT ... 2005
Gaines Farm ............................. AL ... 2005
Hillwinds Farm .......................... VA ... 2005
Krups Farm ............................... IL ... 2005
Jack and Ila Mae Larson ......... CO ... 2005
Mule Creek Ranch ......... KS ... 2005
 Paxton Ranch ............................. NE ... 2005
Pontious Farms ........................... OH ... 2005

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<tr>
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<tr>
<td>Virgil &amp; Mary Jo Huseman</td>
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<td>Merlin &amp; Bonnie Anderson</td>
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<td>Mike &amp; Priscilla Kasten</td>
<td>Missouri</td>
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<td>Randy &amp; Judy Mills</td>
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<td>Giles Family</td>
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<td>Mossy Creek Farm</td>
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<td>Bill &amp; Claudia Tucker</td>
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<td>Maxey Farms</td>
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<td>Tailgate Ranch</td>
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<td>Olsen Ranches, Inc.</td>
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<td>Prather Ranch, Inc.</td>
<td>California</td>
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<td>Pitchfork Ranch</td>
<td>Illinois</td>
<td>2006</td>
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The Beef Improvement Federation (BIF) named Pitchfork Farm, Stronghurst, Ill., its 2006 Commercial Producer of the Year during the organization’s 38th annual meeting April 18-21 in Choctaw, Miss.

Owners Ken and Sara Nimrick operate a grain and commercial beef cattle operation consisting of 220 cow-calf pairs and 35 replacement heifers on 340 acres of permanent and rotational pasture. They have been on the same farm in Henderson County since 1971; the land has been in Sara’s family since 1852.

The herd excels in reproductive management through the use of estrus synchronization, artificial insemination (AI) of replacement heifers, and limiting the length of the breeding season for the mature cow herd. Whereas many herds have continued to move their calving dates earlier, the Nimricks calve from late April to late June. This results in a number of heifers and all the cows calving on pasture. Their genetic program for the past 10 years has centered around the use of composite bulls, consisting of 50%-75% Angus or Red Angus and 25%-50% Simmental or Gelbvieh.

The Nimricks were one of the first herds in Illinois to adopt early weaning, weaning at 75-135 days of age in early September. After weaning, calves are backgrounded until mid-winter. Most are sold through a preconditioned feeder calf sale. To monitor feedlot performance and carcass quality, one or two loads of cattle are fed at a commercial lot each year.

The Nimricks continually study their base herd and select sires that will improve traits that are underdeveloped. For the heifers and mature cow herd, they want a trouble-free, low-labor calving season. They feel growth and milk are adequate, so in recent years they have begun to place more emphasis on some of the more subjective traits that are important to their low-input system, such as moderate frame size, body capacity and fleshing ability, thickness, masculinity, mammary structure and disposition. They are also placing more emphasis on carcass EPDs and scan information.

Of exceptional importance to the Nimrick beef cattle operation is to provide the most productive, highest-quality pastures to allow the cow herd to reach its genetic potential. Pasture performance and carrying capacity have increased dramatically with the incorporation of rotational grazing and improved pasture species. In addition, the Nimricks keep complete records on grazing days in each pasture to
monitor feed availability and evaluate grass varieties and other pasture management practices.

A unique management practice the Nimricks use to reduce the cost of wintering cows is the grazing of standing corn from January through March. Two items that make this work include the use of strip-grazing, so cows consume approximately 9 pounds (lb.) of corn each day, and supplementation with corn gluten feed three times per week.

Environmental stewardship is emphasized by the Nimricks and consists of utilizing management intensive grazing (MIG), converting much of the cropland into pasture, and installing erosion-control structures where needed. Also, they are in the process of developing natural springs and extending water lines to various areas to eliminate using ponds and streams.

Individuals who have had the opportunity to visit the Nimrick’s farm realize that Ken is extremely knowledgeable about the operation and the overall goals of a successful cow-calf enterprise. He summarizes his goals for the operation in what could be identified as a mission statement: “To maintain reproductive rates while controlling feed and overhead expenses by improving and managing pastures, minimizing machinery and building expenses, utilizing a low-cost wintering program, and grazing as many days of the year as possible.”

Ken is known as Dr. Nimrick to his students at Western Illinois University, where he serves as beef cattle professor in the ag department. Since Ken is gone a number of days, assistance is provided by the Nimricks’ daughter and son-in-law, Kristin and Alan Durkee of Stronghurst. This help allows him to share his many years of practical experience and expertise with future producers and leaders of the Illinois beef cattle industry.

BIF was formed as a means to standardize programs and methodology and to create greater awareness, acceptance and usage of beef cattle performance concepts. More information can be found on the organization’s web site, www.beefimprovement.org.
4Z Farms
Owners/Managers: Dennis and Cheryl Zumbrunn
Kansas

4Z Farms is located in eastern Dickinson County in north central Kansas. They have been operating as a family farm from this location for 30 years. They have 100 Black Angus and Angus-cross cows that they breed to black purebred Simmental bulls. They calve in the spring, with heifers beginning the last week in January and the balance of the herd in mid-February. Calves are weaned in early September and backgrounded at 4Z Farms through mid-December. The calves then are sent to Decatur County Feed Yard, Oberlin, Kansas, to be finished and sold at 14 to 15 months of age. These calves have been sorted by an electronic cattle management system to maximize profitability. Recently, the top end of the heifers to be sold as herd replacements during the Moser Simmental Ranch Annual Production Sale.

4Z Farms backgrounds 200 steers, purchased locally each winter and sold in the spring when they weight about 900 pounds. They also buy 200 steers in the spring to pasture during summer months. These calves are sold in August or taken back home to feed, depending on pasture conditions and the weight of the steers. Typically these stocker steers will weigh between 800 to 900 pounds.

4Z Farms was proudly nominated by the Kansas Livestock Association.

