Proceedings of the

Beef Improvement Federation's 37th Annual Research Symposium and Annual Meeting

July 6 – 9, 2005
Holiday Inn Grand Montana
Billings, Montana

Hosted by

MONTANA STATE UNIVERSITY

MSGA
MONTANA STOCKGROWERS ASSOCIATION

Sponsored by the Cattlemen's Beef Board and the National Cattlemen's Beef Association

2004 – 2005 Beef Improvement Federation Board of Directors

Beef Improvement Federation
37th Annual Research Symposium and Annual Meeting

Holiday Inn – Grand Montana
Billings, Montana
July 6-9, 2005

Wednesday, July 6, 2005

5:00 pm Montana Welcome Reception

7:00 pm National Association of Animal Breeders Symposium

How to Get Cows Pregnant for the Purebred and Commercial Sectors of the Beef Industry – Using GnRH and CIDRs. *Cliff Lamb, University of Minnesota*

New Opportunities to Synchronize Estrus and Ovulation and Facilitate Fixed-Time AI. *David Patterson, University of Missouri*

Thursday, July 7, 2005

7:00 am Hot Breakfast

8:00 am Welcome and Opening Remarks. *Jeff Jacobsen, Montana State University*

8:10 am WHERE ARE WE AT, WHERE DO WE WANT TO BE, AND WHAT CAN WE USE TO GET THERE? *Moderator: Joe Roybal,BEEF Magazine*

8:15 am Defining your Goals and Opportunities for Profitability. *Randy Blach, Cattle-Fax*

9:00 am How Do We Get There? Bridging the Gap. *Vern Pierce, University of Missouri*

9:45 am Break

10:15 am Introduction to Indexes. *Bob Weaber, University of Missouri*

10:30 am Breeding Objectives for Terminal Sires For Use in U.S. Beef Production Systems Making Bulls. *Mike MacNeil, USDA-ARS Miles City*

11:00 am Multiple Trait Selection for Maternal Productivity: The Hereford Maternal Productivity Index. *Denny Crews, Ag Canada*

11:30 am Question & Answer Session

12:00 pm BIF Awards Recognition Luncheon

2:00 pm Round Table Discussions

Live Animal, Carcass, and End Product. *Chair, Robert Williams, Amer. Int'l Charolais Assn.*

Producer Applications. *Chair, Sally Northcutt, Amer. Angus Assn.*

Selection Decisions. *Chair, Darrh Bullock, University of Kentucky*

6:00 p.m. Montana Thursday Night Out. *ORIgen (Busses will be leaving the Holiday Inn every 10 minutes from 5pm – 6pm.)*

Friday, July 8, 2005

7:00 am Hot Breakfast

8:00 am MORE TOOLS TO USE TO ACHIEVE OUR GOALS. *Moderator: Clint Peck, BEEF Magazine*

8:05 am An Example from the Dairy Industry: The Net Merit Index. *Paul VanRaden, USDA-ARS Beltsville*

8:45 am Multibreed Genetic Evaluations of Beef Cattle. *John Pollak, Cornell University*

9:30 am Break

10 am Making the Web Equal Profit: Surfing for Genetics. *Dorian Garrick and Mark Enns, Colorado State University*

10:45 am A Look at the Bovine Genome Project. *Ronnie Green, USDA-ARS*

11:30 am Elections

12:00 pm BIF Awards Recognition Luncheon

2:00 pm Round Table Discussions

Cow Herd Efficiency. *Chair, Mark Enns, Colorado State University*

Genetic Prediction. *Chair, Larry Cundiff, USDA-MARC*

Emerging Technology. *Chair, Craig Huffhines, American Hereford Association*

6:00 pm Montana Friday Night Out. *Genex Hawkeye West (Busses will be leaving the Holiday Inn at from 5:30 pm – 6pm.)*

Saturday, July 9, 2005

7 am – 7 pm Montana Beef Industry Tour

Option 1: Purebred/Seedstock Focus
Option 2: Commercial Focus

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BIF Ambassador, Continuing Service, and Pioneer Awards

A LITTLE ABOUT OUR SPEAKERS AND MODERATORS...

Randy Blach, Executive Vice-President
Cattle-Fax

Randy Blach, a Colorado native, was raised on a family ranching and farming operation at Yuma, Colorado. He graduated from Colorado State University with a degree in Animal Science.

He has been with Cattle-Fax since 1981. He worked as an Analyst for many regions, was Director of Market Analysis for 15 years, and was appointed to Executive Vice President in February of 2001. Cattle-Fax is a member-owned organization whose objective is to help member cattlemen make more profitable marketing and management decisions. Cattle-Fax supplies its members, in all segments of cattle production and feeding throughout the United States, with timely market information, analyses and educational programs to assist them in making better decisions.

Blach has also served as a director of the National Western Stock Show for the past seven years and has been actively involved on the Junior Sale Committee for more than a decade.

Blach has been a keynote speaker at hundreds of cattle and beef industry conventions, meetings and seminars during the past twenty years.

Blach and his family remain actively involved in a cattle ranching business that includes cow/calf, stocker and finishing cattle. He is also an owner/operator of High Country Steaks which deliveries high quality aged steaks to consumers across the U.S.

Denny Crews, Quantitative Geneticist
Agriculture and Agri-Food Canada, Lethbridge Research Center

Dr. Denny Crews was raised in southern Florida on an extensive beef cattle and citrus operation owned by his family. He received his M.S. degree in Beef Cattle Science from the University of Florida in 1992 and his Ph.D. in Beef Quantitative Genetics under the direction of Dr. Don Franke at Louisiana State University in 1996. Dr. Crews is currently Program Leader in Beef Genetics and AAFC National Study Leader in Livestock Genetics & Genomics. He has adjunct faculty appointments at Colorado State University, the University of Alberta, and the University of Lethbridge.

Denny was winner of the Beef Improvement Federation Baker Award in both 1995 and 1996, and the Southern Section American Society of Animal Science (ASAS) Graduate Presentation Award in 1997. Denny received the 2004 Western Section ASAS Young Scientist Award. He currently participates in three international research and coordinating committees on beef cattle genetics and national cattle evaluation. He also advises the breed improvement efforts of four beef breed associations.

Denny's research interests include large-scale genetic evaluation and improvement programs for beef cattle, with specific projects on carcass merit, efficiency of feed utilization, and fertility. He and his team at Lethbridge currently conduct five multiple trait national cattle evaluations for three breeds involving more than 2 million cattle. In the past seven years, his program has attracted more than $2.5 million in funding support.

Denny and his wife Ronda live in Lethbridge with their daughter, Emily, and son, Garrett.

Mark Enns, Asst. Professor of Animal Breeding & Genetics
Colorado State University
Dr. Mark Enns received his M.S. and Ph.D. degrees from Colorado State University in Animal Breeding and Genetics. At his current position at Colorado State University, Mark teaches and does research primarily in the area of animal breeding and genetic improvement of beef cattle. His research focuses on methods to genetically evaluate and select animals that fit their production environment both biologically and economically. These efforts include development of new methods for evaluating and improving cow and heifer fertility, cow maintenance requirements, time to finish in the feedlot; and development of methods to better use economic information in selection decisions for increased profitability of beef production. He also serves as the Operations Manager for the Colorado State University Center for the Genetic Evaluation of Livestock. The Center performs genetic evaluations for many beef breed associations and producer groups both nationally and internationally.

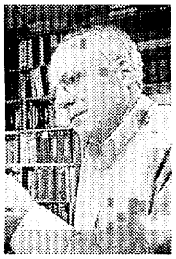
Dorian Garrick, Professor of Animal Breeding & Genetics
Colorado State University
Dr. Dorian Garrick is Professor of Animal Breeding & Genetics at Colorado State University. He received a First Class Honors degree in Agricultural Science from Massey University in New Zealand and a PhD from Cornell University. Dorian was appointed to the A.L. Rae Chair in Animal Breeding & Genetics at Massey University in 1994 and as a Professor at CSU from Fall 2002. Dorian has been integrally involved in the development and implementation of national animal evaluation programs, performance recording databases and breeding schemes. He has worked in the design of experiments to detect quantitative trait loci (QTL) and to exploit them in breeding programs. Dorian views animal breeding in a systems context, involving the integration of knowledge and understanding of business goals, production systems, processing and marketing, in concert with quantitative and molecular genetics. Dorian works with a variety of genetic improvement programs, including beef cattle, dairy cattle, dual-purpose sheep, fine-wooled sheep, pigs, elk, salmon and tree breeding. Dorian works well with other researchers and equally enjoys working with enthusiastic producer and industry groups that seek to include animal breeding approaches in the attainment of their ranch business goals.

Ronnie Green, National Program Leader
USDA-ARS
Dr. Ronnie Green received his B.S. degree in Animal Science/Agricultural Economics from Virginia Tech, M.S. degree in Animal Science/Beef Cattle Breeding from Colorado State University, and his Ph.D. in Quantitative Genetics and Beef Cattle Breeding from the University of Nebraska. Ronnie than took an assistant professor position at Texas Tech University from 1988 to 1993 and an associate and then full professor position at Colorado State University from 1994 to 2000. Following that, Ronnie was involved in Future Beef Operations before becoming the National Program Leader for USDA-ARS in 2003. In this position, Ronnie oversees the national research program in animal production (beef, dairy, poultry, sheep, and swine) for USDA's Agricultural Research Service which includes 81 projects, 91 scientists, 17 research locations, and a $40M annual budget. Ronnie is a former member of the BIF board of directors. In 2003, Ronnie received the Continuing Service Award from BIF.

Jeff Jacobsen, Dean and Director
College of Agriculture/Montana Agricultural Experiment Station
Dr. Jeff Jacobsen is currently the Dean and Director of the College of Agriculture/Montana Agricultural Experiment Station, Montana State University (MSU)-Bozeman, Montana. Previously he has served as Interim Dean, Department Head of what is now Land Resources and Environmental Sciences and a MSU faculty member with Soil Science expertise since 1986.

Jeff has a B.S. in Soil Science from California Polytechnic State University, a M.S. in Agronomy from Colorado State University, and a Ph.D. in Soil Science from Oklahoma State University.

G. Cliff Lamb, Associate Professor and Beef Cow/Calf Specialist
University of Minnesota
Dr. Lamb is currently an Associate Professor and Beef Cow/Calf Specialist at the University of Minnesota. He earned his B.S. degree in Animal Science at Middle Tennessee State University, and his M.S. and Ph.D. degrees from Kansas State University in Reproductive Physiology. In 1998 Dr. Lamb moved to Minnesota to become an Assistant Professor at the University of Minnesota. His primary research efforts focus on applied reproductive physiology in beef and dairy cattle emphasizing synchronization of estrus in replacement heifers and postpartum suckled cows. Recently, Dr. Lamb has spent much of his time developing fixed-time artificial insemination and embryo transfer protocols with the use of the CIDR, GnRH and PGF. In addition to research and extension, Dr. Lamb coordinates the NCROC Reproductive Biotechnology Center, an assisted reproductive technology center that provides research and commercial services to the cattle industry in the area of embryo transfer, IVF, and ultrasound technology.



Michael MacNeil, Research Geneticist
USDA-ARS Fort Keogh Livestock and Range Research Laboratory, Miles City, Montana
Dr. Michael "Mike" MacNeil was awarded a Ph.D. by South Dakota State University in 1982. His dissertation research was on the relationships between growth and carcass composition of steers and reproductive traits of half-sib heifers. Since that time he has worked for USDA-ARS at Clay Center, NE (through 1988) and Miles City, MT. Throughout his career he has focused on genetic and production system approaches to increase the level of beef production and currently leads a multidisciplinary project to "Develop beef cattle better suited for sustainable production." His accomplishments include: identification of genetic antagonisms that compromise efficient production, documentation of response to selection for growth and functions of weight traits, development of bio-economic breeding objectives that are widely used in the beef industry, and mapping quantitative trait loci affecting growth, carcass traits and palatability of beef. He is author or coauthor of more than 230 scientific and technical publications and has received more than 100 invitations to speak nationally or internationally on various topics related to breeding and genetics. He is active member of the American Society of Animal Science and regular participant in meetings of the Beef Improvement Federation.

David J. Patterson, Professor of Beef Cattle Reproduction
University of Missouri
Dr. David J. Patterson was raised on a diversified farming and ranching operation in South Central Montana. He received the B.S. degree (1976) in Agriculture Science and MS degree (1979) in Animal Science from Montana State University in Bozeman, and the PhD (1988) in Animal Science from Kansas State University. Dave joined the faculty in the Department of Animal Sciences at the University of Missouri-Columbia (UMC) in August of 1996. Prior to his appointment at UMC, he served on the faculty in the Department of Animal Sciences at the University of Kentucky (UK) in Lexington. His Outreach & Extension program in Missouri is directed toward the development of a progressive state-wide educational program in cow-calf production with emphasis on reproduction and management of beef heifers and cows. His efforts have focused on implementation of a comprehensive state-wide program in beef heifer development and marketing, the Show-Me-Select Replacement Heifer Program^{TM}.

Dave was the 1999 recipient of the J. W. Burch State Specialist Award in Agricultural Extension for Outstanding Program Leadership and the 2002 recipient of the Executive Vice President's Award for Outstanding Achievement in Extension at UMC; the 2000 recipient of the Outstanding Service to the Missouri Beef Industry Award, presented by the Missouri Cattlemen's Association; and the "Man of the Year in Missouri Agriculture for 2001", presented by Progressive Farmer for development and implementation of the Missouri Show-Me-Select Replacement Heifer Program and Sales. Dave's research program supports his extension programming efforts by providing a continuum of relevant research that has immediate application in the field. His research program is designed to develop and evaluate practices that improve reproductive management on farming and ranching operations involved with beef cow-calf production. His long-term research objective is to develop highly effective and economical protocol(s) to synchronize estrus in postpartum beef cows and replacement beef heifers that result in excellent pregnancy rates following artificial insemination (AI) at a fixed time. Two protocols to synchronize estrus in beef cows and replacement beef heifers were recently developed in his research program. These include the MGA® Select and 7-11 Synch protocols, both of which have gained wide industry acceptance.

Clint Peck, Senior Editor
BEEF magazine

Clint Peck is a recognized authority on Western issues, particularly land and water issues, property rights, endangered species and public lands grazing. He's also written extensively on border relations.

Peck was born on a farming and ranching operation near Pompey's Pillar, MT - about 30 miles east of Billings - and was raised in the Yellowstone Valley. He's a Montana State University graduate with a BS in Agricultural Production.

His work experience includes a stint as foreman of a large ranch near Cascade, MT. He also served for six years as a county Extension agent for Judith Basin County in central Montana. Clint served as editor of *Montana Farmer-Stockman* and *Western Beef Producer* before joining *BEEF* in 2000. In addition to other writing duties, he's in charge of the *BEEF Feeder*, a six time/year supplement in *BEEF* for high-end cattle feeders.

In his spare time he enjoys spending time with his children - Sarah and Ellen.

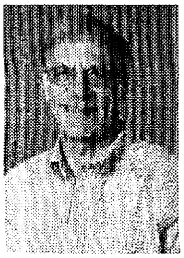
Vern L. Pierce, Beef and Dairy Economist
University of Missouri

Dr. Vern L. Pierce is the Beef & Dairy Economist with the Commercial Agriculture Beef and Dairy Focus Team and Associate Professor of Agricultural Economics with the University of Missouri. He is Adjunct Professor at the University of Nebraska. In his work on the Beef and Dairy Teams, he was a part of establishing both the Missouri Premier Beef Marketing Program and the Show-Me Select Replacement Heifer Program.

He specializes strategic planning through identifying, measuring, and interpreting business efficiency. He has been a frequent columnist in Feedstuffs, The Angus Journal, Beef Today, The Western Livestock Journal, and Feedlot Magazine. He is a founding partner of FarmPage.Com, an on-line farm information and decision-making website. He is a partner in the HP Group, consultants providing integrated solutions.

He received a B.S. in Agricultural Economics and M.S. in Agribusiness Management from The University of Wisconsin-Platteville, M.S. in Agricultural Economics from The University of Wisconsin-Madison and Ph.D. in Agricultural Economics from The University of Missouri. He has taught undergraduate and graduate courses and conducted research in marketing, futures and options, finance, international marketing and farm management.

He may be reached at: Dr. Vern Pierce; Beef and Dairy Economist; Department of Agricultural Economics; University of Missouri; Columbia, MO 65211; Phone: (573) 882-8229; Fax: (573) 884-8229; E-mail: piercev@missouri.edu.

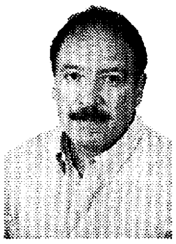


John Pollak, Professor
Cornell University

Dr. John Pollak received his B.S. from Cornell University and his M.S. and Ph.D. degrees from Iowa State University. Following this, John was on the faculty at the University of California, Davis before returning to Cornell where he has served on the faculty for 25 years. John is active in the NCBA Carcass Merit Project, the American Simmental Association genetic analysis, and is the Director of the National Beef Cattle Evaluation Consortium.

Along with fellow Cornell Beef Cattle Geneticist, Dick Quaas, John has spent 3 decades collaborating on developing and applying new statistical techniques for evaluating genetic merit of beef cattle using field data. Their work was integral to the expected progeny differences (EPD) revolution of the 1980s and 1990s. Currently, he and Dick are working on a multiple-breed evaluation which includes association data on Simmental (American and Canadian), Simbrah, Maine-Anjou and Chianina, plus a variety of composites and individual herds.

In 1999, John and Dick jointly received the BIF Pioneer Award. The duo also received the World Simmental Federation Golden Book Award in 2002 and were named one of BEEF Magazine's Top 40 in 2004.