Broseco Ranch
Owner: Broventure Co., Inc.
Manager: Tom Woodward
Texas

Sandwiched between the Sulphur River and White Oak Creek at 300 foot elevation in North East Texas sets Broseco Ranch. In 1961, Paul Pewitt sold his 45,000 acre spread to Broventure Co., Inc. During the past 46 years, Broventure Co. has operated a commercial cow/calf operation under the banner of Broseco Ranch. The bottomland hardwood timber and a pine farm have been sold, 11,000 acres were taken by the Corp of Engineers, and another 10,000 acres of upland have been sold leaving 10,000 acres of upland improved pasture in the current operation.

The cow herd consists of 2700 mother cows that are exposed for a 60-day, spring breeding season. Yearling replacement heifers are exposed for 45 days. Prior to turning out bulls, they will synchronize and artificially inseminate. A normal year will have a breeding herd consisting of 300 to 400 yearling heifers and 300 to 400 mature cows. At weaning time all cows are pregnancy tested and all open cows are rebred for fall calving, sold, or removed from the herd.
In 1981, the ranch infused Brahman genetics into its primarily English cross cowherd. Then in 1984, a three breed rotational crossing system was established to stabilize the Brahman influence and optimize heterosis. Currently, the genetics used include Red Angus, and two composites (SimAngus and Hotlander). A 200 head Red Angus herd to produce bulls for use on replacement heifers and "balance bulls” for mature cows. They balance the adaptation, maternal, growth, and carcass traits to optimize performance at all phases of production.

Since 1988, Broseco has retained ownership on a majority of its production. Calves are individually weighed, preconditioned and electronically identified at weaning. The calves go to a wheat stocker program in the rolling plains of Texas and are then finished in the Southern Plains. The operation is QSA qualified. Finished cattle are marketed in the meat and sold on a value based marketing system. Through the Ranchers Renaissance Cooperation in partnership with Cargill Meat Solutions, the beef will be marketed in the Ranchers Registry product line to several major food store chains.

The Red Angus Association of America is proud to nominate Broseco Ranch.

**CK Ranch**  
**Owner:** John K. Vanier  
**Manager:** Ray Negus  
**Kansas**

CK Ranch is located in the Smoky Hills region of Saline and Ellsworth counties of Central Kansas. This area is known as one of the best cow-calf grazing areas in the country. The CK Ranch has approximately 15,000 acres of native pastures and 1,000 acres of tillable crop ground. CK Ranch was founded by JJ Vanier, father of Jack and grandfather of John. The Ellsworth County land was first purchased in 1933. Mr. Vanier purchased the 5,600 acre Root Ranch that is now the ranch headquarters.

The CK Ranch was first stocked with steers. The Herefords arrived in 1936 and in the 1950’s the ranch ran 2,000 head of registered cows and registered approximately 1,200 calves. CK became the largest Hereford operation in the world and enjoyed much success in the sale and show ring. Currently, a commercial herd consists of 600 to 950 Hereford and Red Angus cows and 175 to 200 registered Hereford and Red Angus cows make up the seedstock herd.

The primary purpose of the commercial cows is to serve as a genetic testing herd for Hereford and Red Angus. The cows calve in the spring with 100 to 400 heifers calving in January and February and the commercial cows in March and April. CK Ranch uses premium programs to collect data and to improve traits in the commercial herd. The ranch actively participates in the American Hereford Association’s (AHA) National Reference Sire Evaluation (NRSEP) and Certified Hereford Beef’s (CHB) Hereford Verified program. Prior to participating in the NRSEP, CK Ranch structured their own sire testing programs in conjunction with producers in Kansas and Nebraska.

The American Hereford Association is proud to nominate the CK Ranch.

**Barry and Larry Dowell Families**  
**Owner:** Barry and Larry Dowell  
**Illinois**

Barry and Larry Dowell of Stronghurst, Illinois were the recipients of the Illinois Beef Association Commercial Producer of the Year Award at the 2005 IBA Annual Meeting held near Carbondale, Illinois. The Dowells run a grain and commercial beef cattle operation consisting of 325 spring calving cows, 80 head of fall calving cows and 80 head of replacement heifers on 680 acres of permanent and rotational pasture. Besides the cow-calf operations, the Dowells farm more than 900 tillable acres with 650 being corn, 200 acres soybeans and about 60 acres of hay.

The Dowells are sixth generation farmers. The Henderson County land has been in the same family since 1840. The farm was
homesteaded by Larry’s great-great-grandfather who traveled from Chicago to Peoria on boat and then on horseback to western Illinois.

Many of the acres on the Dowell’s operation are ideal for pasture due to the rolling hills that approach the Mississippi River bluffs. The pastures are seeded with cool season grasses and legumes with shade provided by groves of hardwood trees including many walnut trees. The majority of the pastures are rotationally grazed with watering points centrally located.

The cowherd started with mostly Hereford cows. These were bred to Angus, Hereford and Limousin in a three breed rotation. Starting in the 1990’s Angus bulls were used for several years to obtain a more uniform cowherd. After preconditioning, the uniform calf crop is shipped to a feedlot and sold finished beef. In recent years the herd has utilized the use of Angus-Gelbvieh composite bulls to increase growth potential in the feedlot and composition on the rail. The heifers are bred to calving ease Angus bulls.

Barry and Larry Dowell Families were proudly nominated by the University of Illinois Extension and the Illinois Beef Association.

Eagle Rock Ranch
Owner: Lawlor Wakem
Manager: Chris Christianson
Colorado

Eagle Rock Ranch is at 9,000 foot elevation above sea level and is located just above the Tarryall Reservoir in Park County. Average annual rainfall is only 14 inches, although significant drought conditions have been experienced over the past five years. Tarryall Creek runs through the middle of the ranch, with irrigated hay meadows on both sides of the river. The ranch, including leased property, is 8,500 acres. The herd is almost all purebred Angus. Currently they have 220 cows, 200 calves and 9 bulls, down from a total herd of 340 head in 2001. Cows calve in April and May. The herd is PAP tested and has virtually eliminated brisket disease which experienced at high altitudes. The herd has access to Tarryall Creek at hard crossing points or to pumped well water tanks.

The ranch was purchased in 1993. At that time there was no irrigation. Water rights were subsequently purchased and irrigated hay meadows now total 265 acres. Currently they are in the process of acquiring additional water rights and water will be pumped from Tarryall Creek to gated pipe which will cover an additional 85 acres. The pump and gated pipe were installed this year. The area to be irrigated by gated pipe was previously largely low productivity short grasses and fringed sage and some native grasses. The entire area has been disked, plowed, dragged, and reseeded.

The Eagle Rock Ranch was proudly nominated by the Colorado Cattlemen’s Association.

Eatinger Cattle Co. Inc.
Owner: Wayne and Roxanne Eatinger
Manager: Wayne Eatinger
Nebraska

Eatinger Cattle Co. is located in the southwest part of Cherry County in north central Nebraska. It was founded by Charles Henry Eatinger who, in 1878, purchased and then drove southern steers from Abilene, Kansas to the present location. Wayne and Roxanne Eatinger’s son, Miles, is the sixth generation to live and work on the ranch. The ranch is run by Wayne and Miles Eatinger and Dennis Drews. Wayne’s parents, Byron and Mary Eatinger, and Wayne’s uncle, Ralph Eatinger, are retired and live on the ranch.

Eatinger Cattle Co. is a commercial cow calf operation, running 1,400 beef cows on 16,000 acres. Two thousand of these acres are sub-irrigated. Angus and Simmental cross are the predominant genetics used on the ranch. Calving occurs from late May through July, with the greatest number of calves coming in June. Emphasis is placed on land management and livestock marketing. Fence and water
renovations have been a constant for the Eatinger Ranch. These improvements are made without any assistance from government programs. A large embryo transfer program has been developed on the ranch. This has enabled the Eatingers to receive large premiums for calves. Eatinger Cattle Co. has taken a novel approach to marketing by forming synergistic relationships with other producers.

The Nebraska Cattlemen and the University of Nebraska are proud to nominate Eatinger Cattle Co. Inc.

**JHL Ranch**
**Owner:** Art and Merry Brownlee  
**Manager:** Tom Erxleben  
**Nebraska**

The JHL ranch owned and operated by Art and Merry Brownlee is located in the Nebraska Sandhills, a semi-arid region of grass covered sand dunes receiving 12-14” of moisture and situated over the deepest part of the largest aquifer in the United States. The operation has been under current ownership since 1995. Merry’s family, who has raised cattle since 1885, leased the ranch for 30 years prior to Art arrival. In 1995, city boy Art, who had worked in scientific research and financial analysis, decided to change directions and switched to ranching. At that time they also made a change in genetic direction, changing from Continental pounds of gain towards Continental/British crossbreds with an intentional push to higher quality grades.

Data analyses along with DNA, ultrasound, linear measurements and EPDs have been key technologies in the operation. The JHL cross breeding system uses moderate Angus and Braunvieh genetics. The current genetics and technology provide an end product harvest weight of 830lb, improved Choice grade from 26% to 90% with 50% achieving the upper two thirds of Choice. During the same genetic selection period, rib-eye area has been increased to 14.2 inches. The operation consists of 1400 -1600 cow/calf pairs utilizing intensive rotational grazing management on 30,000 acres. Calving season is April and May, with almost the entire herd AI bred in June followed by clean up bulls and weaning in September. The calves are back grounded on the ranch, with ownership retained to the rail, selling source verifiable product since 1995.

The Braunvieh Association of America is proud to nominate JHL Ranch.

**Lacey Livestock**
**Owners/Managers:** John, Mark and Nicki Lacey  
**California**

The Lacey family has been ranching in California since 1870. After settling in the Owens Valley, John William Lacey and his two sons expanded the operation to include 15,000 acres of city of Los Angeles lease land that increased their carrying capacity to 1,000 head. The ranch began with Hereford and Shorthorn cattle, but in 1960 Angus cattle were introduced to replace the Shorthorns.

Mark Lacey passed away in 1964 leaving John and his wife Dee, along with their children, Mark and Nicki to continue to run Lacey Livestock. John and his son, Mark, still ranch most of the original Lacey outfit. They have divested themselves of all Federal Lands and have added 40,000 acres more to the Owens Valley Ranches. Altogether, Lacey Livestock Ranch is 60,000 acres with approximately 2,000 cows.

Today the Lacey family ranch is a cow-calf and stocker operation. They also raise Quarter Horses and in 2003, Lacey Livestock was named AQHA’s Remuda of the Year. The Lacey’s owned several ranches in San Luis Obispo County which they sold in 2000 in order to purchase the historic Dressler Ranch in Bridgeport, California. This ranch has 7,000 acres and annually runs 8,000 steers. Lacey Livestock purchased this ranch with David Wood, under the partnership, Centennial Livestock. The partners just completed an easement with the American Land Conservancy
Lerwick Brothers LLC
Owners/Managers: Michael & Diane, David & Ashley, Jim & Linda Lerwick
Wyoming

Lerwick Brothers LLC is a third and fourth generation cattle operation in the southeast corner of Wyoming. The cow herd started on a 1907 with a 160 acre homestead and a few Milking Shorthorns. Hereford bulls were introduced in the second generation and Angus bulls were used on the Hereford herds in the beginning of the grandsons’ tenure. In the 1960’s, grandsons and great grandsons of homesteader August Lerwick operated various cropping and cattle operations on approximately 60,000 acres in southeast Wyoming and western Nebraska. Some have chosen straight Black Angus and some Red Angus cattle.

Presently, Lerwick Brothers LLC is a father and sons organization which produces about 650 Charolais/Angus calves per year. Cattle are in a partnership with Henry and Rachel Borchardt who operate a farm/ranch for Jim Lerwick, as well as their own at Chugwater, Wyoming. The Angus and Black-baldie cows are bred 20% Hereford/Angus for replacements and 80% Charolais/Black-baldie for terminal cross feeding cattle. Calving is done Jan 15-March 15 prior to farming intensity. Calves are weaned Aug 15-Sept 15 and finished for March and April fed markets. The cattle summer on various owned and leased pastures and winter on irrigated crop aftermath. Retained ownership, either whole or partial, allows for feedlot performance and carcass characteristics to be measured.