Joe Roybal, Editor
BEEF magazine
Joe Roybal is a South Dakota native and a graduate of South Dakota State University with a degree in journalism. He worked as a daily newspaper reporter and photographer before doing a six-year stint as a news bureau feature writer. His livestock magazine experience includes serving as managing editor of *Dairy Herd Management* and editor of *Feedlot Management* magazines before joining the staff of *BEEF* magazine in 1985. He became editor of *BEEF* in 1993 upon the retirement of founding editor Paul D. Andre.

Paul VanRaden, Research Geneticist
USDA-ARS Animal Improvement Programs Laboratory, Beltsville, Maryland
Paul VanRaden is a research geneticist with the Agriculture Research Service, USDA, Beltsville, MD. Paul joined USDA in 1988 after completing a B.S. at the U. of Illinois, PhD at Iowa State U., and postdoctoral appointment at U. of Wisconsin. His research focuses on dairy cattle improvement and his projects have included introducing new genetic evaluations for longevity, cow fertility, and udder health. Paul has combined all available traits according to their economic values in a net merit index published since 1994. Other research topics include inbreeding, crossbreeding, nonadditive inheritance, multi-trait evaluation, and international evaluation. Paul works for the Animal Improvement Programs Laboratory, which maintains the national database and computes genetic evaluations for the dairy breeding industry.

Bob Weaber, Asst. Professor and State Extension Specialist – Beef Genetics
University of Missouri
Dr. Bob Weaber recently joined the faculty of the Division of Animal Sciences at the University of Missouri as an Assistant Professor and State Extension Specialist-Beef Genetics. Weaber completed his doctoral studies in the Animal Breeding and Genetics Group at Cornell University under the direction of Dr. John Pollak. While a graduate student at Cornell University, he served as the Interim Director of Performance Programs for the American Simmental Association for three and one-half years. Bob is a member of the Board of Directors of the Beef Improvement Federation. Weaber's research interests include genetic evaluation systems for large commercial ranches, multi-breed genetic evaluation and crossbreeding systems. Prior to joining the research team at Cornell, Bob was Director of Education and Research at the American Gelbvieh Association for five years. Bob earned a Master's degree in the Beef Industry Leadership Program at Colorado State University where he worked with Dr. Tom Field. He is also the recipient of a B.S. degree from Colorado State in Animal Science with a minor in Agricultural Economics. Bob is originally from Southern Colorado where his family's ranch is located. Bob and his wife, Tami, reside near Harrisburg, Missouri.

How to Get Cows Pregnant for the Purebred and Commercial Sectors of the Beef Industry – Using GnRH and CIDRs

G. Cliff Lamb

North Central Research and Outreach Center, University of Minnesota, Grand Rapids

Introduction

For most artificial insemination programs in the United States, we rely heavily on the ability to synchronize estrus in cows or heifers to ensure that they are at the correct stage of the estrous cycle when we use either estrus detection followed by artificial insemination or fixed time artificial insemination (TAI) alone. Numerous factors affect the response of these recipients to hormonal regimens that we impose on them. Those factors may include weather patterns, nutrition, age or days since calving, body condition, nursing a calf, or breed composition/genetics. A second challenge is to match estrous synchronization products to ensure that we can optimize the number of females that respond to a given estrous synchronization program, and ensure that the greatest number of females are detected in estrus in a short window of time.

The premise behind synchronizing cows and heifers is to first control the timing of onset of estrus by controlling the length of the estrous cycle. The choice of approaches for controlling cycle length are: 1) to regress or "kill" the corpus luteum (CL) of the animal before the time of natural luteolysis, and thereby shorten the cycle (by administration of a prostaglandin $F_{2\alpha}$ [PGF]), or 2) to administer exogenous progestins to delay the time of estrus following natural or induced luteolysis that may extend the length of the estrous cycle. A further approach is to "select" the ovulatory follicle by an injection of GnRH, which should cause premature ovulation of that follicle. Using these concepts, researchers have made tremendous strides in developing numerous system to synchronize the estrous cycle for an artificial insemination and embryo transfer. Table 1 summarizes common products available for use in cattle estrous synchronization systems.

Initial estrous synchronization systems focused on altering the estrous cycle by regressing the CL with an injection of PGF followed by a detected estrus between 18 and 80 hours after the injection. After systems involving a single injection of PGF became successful, researchers focused on multiple injections of PGF to further reduce the days required for heat detection and AI (Lauderdale et al., 1974; Seguin et al., 1978). The next generation of estrous synchronization systems involved progestins, which (while administered) prevent estrus from occurring. Progestins were used to delay the time of estrus following a natural or induced luteolysis and extend the length of the estrous cycle. Until 2002, melengestrol acetate (MGA) was the only progestin approved by the Food and Drug Administration for estrous synchronization, but the CIDR was approved by the FDA for use in 2002. These proceedings will focus on synchronizing estrous in females using GnRH and the CIDR.

Estrus synchronization appears to becoming more complicated every year. New systems are developed and variations of older systems are used. Our goal is to

Table 1. Products, commercial names, and doses for synchronization products.

Product	Commercial name	Administration	Dose
Prostaglandins	Lutalyse®	i.m. injection	5 mL
	Estrumate®	i.m. injection	2 mL
	In-Synch®	i.m. injection	5 mL
	Prostamate®	i.m. injection	5 mL
Progestins	Melengestrol Acetate	Feed	0.5 mg/hd/d
	CIDR	Vaginal implant	1 implant
Gonadotropin Releasing Hormone	Cystorelin®	i.m. injection	2 mL
	Factrel®	i.m. injection	2 mL
	Fertagyl®	i.m. injection	2 mL
	Ovacyst™	i.m. injection	2 mL

ensure that more cows are inseminated artificial on an annual basis; therefore, a group of individuals convened in North Platte, NE in September 2004. The group consisted of veterinarians, pharmaceutical companies, AI companies, and researchers from universities. Our goals were: 1) promote wider adoption of reproductive technologies among cow-calf producers; 2) educate cow-calf producers in management considerations that will increase the likelihood of successful AI breeding; and 3) educate producers in marketing options to capture benefits that result from use of improved reproductive technologies. With these goals in mind, the group established estrus synchronization protocols that were research based and industry used that had the greatest opportunity of success for purebred and commercial producers. These protocols are listed in the back of all major AI company catalogues and are shown in these proceedings as Appendix A (for cows) or Appendix B (for heifers).

Description of the CIDR Insert

The CIDR is an intravaginal progesterone insert, used in conjunction with other hormones to synchronize estrous in beef cows and heifers and dairy heifers. The CIDR was developed in New Zealand and has been used for several years to advance the first pubertal estrus in heifers and the first postpartum estrus in cows. The CIDR is a "T" shaped device with flexible wings that collapse to form a rod that can be inserted into the vagina with an applicator. On the end opposite to the wings of the insert a tail is attached to facilitate removal with ease. The backbone of the CIDR is a nylon spine covered by progesterone (1.38g) impregnated silicone skin. Upon insertion blood progesterone concentrations rise rapidly, with maximal concentrations reached within an hour after insertion. Progesterone concentrations are maintained at a relatively constant level during the seven days the insert is in the vagina. Upon removal of the insert, progesterone concentrations are quickly eliminated.

Retention rate of the CIDR during a seven-day period exceeds 97%. In some cases, vaginal irritation occurs resulting in clear, cloudy or yellow mucus when the CIDR is removed. Cases of mucus are normal and does not have an impact on effectiveness of the CIDR. Caution should be taken when handling CIDRs. Individuals handling CIDRs should wear latex or nitrile gloves to prevent exposure to progesterone on the surface of the insert and to prevent the introduction of contaminants from the hands into the vagina of treated females. The inserts are developed for a one-time use only. Multiple use may increase the incidence of vaginal infections.

Efficacy of Different GnRH Products

The efficacy of the specific GnRH products used for follicle control in estrous synchronization systems has been discussed. The discussion was spurred by the report (Martinez et al., 2003) that Cystorelin induced a greater LH surge than Fertagyl and Factrel. Cystorelin also induced a greater ovulation rate, but all products synchronized follicular wave emergence. GnRH is a decapeptide – a linear chain of ten amino acids. The base for Cystorelin, Fertagyl and Ovacyst is diacetate, tetrahydrate. Therefore, these three products are chemically identical. Factrel has a HCL base, which should not alter bioactivity. Since the products are chemically similar, why were the differences observed by Martinez et al. (2003)? Pharmaceutical manufacturers are permitted to include a wide range of active compound in the product. Therefore, the Martinez et al. (2003) report may only be a difference in active GnRH within the product. The dose was selected based on cystic ovarian disease, the clinical claim for GnRH products. Perhaps this explains the variability in response when doses less than the recommended dose used. In a retrospective analysis between Cystorelin and Factrel we (Stevenson et al., 2000) we did not see an effect of GnRH product on AI pregnancy rates in cows treated with two different GnRH estrous synchronization protocols. Certainly, more research needs to be performed in this area.