Lerwick Brothers LLC is proudly nominated by the American International Charolais Association.

MG Farms
Owner: Ron and Shaunna Melancon
Manager: Ron Melancon
Mississippi

Ron and Shaunna Melancon established MG Farms in 1994 in Southwest Mississippi. The Melancons own and manage MG Farms as a family beef cattle operation and rely on the operation to supply their entire living. The ranch has successfully grown from the original 550 acres to the present day operation consisting of 1,700 acres dedicated to the cow-calf operation and an additional 1,800 acres of timberland for a diversified operation including cattle, forestry, wildlife, and equine enterprises.

MG Farms currently consists of approximately 600 commercial cows and 200 replacement heifers, based on high performance Brangus, Angus, and Hereford genetics. Calving seasons are 75 days in length in both spring and fall seasons. The Melancons readily adopt profitable production practices based on research-based information. One example of this is that all calves are tested and culled for persistently-infected BVD. MG Farms utilizes a variety of marketing strategies including forward contracts, video sales, preconditioned calf sale participation, and private treaty marketing.

Extensive cow-calf production and financial records including feedlot performance and carcass data are kept to continually monitor and make needed management changes. Intensive forage management including rotational and limit grazing systems on improved forages and baleage production is an essential focus at MG Farms resulting in cost-efficient beef production. Even with all of the evidence of success in beef cattle production, Ron and Shaunna will both tell you that their greatest responsibility and most notable
accomplishment is that they are raising two children on the farm that provides their living. The Mississippi Beef Cattle Improvement Association is proud to nominate MG Farms.

**Stuart Land and Cattle Co. of Virginia, Inc.**  
**Owner:** Family Corporation  
**Manager:** Zan Stuart  
**Virginia**

Stuart Land & Cattle consists of 16,000 acres on three closely located farms in Russell, Tazewell and Washington Counties of Virginia. It is on land that was deeded in 1774 by Patrick Henry, then Colonial Governor of Virginia to Henry Smith as a reward for building an Indian fort on the Clinch River. Henry Smith was the great, great, great, great grandfather of the present manager and part owner, W. Alexander (Zan) Stuart, Jr. The operation is recognized as the oldest ranching establishment in the country still being run by the same family.

It may well have one of the oldest managers, too. Zan Stuart is 84 years young, still working every day. Zan eagerly checks this year’s calves as they arrive even after 61 years on the farm. He still attends meetings and educational seminars and the National Western Stock Show every year.

The breed composition of the herd is 5/8 Angus and 3/8 Simmental and Gelbvieh which is closely monitored. Approximately 1,100 cows and heifers will be bred artificially this coming year using the Co-Synch+CIDR fixed time protocol on cows and MGA-PG system on heifers. All calves are born in March and April, are electronically identified, BQA qualified, and source verified as well as preconditioned for seven weeks.

The Virginia Beef Cattle Improvement Association is proud to nominate the Stuart Land and Cattle Co. of Virginia, Inc.
BIF Ambassador Award Recipients

Warren Kester ..................BEEF Magazine, Minnesota ...............................1986
Chester Peterson................Simmental Shield, Kansas ................................1987
Fred Knop .......................Drovers Journal, Kansas ....................................1988
Forrest Bassford ...............Western Livestock Journal, Colorado .................1989
Robert C. DeBaca ..............The Ideal Beef Memo, Iowa ..............................1990
Dick Crow ........................Western Livestock Journal, Colorado .................1991
J.T. “Johnny” Jenkins ........Livestock Breeder Journal, Georgia ...................1993
Hayes Walker, III ..............America’s Beef Cattleman, Kansas ....................1994
Nita Effertz .....................Beef Today, Idaho ...........................................1995
Ed Bible ..........................Hereford World, Missouri .................................1996
Bill Miller .......................Beef Today, Kansas ...........................................1997
Keith Evans ......................American Angus Association, Missouri ..............1998
Shauna Rose Hermel ...........Angus Journal & BEEF Magazine, Missouri .........1999
Wes Ishmael .....................Clear Point Communications, Texas ....................2000
Greg Hendersen ...............Drovers, Kansas ..............................................2001
Joe Roybal .......................BEEF Magazine, Minnesota ................................2002
Troy Marshall ....................Seedstock Digest, Missouri ...............................2003
Kindra Gordon .................Freelance Writer, South Dakota..........................2004
Steve Suther .....................Certified Angus Beef LLC, Kansas ......................2005
Belinda Ary ......................Cattle Today, Alabama .....................................2006
2006 BIF Ambassador Award
Belinda Ary – Texas

The Beef Improvement Federation (BIF) named Cattle Today Editor Belinda Hood Ary recipient of its 2006 Ambassador Award during the organization’s 38th annual meeting April 18-21 in Choctaw, Miss. The honor is given to a member of the media each year for that individual’s efforts to help cattle producers understand cattle performance testing and genetic prediction tools.

Ary has been with Cattle Today since it was a concept in the minds of two cattlemen almost 20 years ago. They envisioned a publication for both purebred and commercial cattlemen in the Southeast. Through Ary’s dedication and attention to detail, Cattle Today has grown into a widely read, biweekly publication dedicated to educating the cattle industry in the Southeast.

Ary joined the company in 1987 and helped build a slate of services for the livestock industry through Cattle Today Inc., which includes publications, advertising and Web site design and hosting.

Ary, who was raised on a purebred Santa Gertrudis ranch in Franklin, Texas, earned a degree in agricultural journalism from Texas A&M University, as well as certification in animal breeding. Her hands-on experience with a purebred cattle operation and innovative management practices have contributed to the success of the publication.

Today, Cattle Today has more than 14,000 subscribers and is delivered to all regions of the country. It is published twice a month and provides sale services to both purebred and commercial producers throughout the Southeast. The Web services offered by Cattle Today help those in the livestock industry connect to buyers and sellers. The site, www.cattletoday.com, sees 450,000 visits monthly.

Ary is involved in various community and industry associations, having been an active member of the Livestock Publications Council (LPC), an international organization serving the livestock communications industry, since 1987. She has served on various LPC committees, was on the board of directors for seven years and served as president of the organization from 1998-99. She is an active member of Southside Baptist Church in Fayette, Ala., and volunteers with her two sons’ school and community activities.

She is married to Rickey Ary and has two sons — Tanner, 9, and Coulter, 5.
# BIF Continuing Service Award Recipients

Clarence Burch ........................................ Oklahoma .............. 1972
F. R. Carpenter .......................................... Colorado .............. 1973
Robert DeBaca .......................................... Iowa ...................... 1973
E.J. Warwick ............................................. Washington, D.C. .... 1973
Frank H. Baker .......................................... Oklahoma .............. 1974
D.D. Bennett ............................................. Oregon .................. 1974
Richard Willham ......................................... Iowa ...................... 1974
Larry V. Cundiff .......................................... Nebraska .............. 1975
Dixon D. Hubbard ........................................ Washington, D.C. .... 1975
J. David Nichols .......................................... Iowa ...................... 1975
A.L. Eller, Jr. ............................................. Virginia ............... 1976
Ray Meyer ................................................. South Dakota ......... 1976
Lloyd Schmitt ............................................. Montana ............... 1977
Don Vaniman ............................................. Montana ............... 1977
James S. Brinks .......................................... Colorado ............... 1978
Martin Jorgensen ......................................... South Dakota ......... 1978
Paul D. Miller .............................................. Wisconsin ......... 1978
C.K. Allen .................................................. Missouri .............. 1979
William Durfey ......................................... NAAB .................... 1979
Glenn Butts ................................................ PRI ............... 1980
Jim Gosey ............................................... Nebraska .............. 1980
Mark Keffeler ............................................. South Dakota ....... 1981
J.D. Mankin ............................................... Idaho ..................... 1982
Art Linton .................................................. Montana .............. 1983
James Bennett .............................................. Virginia .......... 1984
M.K. Cook ................................................ Georgia ............... 1984
Craig Ludwig ............................................. Missouri .............. 1984
Jim Glenn .................................................. IBIA .................... 1985
Dick Spader ................................................. Missouri .......... 1985
Roy Wallace .............................................. Ohio ..................... 1985
Larry Benyshek .......................................... Georgia ............... 1986
Ken W. Ellis .............................................. California .......... 1986
Earl Peterson ............................................. Montana .............. 1986
Bill Borror ............................................... California .......... 1987
Jim Gibb .................................................... Missouri .......... 1987
Daryl Strohbehn .......................................... Iowa ............... 1987
Bruce Howard ............................................. Canada ............ 1988
Roger McCraw ........................................... North Carolina .... 1989
Robert Dickinson ......................................... Kansas ............... 1990
John Crouch .............................................. Missouri .............. 1991
Jack Chase ................................................. Wyoming ............. 1992
Leonard Wulf ............................................. Minnesota ......... 1992
Robert McGuire .......................................... Alabama ............. 1993
Charles McPeake ...................................... Georgia .......... 1993
Henry W. Webster ....................South Carolina ......................1993
Bruce E. Cunningham ...............Montana ............................1994
Loren Jackson ........................Texas ......................................1994
Marvin D. Nichols ....................Iowa........................................1994
Steve Radakovich ....................Iowa........................................1994
Doyle Wilson ............................Iowa........................................1994
Paul Bennett ............................Virginia .............................1995
Pat Goggins .............................Montana ..............................1995
Brian Pogue ..............................Canada .................................1995
Doug L. Hixon ..........................Wyoming.................................1996
Harlan D. Ritchie ......................Michigan ..............................1996
Glenn Brinkman .........................Texas ..............................1997
Russell Danielson .....................North Dakota ......................1997
Gene Rouse ................................Iowa ..............................1997
Keith Bertrand ............................Georgia ....................................1998
Richard Gilbert .........................Texas ......................................1998
Burke Healey ..............................Oklahoma ..............................1998
Bruce Golden ...........................Colorado ....................................1999
John Hough .................................Georgia ....................................1999
Gary Johnson ..............................Kansas ....................................1999
Norman Vincil ............................Virginia ....................................1999
Ron Bolze .................................Kansas ....................................2000
Jed Dillard .................................Florida ....................................2000
William Altenburg .....................Colorado ....................................2001
Kent Andersen ............................Colorado ....................................2001
Don Boggs .................................South Dakota ......................2001
S.R. Evans .................................Mississippi ......................2002
Galen Fink .................................Kansas ....................................2002
Bill Hohenboken .........................Virginia ....................................2002
Sherry Doubet ................................Colorado ......................2003
Ronnie Green ..............................Virginia ....................................2003
Connee Quinn .............................Nebraska ....................................2003
Ronnie Silcox ..............................Georgia ....................................2003
Chris Christensen ......................South Dakota ......................2004
Robert “Bob” Hough .....................Texas .....................................2004
Steven M. Kappes ........................Nebraska .....................................2004
Richard McClung .........................Virginia .....................................2004
Jerry Lipsey .................................Montana ..............................2005
Micheal MacNeil .............................Montana ..............................2005
Terry O’Neill .................................Montana ..............................2005
Robert Williams .........................Missouri .....................................2005
Jimmy Holliman .........................Alabama .....................................2006
Lisa Kriese-Anderson ....................Alabama .....................................2006
Dave Notter .................................Ohio .....................................2006
2006 Continuing Service Award
Jimmy Holliman – Alabama

CHOCTAW, Miss. (April 20, 2006) — The Beef Improvement Federation (BIF) honored Jimmy Holliman with its Continuing Service Award during the organization’s 38th annual meeting April 18-21 in Choctaw, Miss. The award recognizes individuals for their service to the organization and to the beef industry.