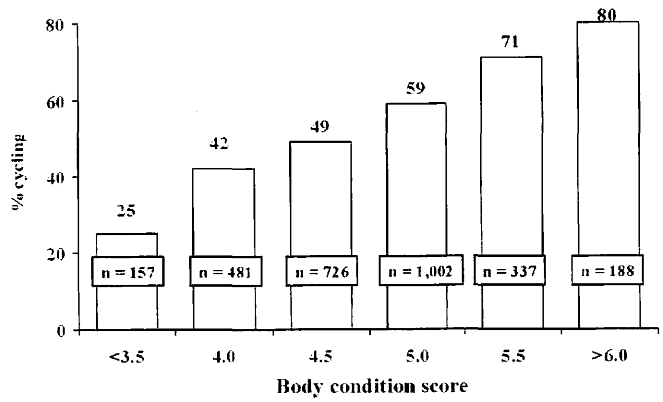
Factors Affecting The Response of Cows to Estrous Synchronization

The two primary factors that affect the response of cows to GnRH and CIDR based estrous synchronization systems are body condition, parity, and days since calving. By managing these two factors, the incidence of anestrus/anovulation can be reduced and more females will respond to be eligible to receive an embryo at the time of embryo transfer.

Body Condition

Body condition is a reflection of the immediate past and current nutritional status of the female. Gestating cows that endure varied wintering conditions with inadequate supplementation are likely to be thinner as calving approaches. Body condition is a good predictor of when the first postpartum estrus may occur. Certainly as body condition score increases at the onset of the breeding season, the proportion of cows cycling also increases by about 18% for each unit increase in body condition score (Figure 1; Stevenson et al., 2003).

Figure 1. Proportion of suckled cows that were cycling on the first day of the breeding season on the basis of body condition score assessed at that time. Cycling status was estimated by concentrations of progesterone in blood serum of cows sampled during 7 and 10 days before the breeding week (adapted from Stevenson et al., 2003).



Parity

Two-year-old (primiparous) cows require more time to initiate cycling activity than older (multiparous) cows, even when they calve before the multiparous cows. This is due to their greater energy needs and added burden to sustain lactation and their own growth, which have greater energy priority than the onset of reproductive estrous cycles. The cow's first priority is for maintenance of essential body functions to preserve life. Once that maintenance requirement is met, remaining nutrients accommodate her own growth. Finally, lactation and the initiation of estrous cycles are supported. Older cows have now growth requirement, thus the nutrients are more likely to be prioritized for milk synthesis and initiation of estrous cycles. Because of this priority system, young, growing cows generally produce less milk and are anestrus longer.

Days Since Calving/Days Postpartum

As a general rule and not unexpected, more cows begin their estrous cycles when they have longer intervals between calving and the onset of estrous synchronization. The proportion of cows cycling increases in a curvilinear fashion across days postpartum (Figure 2; Stevenson et al., 2003). For best result synchronization of estrus should not occur prior to 50 days postpartum in an embryo transfer program.

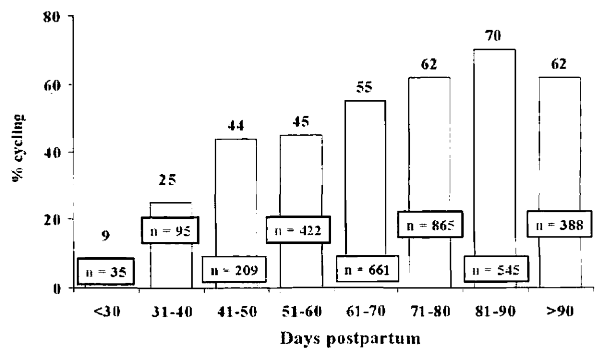
Record Keeping. Maintaining a sound recording keeping system is a key to success in any reproductive management system. For synchronization to work, producers need to know when their cows calved, whether the cow had a difficult birth, and what the birth weights of all calves were. We aim at starting a synchronization protocol when cows are greater than 45 days from calving; however, if your cow had a difficult birth or large calf, perhaps it would be wise to wait an extra few weeks. Without accurate records, these decisions can be extremely subjective.

Facilities. With synchronization, you can expect many more females to be in heat at a single time than without synchronization. Plus, females will need to be pushed through the chute for injections more frequently than usual; therefore, working facilities need to be able to accommodate the extra work. Not only should you consider reliable holding and sorting pens, but also a good solid alley and chute system. Anticipating an increase in facility use will certainly ensure a successful synchronization program.

Labor. Reliable labor is an issue that many people neglect to consider when planning a synchronization program. Detecting when cows are in heat is important for the success of a synchronization program. Any labor associated with this process needs to know exactly how cows act when they are in heat. In many cases, this is often when a program fails. A producer feels that they have more important things to do than spend time heat checking. They will often leave for the "more important" job or leave the heat checking to a less than competent individual. The end result is poor estrus response or poor conception rates.

Many more factors need to be considered, such as

Figure 2. Proportion of suckled cows that were cycling on the first day of the breeding season on the basis of days since calving. Cycling status was estimated by concentrations of progesterone in blood serum of cows sampled during 7 and 10 days before the breeding week (adapted from Stevenson et al., 2003).



using a proficient AI technician. Regardless of the system that you use, be sure to follow the directions on the drug label and don't take short cuts, believing that it will be more simple and save time. Invariably this is when results are at their poorest.

CIDR/PGF Protocols for Cows

During the seven days of CIDR insertion, progesterone diffusion from the CIDR does not affect spontaneous luteolysis. Assuming all cows have 21 day estrous cycles, there will be two populations of females after six days of CIDR treatment: females without corpora lutea and females with corpora lutea more than six days after ovulation. All females, therefore, have corpora lutea that are potentially responsive to an injection of PGF. Although most research data indicates that only about 90% of corpora lutea in cows more than six days after ovulation regress promptly to an injection PGF, only about 60% of the females will have corpora lutea at the time of PGF treatment (assuming that spontaneous corpora lutea regression beings about 18 days after ovulation). Therefore, about 95% of the females treated with the FDA approved CIDR/PGF protocol are synchronized to exhibit estrus within a few days of CIDR insert removal. However, more than 95% of the treated females will be synchronized to exhibit estrus if estrous behavior is monitored for five days after removal of the CIDR insert.

An advantage of a progestin-based estrous synchronization protocol is that administration of progestins to prepubertal heifers and postpartum anestrous cows have been demonstrated to hasten cyclicity. When suckled beef cows were assigned randomly in replicates to one of three groups (Table 2; Lucy et al., 2001): 1) untreated controls, 2) a single intramuscular (IM) injection of 25 mg PGF (PGF alone), or 3) administration of a CIDR insert for 7 d with an IM administration of PGF on day 6 of the 7 d CIDR insert administration period (CIDR + $PGF_{2\alpha}$) no differences were detected between the CIDR + PGF treatment group and either the $PGF_{2\alpha}$ alone or control groups for first-service CR for either the first 3 d of AI or the entire 31 d of AI. More cows were pregnant after either 3 d or 7 d of AI in the CIDR + PGF group than in either the PGF alone or the control group. No differences were detected in PR to first services during the 31 d AI period between the CIDR and PGF and either the PGF alone or the control group. Therefore, insertion of the CIDR increased the synchronization rates within the first 3 d following PGF, resulting in enhanced pregnancy rates. A drawback of the current protocol is that PGF was administered on d 6 after CIDR insertion (a day before CIDR removal). For beef producers this tends to be impractical, because the cows need to be handled a minimum of four times including an AI. Therefore, a more practical modification of this protocol is to inject PGF the on the day of CIDR removal.

Recent Advances in Protocols Using the CIDR for Cows

Several alterations of the basic protocol are being evaluated; however, much work is yet to be done since field trials with CIDRs were limited during the FDA approval process. Inclusion of the CIDR in the CO-Synch procedure appears to be the most researched alternative method for synchronizing beef cows. We (Lamb et al., 2001) published data in which the CIDR was included in the CO-Synch estrous synchronization procedure (Table 1). The CIDR was inserted at the time of the first injection of GnRH and removed at the time of the injection of PGF. Overall, there was a positive effect of including the CIDR in the CO-Synch protocol; however, this positive effect was not consistent across all locations. Second, the positive effect of including the CIDR was absent in the cows that were cycling and had high progesterone concentrations at the time of PGF treatment, which may explain why there was not a positive effect at each location. Along with parity, days postpartum, calf removal, and cow body condition (Table 3) our previous report (Lamb et al., 2001) also indicated that location variables, which could include differences in pasture and diet, breed composition, body condition, postpartum interval, and geographic location, may affect the success of fixed-time AI protocols.

In a more recent study involving 14 locations in seven states we (Larson et al., 2004) evaluated both fixed-time AI protocols and detection of estrus protocols with a clean-up AI. These protocols were compared to GnRH/$PGF_{2\alpha}$ protocols. Although the location accounted for the greatest variation in overall pregnancy rates the Hybrid-Synch+CIDR protocol (Figure 1) was the protocol that most consistently yielded the greatest pregnancy rates within each location. However, the CO-Synch protocol (Appendix A) was an effective Fixed-time AI protocol that yielded pregnancy rates of 54%. Additional factors that affect pregnancy rates were cycling status, parity, and days postpartum (Table 4).

Interestingly, the distribution of estrus among the CIDR/PGF, Select Synch & TAI and Select Synch+CIDR & TAI protocols was similar (Figure 3) and the average time from PGF to estrus or AI was similar to among all three treatments (Figure 4). Since the estrus response was greater in the Select Synch+CIDR & TAI protocol overall pregnancy rates were greater.

Table 2. Fertility rates in suckled beef cows treated with estrous synchronization protocols containing progestins.

Reference and treatment description	No. of cows	Conception rate[a], %	Pregnancy rate[b], %
Stevenson et al., 2000			
Exp. 1			
Select Synch	289	115/175 (66)	115/289 (38)
Select Synch + Norgestomet	289	123/208 (59)	123/289 (42)
2 × PGF	294	86/142 (61)	86/294 (28)
Dejarnette et al., 2001			
Exp. 2			
Select Synch	77	40/60 (67)	40/77 (52)
Select Synch + MGA from d -7 to -1	73	43/61 (72)	43/73 (60)
Lamb et al., 2001			
CO-Synch	287	-	138/287 (48)
CO-Synch + CIDR from d –7 to 0	273	-	160/273 (59)
Larson et al.., 2004a			
CIDR/PGF (PG on d 0) - anestrous	147	-	74/147 (50)
CIDR/PGF (PG on d 0) - cyclic	296	-	159/296 (54)
CO-Synch - anestrous	156	-	59/156 (38)
CO-Synch - cyclic	330	-	145/330 (44)
CO-Synch + CIDR - anestrous	180	-	85/180 (47)
CO-Synch + CIDR - cyclic	294	-	169/294 (57)
Select Synch & TAI - anestrous	143	-	60/143 (42)
Select Synch & TAI - cyclic	308	-	182/308 (59)
Select Synch+CIDR & TAI - anestrous	136	-	72/136 (53)
Select Synch+CIDR & TAI - cyclic	306	-	180/306 (59)
Lucy et al., 2001			
Control - anestrous	151	6/16 (38)	6/151 (4)
Control - cyclic	134	15/26 (58)	15/134 (11)
PGF - anestrous	154	17/30 (57)	17/154 (11)
PGF - cyclic	129	44/63 (70)	44/129 (34)
CIDR/PGF (PG on d –1) - anestrous	141	36/63 (57)	36/141 (26)
CIDR/PGF (PG on d –1) - cyclic	140	64/101 (63)	64/140 (46)

[a] Percentage of cows pregnant exposed to AI.
[b] Percentage of cows pregnant of all cows treated.

CIDR/PGF Protocols for Heifers

As with cows, beef heifers have 21-day estrous cycles and respond to the CIDR in a similar fashion to cows, resulting in a majority of heifers that should be synchronized using the FDA approved CIDR/PGF protocol. Heifers tend to be an easier population of females to synchronize for estrus, because they are not nursing calves, tend to express estrus well, and most of the heifers usually are cycling, and can be maintained in areas where they can be fed allowing them to respond well to the MGA/PGF system (Wood et al., 2001; Brown et al., 1988; Lamb, et al., 2000). In addition, MGA delivered in feed has the ability to induce puberty in some peripubertal heifers (Patterson et al., 1992). However, the length of time to apply this system (31 to 33 d) is a drawback. During a late spring/early summer breeding season, MGA must be delivered in a grain carrier when cattle tend to be grazing forage pastures. Thus, the challenge is to

Table 3. Pregnancy rates in suckled beef cows after treatment with Cosynch or Cosynch+CIDR (Lamb et al., 2001)

	Treatment[a]		
Item	Cosynch	Cosynch+P	Overall
	---------------- no. (%) ----------------		
Body condition[b]			
≤ 4.5	12/40 (30)	11/36 (31)	23/76[x] (30)
4.5 to 5.5	30/74 (41)	40/80 (50)	70/154[y] (45)
≥ 5.5	19/32 (59)	11/13 (85)	31/45[z] (69)
Days postpartum			
≤ 50	23/60 (38)	27/58 (47)	50/118[x] (42)
51-60	25/62 (47)	36/54 (67)	61/116[y] (53)
61-70	28/49 (62)	25/44 (57)	53/93[y] (57)
71-80	18/41 (44)	30/45 (67)	48/86[y] (56)
> 80	44/75 (59)	42/72 (58)	86/147[y] (59)
Parity[c]			
Multiparous	61/138 (44)	79/132 (60)	140/270 (52)
Primiparous	25/50 (50)	20/45 (44)	45/95 (47)

[a] See experimental design for treatments in Figure 1.
[b] Body condition scores from IL and MN only.
[c] Parity data from KS and MN only.
[xyz] Percentages within an item and column lacking a common superscript letter differ ($P < .05$).

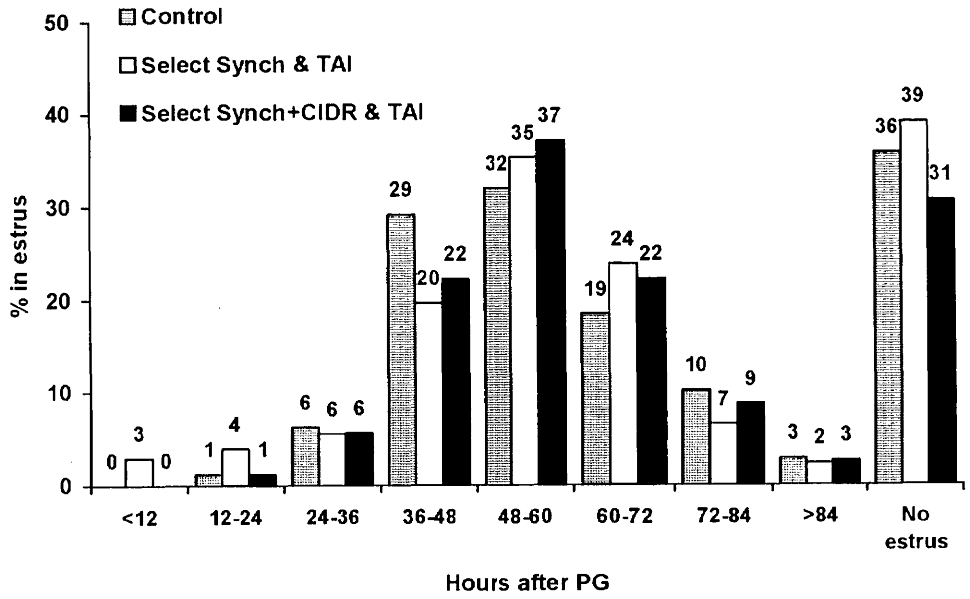


Figure 3. Percentage of cows treated with CIDR/ PGF, Select Synch & TAI, or Select Synch+CIDR & TAI that were observed in estrus, separated by hours from PG injection to AI (Larson et al., 2004a)

Table 4. First-service pregnancy rates in suckled beef cows after estrus synchronization with PG, GnRH, and/or a CIDR.

Item	Treatments[a]					Overall
	Control	CO-Synch	CO-Synch+CIDR	Select Synch & TAI	Select Synch+CIDR & TAI	
			--------------------no. (%) --------------------			
Pregnancy rates[b]	266/506[x] (53)	238/548[y] (43)	290/539[x] (54)	269/507[x] (53)	289/498[x] (58)	1352/2598 (52)
Cycling Status[c]						
Cycling	154/282 (55)	142/316 (45)	165/278 (59)	175/291(60)	170/288 (59)	806/1455 (55)
Noncycling	74/147 (51)	57/155 (37)	84/178 (47)	59/141 (42)	73/136 (54)	347/757 (46)
Parity[d]						
Primiparous	38/84 (45.2)	33/84 (39.3)	49/89 (55.1)	37/86 (43.0)	48/85 (56.5)	205/428[x] (47.9)
Multiparous	196/365 (53.7)	178/400 (44.5)	222/394 (56.3)	205/362 (56.6)	207/355 (58.3)	1007/1876[y] (53.7)
Body Condition Score						
< 5	43/85 (51)	39/100 (39)	54/96 (56)	42/79 (50)	34/67 (51)	212/427 (50)
5-6	115/231 (50)	114/252 (45)	140/268 (52)	114/231 (49)	137/237 (58)	620/1219 (51)
≥ 6	105/183 (57)	80/182 (44)	93/163 (57)	108/182 (59)	110/181 (61)	496/891 (56)
Days Postpartum						
≤ 50	36/85 (42)	29/90 (32)	46/89 (52)	42/91 (46)	53/93 (57)	206/448[x] (46)
51-60	52/83 (63)	42/91 (46)	52/88 (59)	34/79 (43)	40/66 (61)	220/407[y] (54)
61-70	50/100 (50)	45/108 (42)	57/107 (53)	56/98 (57)	60/104 (58)	268/517[y] (52)
71-80	63/116 (54)	73/149 (50)	76/134 (57)	75/120 (63)	63/115 (55)	350/631[y] (55)
> 80	65/122 (53)	49/113 (43)	59/121 (49)	62/119 (52)	73/120 (61)	308/595[y] (52)

[a] See experimental design or treatments in Figure 1.
[b] Pregnancy rates = percentage of cows pregnant compared to all cows estrus synchronized and inseminated artificially.
[c] Cycling status excludes locations OH-1 and OH-2.
[d] Parity data excludes MN-1, MN-3, and OH-1.
[xy] Percentages within an item and column lacking a common superscript letter differ ($P < .05$).