Holliman attended his first BIF research symposium and annual meeting 17 years ago in Nashville, Tenn. Though a little intimidated at that first meeting, he says he understood enough to know he wanted to attend the BIF meeting again, have Alabama serve as host for a BIF meeting and join the board of directors. In 1996, almost 500 people from around the world visited Birmingham, Ala., for the 1996 BIF convention. Holliman was elected to the BIF board in 1998, and he became president of the organization in May 2004.

Holliman; his wife, Kathleen; and their son, Bret, own Circle H Cattle Farm of Marion Junction, Ala. They have bred quality Simmental cattle known for performance, structural correctness and carcass quality for more than 25 years. When the Simmental cattle market reached rock bottom prices in the mid-1990s, he joined an alliance, the Sunshine Group, with other performance-oriented Alabama Simmental breeders with the goal to change buyers’ minds about Simmental cattle. They established one of the most successful sales in Alabama.

Holliman is a native of Itta Bena, Miss., a small town in the delta region. He grew up on a farm that fostered his love for beef cattle. A gifted athlete, he attended junior college on a scholarship, where he was a fullback on the football team. Holliman then completed his education at Mississippi State University, earning bachelor’s and master’s degrees in animal science.

He began his career as assistant superintendent at the Auburn University Black Belt Research Center in Marion Junction 31 years ago. Today, Holliman is superintendent of the Center, overseeing research projects in agronomy, plant breeding, and beef cattle breeding and production.

Holliman has held many leadership roles in his community and church. He is past president of the Alabama Purebred Beef Breeds Council and the Alabama Beef Cattle Improvement Association (BCIA). Currently, he is a regional vice president of the Alabama Cattlemen's Association, active in the Alabama Farmers Federation, a member of the Alabama BCIA Board, and on several key beef committees in Alabama.

Holliman was awarded the Alabama BCIA’s most prestigious award, the Richard Deese Award for 2003. It is awarded to individuals exhibiting outstanding dedication to Alabama BCIA and its performance principles.
2006 Continuing Service Award
Lisa Kriese-Anderson - Alabama

The Beef Improvement Federation (BIF) honored Lisa Kriese-Anderson with its Continuing Service Award during the organization’s 38th annual meeting April 18-21 in Choctaw, Miss. The award recognizes individuals for their service to the organization and to the beef industry.

Kriese-Anderson is an associate professor in the department of animal sciences at Auburn University. She earned a bachelor’s degree from Cornell University, a master’s degree from Kansas State University, and doctorate from the University of Georgia. Now in her 12th year at Auburn, Kriese-Anderson holds responsibilities in all areas of the land-grant university — teaching, research and Extension. As a faculty member, she has developed solutions and designed programs in beef cattle breeding to help beef producers in Alabama. She has led many research projects evaluating the application and use of expected progeny differences (EPDs), along with studies on the use of ultrasound to determine carcass traits in beef cattle.

She provides leadership to a number of Extension programs throughout the state. She serves the Alabama Beef Cattle Improvement Association (BCIA) as advising geneticist, supervises the Auburn University Bull Test and analyzes BCIA data. Kriese-Anderson has played an essential role in the Alabama BCIA program, helping it grow to meet the performance and marketing needs of its cattle producers.

Kriese-Anderson coordinates the Alabama Pasture-to-Rail program, allowing retained ownership for small-scale beef producers. This provides them the opportunity to obtain feedlot data and carcass information on their cattle.

Within Extension, Kriese-Anderson serves as team leader for the Animal Science and Forage Extension Team, and she helped develop the National Beef Quality Assurance (BQA) Pilot Project and the Alabama Master Cattle Producers Training Program. She is a member of the Ultrasound Guidelines Council (UGC) Governance Committee that certifies ultrasound technicians.

She has been an avid supporter of BIF, appearing on the program numerous times, and she was instrumental in bringing the BIF convention to Birmingham, Ala., in 1996.

She is married to Brian Anderson. They have one daughter, Shelby.
The Beef Improvement Federation (BIF) honored Dave Notter with its Continuing Service Award during the organization’s 38th annual meeting April 18-21 in Choctaw, Miss. The award recognizes individuals for their service to the organization and to the beef industry.

Notter began a lifetime of involvement with livestock on a small farm in southern Ohio. Actively involved in 4-H and FFA as a youth, he went on to receive a bachelor’s degree in animal science from Ohio State University. He obtained his master’s and doctoral degrees in animal breeding from the University of Nebraska under the mentorship of G.E. Dickerson. After two years on staff at the Roman L. Hruska U.S. Meat Animal Research Center (MARC) at Clay Center, Neb., Notter joined the faculty at Virginia Tech in 1977 and is currently a professor of animal and poultry sciences.

Notter’s research has been primarily directed toward the application of quantitative and statistical genetic theory to the improvement of farm animals. His program objectives include the discovery of new knowledge in animal genetics, the integration of that knowledge into practical livestock breeding and improvement programs, and the training of graduate students capable of making continued contributions to the field.

His effect on the beef industry has been substantial. Working collaboratively with Larry Cundiff, he helped develop procedures for the across-breed expected progeny differences (EPDs) being used by the industry today. Other highly influential work has included the use of simulation modeling and systems analysis in evaluation of livestock breeding and improvement programs and the use of simulation modeling to dissect complex biological systems. In 1998 he received the Rockefeller Prentice Memorial Award in Animal Breeding and Genetics, which is the highest recognition in his field awarded by the American Society of Animal Science.

Notter’s research has had significant and sustained impacts on industry livestock breeding programs in the United States. He has published more than 140 articles in refereed journals and reviewed proceedings. Delivery of information to the livestock industry has been a particular strength of his program and has been achieved through extensive involvement in industry programs and organizations, including BIF.
Notter has made 55 invited presentations at a wide range of international, national and regional meetings. He has presented 11 invited papers at BIF, the most recent featuring the use of molecular genetic markers in applied breeding programs. His international recognition for research in sheep breeding and genetics attest to the breadth of his effect on livestock improvement.