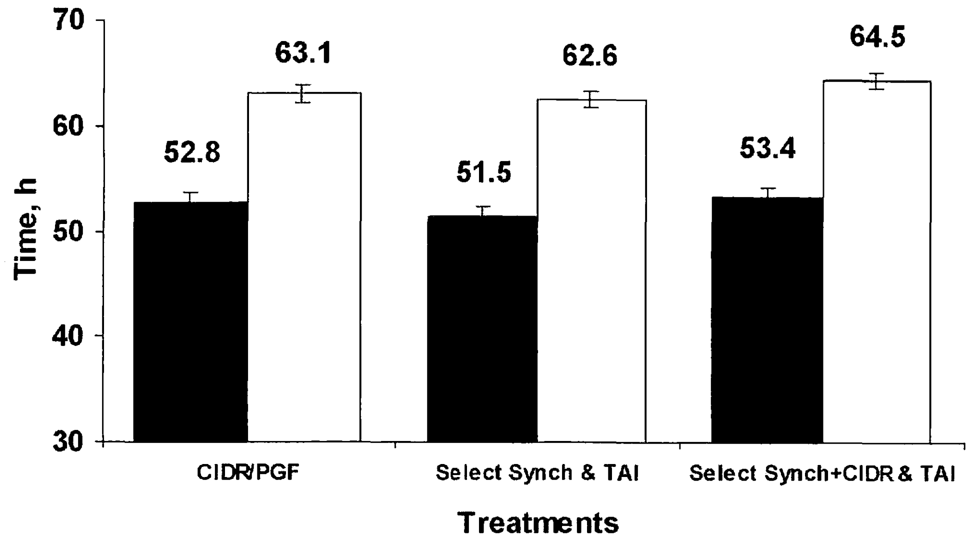


Figure 4. Time from PG injection to estrus (black bar) and time from PG injection to AI (white bar) for those cows exhibiting estrus in Control, Select Synch & TAI, and Select Synch+CIDR & TAI treatments (Larson et al., 2004a).

ensure that each heifer receives the required MGA dose. Therefore, producers could benefit from an alternative estrous synchronization system that eliminates the use of MGA.

First attempts focused at synchronizing estrus in heifers with a CIDR and PGF. The study by Lucy et al., (2001; Table 5) demonstrates the pregnancy rates of heifers synchronized with the FDA approved CIDR/ PGF protocol. As in cows, the CIDR/PGF protocol yielded greater pregnancy rates in heifers than for heifers that were untreated or for heifers treated with PGF alone. Therefore, insertion of the CIDR increased the synchronization rates within the first 3 d following PGF, resulting in enhanced pregnancy rates. Again, the drawback of the current protocol is that PGF was administered on d 6 after CIDR insertion, which requires an additional day of handling the heifers. Therefore, consideration should be to inject PGF the on the day of CIDR removal.

The CIDR + PGF treatment reduced the interval to first estrus (2 d) compared with either the control (15 d) or PGF alone (16 d) treatments (Table 4). Similarly, for heifers that were prepubertal when the study was initiated the CIDR + PGF shortened the interval to first estrus (14 d) compared to control (27 d) and PGF alone (31 d). The CIDR + PGF treatment improved the synchrony of estrus compared with the PGF alone, with 60% vs. 25%, of heifers in estrus over 3 d after CIDR inserts were removed.

Recent Advances in Protocols Using the CIDR for Heifers

Although excellent pregnancy rates can be achieved with the MGA/PGF protocol and acceptable pregnancy rates can be achieved with the CIDR/PGF protocol, no system short duration system has managed to successfully synchronize estrus in replacement beef heifers that consistently yields pregnancy rates that match the MGA/PGF protocol. In addition, there has not been a no reliable fixed-time AI protocol exists for synchronizing estrus in beef heifers. Therefore, in a more recent study involving 12 locations in 8 states we (Larson et al., 2004b) focused on developing a study to determine whether: 1) a TAI protocol could yield fertility similar to a protocol requiring detection of estrus; and 2) an injection of GnRH at CIDR insertion enhances pregnancy rates.

To evaluate our objectives, estrus in beef heifers was synchronized and artificial insemination occurred after four treatments (Figure 1): 1) CIDR/PGF & TAI; 2) Select Synch+CIDR & TAI; 3) CO-Synch+CIDR; and 4) CIDR/PGF/TAI. The percentage of heifers cycling at the initiation of estrous synchronization was 91.0%. Percentages of cycling heifers among locations ranged from 78 to 100%. Overall pregnancy rates were at days 30 to 35 after AI ranged from 38 to 74%. Although no differences in pregnancy rates were detected among treatments, heifers that were

Table 5. Interval to estrus, synchrony of estrus and fertility of beef heifers following treatment with PGF or CIDR and an injection of PGF (Lucy et al., 2001).

Criterion	Untreated controls	PGF[1]	CIDR/PGF[2]
Interval[3] to estrus, d (n)			
All heifers	15*	16*	2
Anestrous heifers[5]	27**	31**	14
Estrus d 1-3, %	12**	25**	60
FSCR[4], % (n)			
D 1-3	57	52	60
D 1-31	58	52	58
FSPR[5], % (n)			
D 1-3	7**	14**	36
D 1-7	14**	18**	38
D 1-31	42	36*	47

[1]25 mg PGF.
[2]CIDR insert administered intravaginally for 7 days with PGF administered on day 6.
[3] Median interval in days from removal of CIDR inserts.
[4] First-service conception rate (number of heifers).
[5] First-service pregnancy rate (number of heifers).
* Different from CIDR/PGF, $P < 0.05$.
** Different from CIDR/PGF, $P \leq 0.01$.

inseminated in the estrus-detection treatments had greater pregnancy rates than heifers in the fixed-time AI treatments (56 vs. 51%, respectively). However, the the CO-Synch+CIDR treatment provides a reliable fixed-time AI protocol for beef producers (Figure 5).

For the two estrus-detection protocols, CIDR/PGF and Select Synch+CIDR & TAI, pregnancy rates for heifers detected in estrus before 84 hr were 44.6 and 45.0%, respectively. Therefore, the clean-up TAI at 84 hr enhanced pregnancy rates by 9.9 and 12.3 percentage points for CIDR/PGF and Select Synch+CIDR & TAI protocols, respectively. These results indicate that TAI after a period of estrus detection enhances the potential for improving pregnancy rates to exceed those of estrus detection alone (Figure 6).

The time from PG injection to detection of estrus and AI for those heifers exhibiting estrus was similar among CIDR/PGF & TAI (49.9 and 61.7 hr, respectively) and Select Synch+CIDR & TAI (49.8 and 61.3 h, respectively). These results demonstrate that estrus in heifers can be synchronized effectively with GnRH, PG, and a CIDR. The Select Synch+CIDR & TAI treatment most frequently produced the greatest pregnancy rates and provided a reliable alternative to an MGA/PGF protocol.

Summary

To achieve optimal pregnancy rates with CIDR based estrous synchronization protocol, cows should be in good body condition (BCS ≥ 5) and treatments should be initiated only when cows are at least 50 days postpartum. Treatment of suckled cows and replacement beef heifers with a CIDR and GnRH will yield industry accepted pregnancy rates. Results of the most recent CIDR based studies indicate that for a fixed-timed AI protocol the CO-Synch+CIDR protocol yields the most impressive pregnancy rates for a fixed-time AI protocol, whereas the Select Synch+CIDR & TAI treatment yields the best overall pregnancy rates. Similarly, heifers can be synchronized effectively with GnRH, PG, and a CIDR. The Select Synch+CIDR protocol most frequently yields the greatest pregnancy rates and provides a reliable alternative to an MGA/PGF. In addition, a fixed-time AI CIDR-based estrus synchronization protocol has been developed to inseminate both suckled beef cows and replacement heifers with acceptable pregnancy rates.

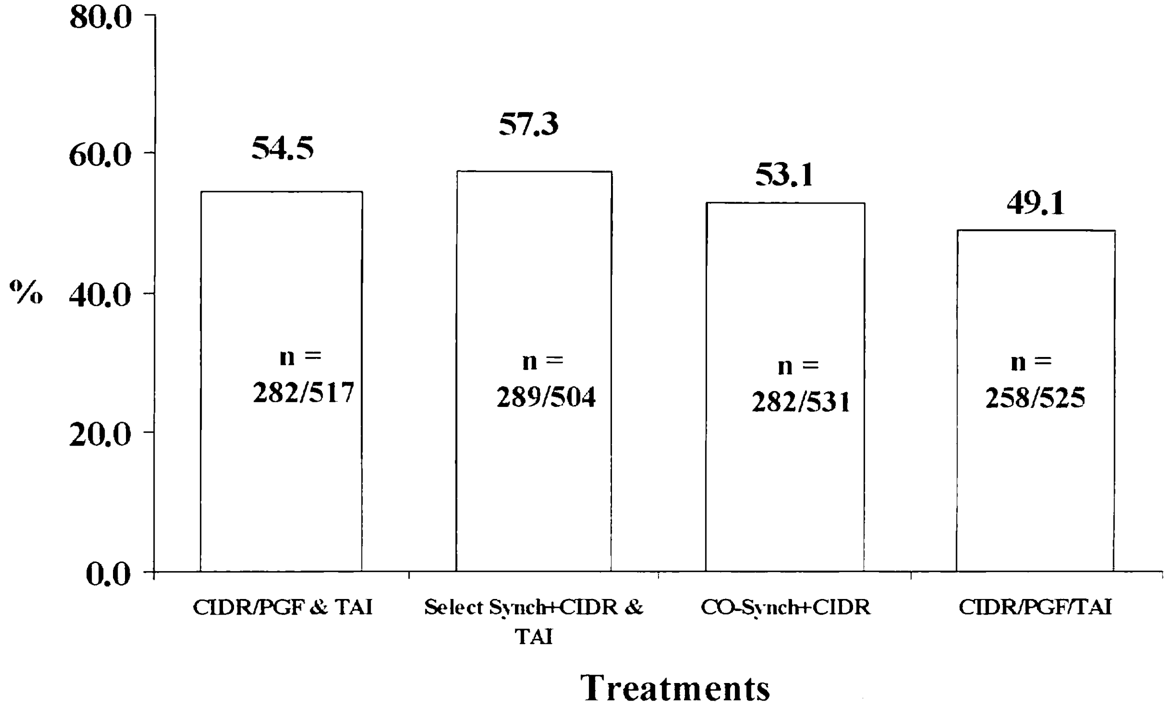


Figure 5. First service pregnancy rates in heifers after receiving one of four CIDR treatments (Larson et al., 2004).

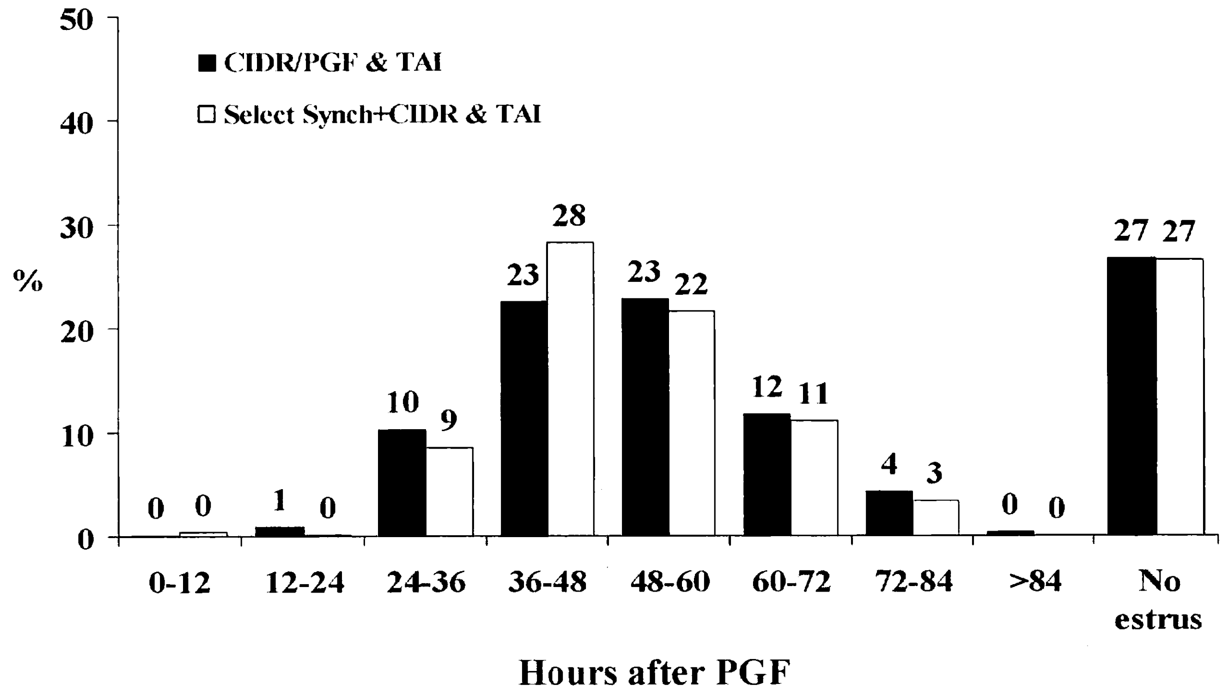


Figure 6. Percentage of heifers treated with CIDR/ PGF or Select Synch+CIDR & TAI that were observed in estrus, separated by hours from PG injection to AI (Larson et al., 2004b).

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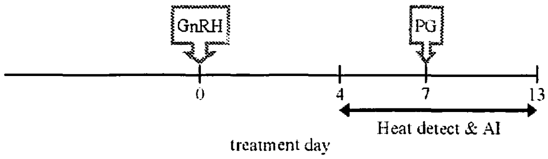
APPENDIX A

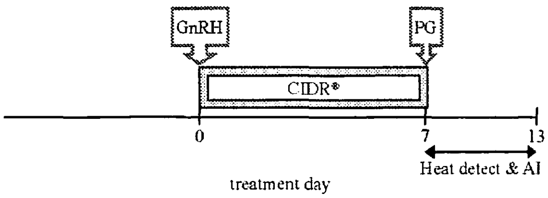
BEEF COW PROTOCOLS

HEAT DETECTION

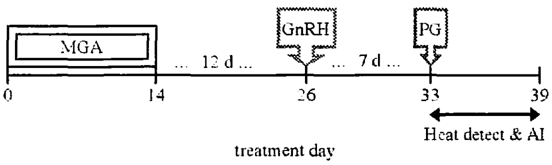
Select Synch



Select Synch + CIDR®



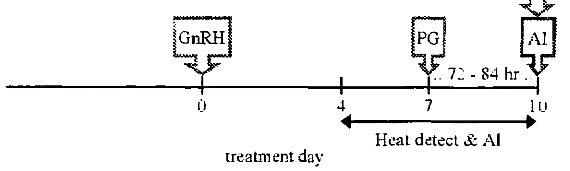
MGA® Select



HEAT DETECT & TIME AI (TAI)

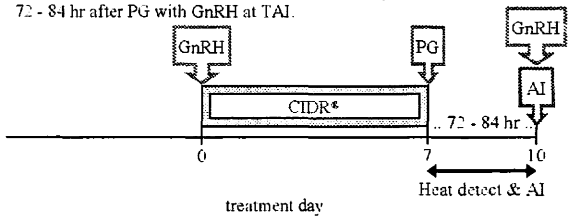
Select Synch & TAI

Heat detect and AI day 4 to 10 and TAI all non-responders 72 – 84 hr after PG with GnRH at TAI.



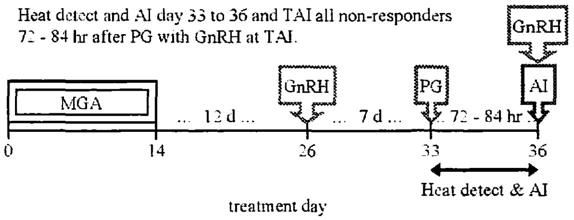
Select Synch + CIDR® & TAI

Heat detect and AI day 7 to 10 and TAI all non-responders 72 - 84 hr after PG with GnRH at TAI.



MGA® Select & TAI

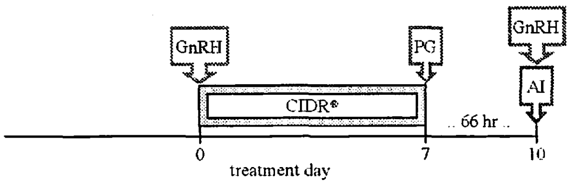
Heat detect and AI day 33 to 36 and TAI all non-responders 72 - 84 hr after PG with GnRH at TAI.



FIXED-TIME AI (TAI)

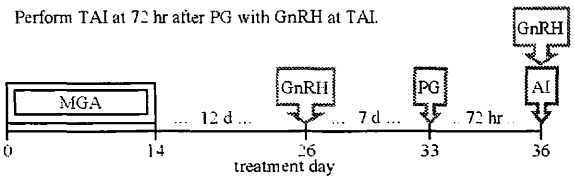
CO-Synch + CIDR®

Perform TAI at 66 hr after PG with GnRH at TAI.



MGA® Select

Perform TAI at 72 hr after PG with GnRH at TAI.



D.J. Schafer and D.J. Patterson
Division of Animal Sciences - University of Missouri – Columbia
These protocols are recommended by the North Central Region Bovine Reproduction Task Force.