He is recognized as an international expert on the management and utilization of farm animal genetic resources, as shown by many consultancies, writing assignments and presentations for the United Nations (UN) Food and Agriculture Organization (FAO).

Dave and his wife, Jan, have two daughters, Megan and Heather.
# BIF Pioneer Award Recipients

<table>
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<tr>
<th>Name</th>
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Murray Corbin ............................. Oklahoma ............................1987
Max Deets ................................. Kansas .................................1987
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A.F. “Frankie” Flint ....................... New Mexico ............................1988
Roy Beeby ................................. Oklahoma ............................1989
Will Butts ................................. Tennessee ............................1989
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Bill Turner ................................. Texas .................................1991
Frank Baker .............................. Arkansas .................................1992
Ron Baker ................................. Oregon .................................1992
Bill Borror ................................. California .............................1992
Walter Rowden .............................. Arkansas ............................1992
James D. Bennett ....................... Virginia .................................1993
M.K. “Curly” Cook ....................... Georgia .................................1993
O’Dell G. Daniel ............................ Georgia .................................1993
Hayes Gregory ............................. North Carolina .........................1993
Dixon Hubbard ......................... USDA .................................1993
James W. “Pete” Patterson ............. North Dakota ...........................1993
Richard Willham ....................... Iowa .................................1993
Tom Chrystal .............................. Iowa .................................1994
Robert C. DeBaca ....................... Iowa .................................1994
Roy A. Wallace .............................. Ohio .................................1994
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Robert E. Taylor .......................... Colorado .............................1995
A.L. “Ike” Eller ......................... Virginia .................................1996
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Henry Gardiner ............................. Kansas .................................1997
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John Crouch .............................. Missouri .................................1998
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<td>Dave Pingrey</td>
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2006 BIF Pioneer Award
John Brethour - Kansas

The Beef Improvement Federation honored John Brethour with the Pioneer Award during the organization’s 38th annual meeting April 18-21 in Choctaw, Miss. The award recognizes individuals for their service to the organization and to the beef industry.

Brethour was born Sept. 30, 1934, in northwest Riley County, Kan. He grew up in the family’s cattle business in the Kansas Flint Hills. He graduated high school from Clay Center, and went on to earn his bachelor’s degree in animal husbandry from Kansas State University (K-State) and his master’s degree in animal nutrition from Oklahoma State University. He married Carol June Thomas on Aug. 16, 1964, in Lake City, Fla. They have one son, John Jr.

After completing his master’s degree, Brethour worked for a year as a technician at the University of Tennessee Atomic Energy Commission project at Oak Ridge. In 1957, he became the beef cattle research leader at the K-State Agricultural Research Center in Hays. His research programs have included ultrasound technology; computer software development; ruminant nutrition; feed evaluation, storage and processing; livestock systems design; cow herd management; breed evaluation; and reproduction. He became a full professor in 1975.

Brethour made some of the first observations of the response to reimplanting cattle and the adverse effects of overimplanting on beef quality grade. He put top priority on producing high-quality beef and established the models for both marbling and backfat development on feedlot animals.

He was one of the first to adjust cattle performance to final carcass weight and, with the initiation of carcass-based marketing, has successfully advocated focus on carcass gain rather than liveweight gain. In addition, Brethour has been an enthusiastic advocate of sorting cattle into outcome groups for more effective marketing. In recent years, he has collaborated with colleagues in executing experiments in cattle behavior and has assisted in facility design.

In the 1980s Brethour became interested with the Total Quality Management (TQM) principles of W.E. Deming. He incorporated them into his own work and management practices, and produced a
monograph on the principles’ application to the beef industry. These actions further lended a hand in Brethour’s work developing ultrasound technology. He helped to organize the Cattle Performance Enhancement Company (CPEC). He brought a large amount of software development to produce a user-friendly, dynamic and versatile ultrasonic cattle sorting tool that is becoming widely used in the industry. His novel discoveries — including the ability to estimate intramuscular fat and the upstream projection of future carcass quality with ultrasound — were assigned to and patented by the K-State University Research Foundation.

In other aspects of research, Brethour helped to show that an original research program could be conducted off campus, and that a scientist at an off-campus location may be more in tune with producer needs. He was an off-campus research pioneer in the areas of nutritional value of grain, forage sorghums and wheat; ultrasound technology for the cattle industry to estimate intramuscular fat and predict future carcass merit; and adjusting cattle performance to final carcass weights.

Brethour maintains that his choice to locate his research facilities at a branch experiment station far from the main campus allowed him to remain very close to the practitioners and issues affecting the beef industry. His work was highly applied, relevant and problem-solving in nature.

Over the years, Brethour has received numerous monetary awards for his work in research agriculture, especially with ultrasound. A true example of his character, he has put his award winnings back into the research program when he could have deposited them in his personal bank account.

Currently, Brethour is a member of the American Society of Animal Science, American Registry of Professional Animal Scientists, the National Cattlemen’s Beef Association (NCBA), Kansas Livestock Association, Sigma Xi, Lions Club and the Methodist Church. Since 1991, Brethour has served on the board of directors of Hays Medical Center. He is also a trustee of the Hadley Foundation, has served on the board of directors for both a local bank and feedlot, and supports community committees, including three low-income housing projects.
BIF Honors Mississippi Producers with Pioneer Award

The Beef Improvement Federation (BIF) honored Harlan and Dorotheann Rogers with the Pioneer Award during the organization’s 38th annual meeting April 18-21 in Choctaw, Miss. The award recognizes individuals who have made lasting contributions to the improvement of beef cattle.

Harlan Rogers is the founder of Rogers Bar HR, which is located 100 miles from the Gulf of Mexico in Collins, Miss. He and his wife, Dorotheann, began a lifelong partnership more than 50 years ago. Both have been recognized on local, state and national levels for their contributions to the improvement of cattle.

In 1959 Harlan completed dental school, and he and Dorotheann moved back to Collins. Harlan started ranching with 27 acres of inherited land, four half-breed Charolais cows and one young bull. In 1961 he began performance testing his herd and has diligently worked to improve the Charolais breed since then.

Harlan and Dorotheann live on their 2,500-plus-acre ranch in Covington County where they manage about 500 registered Charolais cattle. Their four sons also live and are involved in various businesses in Covington County. Oby studied law and now has a practice in Collins; Bernie manages his own backgrounding operation; Doug, a West Point graduate, has become the managing partner of Rogers Bar HR; and Joey has assumed his father’s dental practice. All four are still involved in the cattle business.

The family hosts two sales annually, one in March and one in May. Their air-conditioned sale barn, built in 1975, has hosted 60 sales to date. Dorotheann handles all advertisements for the ranch and is the sale manager.

Harlan has been performance-testing his Charolais herd since 1961. Pedigrees in the Rogers Bar HR herd are stacked with accurate trait leaders. They have 156 females in the top 1% of the breed for Total Maternal and 117 females in the top 1% of the breed for Milk.

Rogers Bar HR bulls have won central bull tests in South Carolina, Florida, Mississippi, New Mexico, Montana and Alabama (forage and grain). The ability to gain rapidly is important because it is closely related to feed efficiency — the most important trait in the feedlot.

Rogers Bar HR DNA-types herd sires for tenderness and marbling markers. They are now in the process of testing their top cows and have plans to test all of their cattle in the near future.
The Rogerses currently oversee a stocker operation through which they background more than 10,000 head a year and develop several hundred commercial Brangus replacement heifers. Adding diversity, their commercial operation has also kept them in tune to the needs of commercial cattlemen and feedlots where they feed several thousand head. They have worked to increase rate of gain, feed efficiency, marbling and calving ease in their Charolais herd. It has always been their belief that the purpose of the seedstock breeder is to produce a product that is beneficial and helpful to the commercial cattlemen.

Harlan has been president of many organizations, including the Covington County Cattlemen, Mississippi Charolais Breeders, Mississippi Beef Cattle Improvement Association (BCIA), Southeast Charolais Breeders Association and American-International Charolais Association (AICA). He has served as a director of the Mississippi Cattlemen’s Association; Forrest County Cooperative; Mississippi Federated Cooperative; and SF Services, a large regional cooperative in Little Rock, Ark.

He was named the 1985 Mississippi Cattleman of the Year, and in 2003 received the Mississippi Network Louis N. Wise Award for Mississippi Cattle Farmer of the Year. In 2005 he was selected as the AICA Seedstock Producer of the Year and was awarded the Mississippi Livestock Environmental Stewardship Award.

Says Harlan, “There is no higher form of art, nor a more pleasing task, than that which deals with the genetic manipulation of an animal’s genes in a way that molds the resulting offspring into a creature that is pleasing aesthetically and performs to the expectations of the person who, with God’s help, created it.”

BIF was formed as a means to standardize programs and methodology and to create greater awareness, acceptance and usage of beef cattle performance concepts. More information can be found on the organization’s web site, www.beefimprovement.org.
BIF Honors Pingrey with Pioneer Award

The Beef Improvement Federation (BIF) honored the late Dave Pingrey with the Pioneer Award during the organization’s 38th annual meeting April 18-21 in Choctaw, Miss. The award recognizes individuals who have made lasting contributions to the improvement of beef cattle.

Pingrey was born and raised in Minnesota, graduated from Iowa State University (ISU), and resided in Mississippi for more than 50 years. He first distinguished himself in the livestock arena as a member of the 1947 ISU livestock judging team, which won both the judging contests at the American Royal in Kansas City, Mo., and the International Livestock Show in Chicago, Ill. He was high individual at the International and in the top 10 at the American Royal. These accomplishments led to his hire by Mississippi State University as livestock judging coach in 1948.

Pingrey left teaching to go into the purebred Angus business, moving to Macon, Miss., where he developed and managed his first Angus herd at Prairie Point Farms. From 1963 to 1969, he served as executive secretary of the Mississippi Cattlemen’s Association. While working with the cattlemen’s organization, Dave gained great respect and appreciation of all cattle producers, especially the small-scale commercial cattle owners.

In 1970 Pingrey, in partnership with Harris Swayze, established Black Bull Cattle Co. in Yazoo County, Miss. Pingrey was strongly motivated by Mississippi State’s Leroy Boyd to develop a performance evaluation program. It simply involved the identification of superior performers in his environment and the use of these superior performers at Black Bull Cattle Co.

Pingrey served two three-year terms on the board of directors of the American Angus Association. He served as vice-president of the association in 1979 and as president in 1980. During this time his relationship with Richard Willham, American Angus Association advisor from ISU, and Dale Davis, fellow board member from Belgrade, Mont., gave Dave a better understanding of performance evaluation and its potential benefits to the industry. During his years on the board, he helped shape and guide the Angus Herd Improvement Records (AHIRSM) program and the Angus sire evaluation program. The Certified Angus Beef (CAB) Program was initiated during his time with Angus, and the Association purchased the Angus Journal.
Pingrey has been honored by his induction into the American Angus Hall of Fame, Mississippi Agricultural Hall of Fame, Mississippi Cattlemen’s Hall of Fame and the Mississippi State University Livestock Judging Team Hall of Fame.

He was a man of strong beliefs and influenced many young people in the livestock arena through the years. His dedication to the cattle business will long be remembered.

BIF was formed as a means to standardize programs and methodology and to create greater awareness, acceptance and usage of beef cattle performance concepts. More information can be found on the organization’s web site, www.beefimprovement.org.
2007 BIF Convention Sponsors

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Walco International Inc.
ABS Global
Accelerated Genetics
Allflex
American Gelbvieh Association
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Y-Tex Corp
Albion Advanced Nutrition
American Salers Association
Colorado Angus Association
Colorado Simmental Association
Colorado State University ARDEC
Decatur County Feed Yard LLC
Five Rivers Cattle
Great Western Beef Expo
US Bank
Wardell/Walter Angus
Zinpro
Bar T Bar Ranch
Altenburg Super Baldy Ranch
Colorado Gelbvieh Association
Elmwood Limousin
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