COMPARISON OF PROTOCOLS FOR BEEF COWS

HEAT DETECTION	COST	LABOR
Select Synch	Low	Medium/High
Select Synch + CIDR®	High	Medium
MGA® Select	Medium	Medium/High
HEAT DETECT & TAI		
Select Synch (TAI non-responders 72-84 hr after PG)	Low	Medium/High
Select Synch + CIDR® (TAI non-responders 72-84 hr after PG)	High	Medium
MGA® Select (TAI non-responders 72-84 hr after PG)	Medium	Medium/High
FIXED-TIME AI (TAI)		
CO-Synch + CIDR® (TAI at 66 hr after PG with GnRH at TAI)	High	Medium
MGA® Select (TAI at 72 hr after PG with GnRH at TAI)	Medium	High

• The times listed for "Fixed-time AI" should be considered as the approximate average time of insemination. This should be based on the number of cows to inseminate, labor, and facilities.

 Cystorelin®, Factrel®, Fertagyl®, OvaCyst®

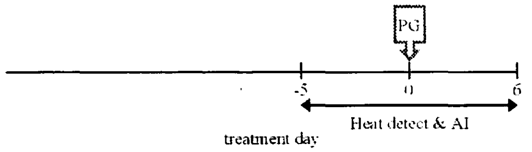
 Estrumate®, In-Synch®, Lutalyse®, ProstaMate®

APPENDIX B

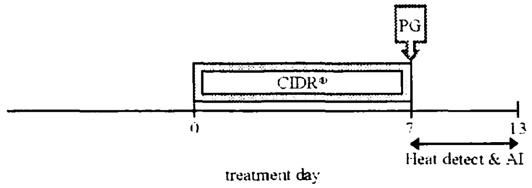
BEEF HEIFER PROTOCOLS

HEAT DETECTION

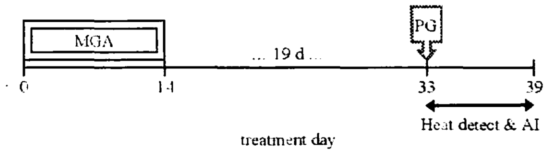
1 Shot PG



CIDR®-PG



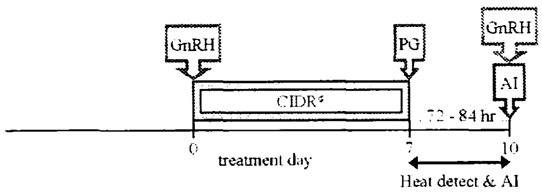
MGA®-PG



HEAT DETECT & TIME AI (TAI)

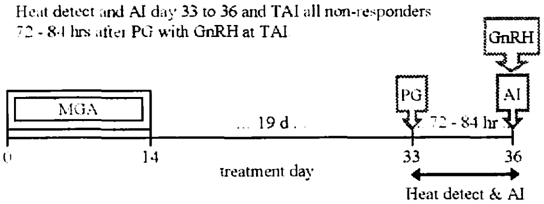
Select Synch + CIDR® & TAI

Heat detect and AI day 7 to 10 and TAI all non-responders 72 - 84 hr after PG with GnRH at TAI.



MGA®-PG & TAI

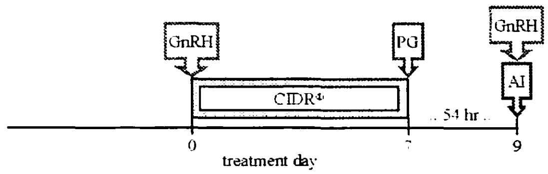
Heat detect and AI day 33 to 36 and TAI all non-responders 72 - 84 hrs after PG with GnRH at TAI



FIXED-TIME AI (TAI)

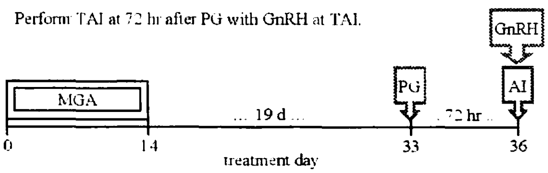
CO-Synch + CIDR®

Perform TAI at 54 hr after PG with GnRH at TAI



MGA®-PG

Perform TAI at 72 hr after PG with GnRH at TAI.



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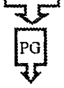
These protocols are recommended by the North Central Region Bovine Reproduction Task Force

COMPARISON OF PROTOCOLS FOR BEEF HEIFERS

HEAT DETECTION	COST	LABOR
1 Shot PG	Low	High
CIDR®-PG	Medium	Medium
MGA®-PG	Low	Low/Medium
HEAT DETECT & TAI		
Select Synch + CIDR® (TAI non-responders 72-84 hr after PG)	High	Medium
MGA®-PG (TAI non-responders 72-84 hr after PG)	Medium	Medium
FIXED-TIME AI (TAI)		
CO-Synch + CIDR® (TAI at 54 hr after PG with GnRH at TAI)	High	Medium
MGA®-PG (TAI at 72 hr after PG with GnRH at TAI)	Medium	Medium

• The times listed for "Fixed-time AI" should be considered as the approximate average time of insemination. This should be based on the number of heifers to inseminate, labor, and facilities.

Cystorelin®, Factrel®, Fertagyl®, OvaCyst®



Estrumate®, In-Synch®, Lutalyse®, ProstaMate®

New Opportunities to Synchronize Estrus and Ovulation and Facilitate Fixed-Time AI

D. J. Patterson, M. F. Smith, and D. J. Schafer
University of Missouri, Columbia

INTRODUCTION

Estrus synchronization and artificial insemination (AI) remain the most important and widely applicable reproductive biotechnologies available for cattle (Seidel, 1995). Although hormonal treatment of heifers and cows to group estrous periods has been a commercial reality now for over 30 years, beef producers have been slow to adopt this management practice. Perhaps this is because of past failures, which resulted when females that were placed on estrus synchronization treatments failed to reach puberty or to resume normal estrous cycles following calving. In addition, early estrus synchronization programs failed to manage follicular waves, resulting in more days in the synchronized period, which ultimately precluded fixed-time artificial insemination with acceptable pregnancy rates. The development of convenient and economical protocols to synchronize estrus and ovulation to facilitate use of fixed-time AI with resulting high fertility should result in increased adoption of these important management practices (Patterson et al., 2003). Current research has focused on the development of methods that effectively synchronize estrus in postpartum beef cows and replacement beef heifers by decreasing the period of time over which estrus detection is required, thus facilitating the use of fixed timed AI.

Although tools are now available for beef producers to successfully utilize these procedures, transfer of the technology must assume a high priority. Transfer of this technology to beef producers in the U.S. will require an increase in technical support to facilitate successful use and adoption of these procedures, otherwise the products of our research and technology may be used more effectively in foreign countries (i.e., Brazil) whose beef products will ultimately compete with our own (Patterson et al., 2000).

Improving traits of major economic importance in beef cattle can be accomplished most rapidly through selection of genetically superior sires and widespread use of artificial insemination. Procedures that facilitate synchronization of estrus in cycling females and induction of an ovulatory estrus in peripubertal heifers and anestrous postpartum cows will increase reproductive rates and expedite genetic progress. Estrus synchronization can be an effective means of increasing the proportion of females that become pregnant early in the breeding season resulting in shorter calving seasons and more uniform calf crops (Dziuk and Bellows, 1983). Females that conceived to a synchronized estrus calved earlier in the calving season and weaned calves that were on average 13 days older and 21 pounds per calf heavier than calves from nonsynchronized females (Schafer et al., 1990).

Effective estrus synchronization programs offer the following advantages: 1) cows or heifers are in estrus at a predicted time which facilitates AI, embryo transfer, or other assisted reproductive techniques; 2) the time required for detection of estrus is reduced thus decreasing labor expense associated with estrus detection; 3) cattle will conceive earlier during the breeding period; 4) AI becomes more practical; and 5) calves will be older and heavier at weaning.

WHY BEEF PRODUCERS DO NOT USE EXISTING AND POTENTIAL TECHNOLOGIES. Beef producers cite several reasons for the lack of widespread use of AI to breed heifers and cows. These reasons include: lack of time and labor, available procedures are viewed as being too complicated or costly to implement, inadequate means to detect estrus, or inconvenience (NAHMS, 1998). Continuation of low adoption rates of these technologies in the U.S. will ultimately erode the competitive position of the U.S. cattle industry. Other countries are adopting new technologies for animal production more rapidly than the U.S. For example, growth in the use of AI in Brazil has outpaced that of the U.S. (ASBIA, 2004; NAAB, 2004; Table 1). Beef producers in Brazil artificially inseminate nearly 5 times more cows annually compared with U.S. producers. Given the current scenario, elite seedstock herds in the U.S. will soon provide a sizeable percentage of the germ plasm used worldwide. Unless, however, owners of commercial cowherds aggressively implement reproductive and genetic improvement, the U.S. will lose its competitive advantage in production of high quality beef. International players that are more technically astute and competitively advantaged will position themselves to dominate the production and sale of beef worldwide.

The inability to predict time of estrus for individual cows or heifers in a group often makes it impractical to use AI because of the labor required for detection of estrus. Available procedures to control the estrous cycle of the cow can improve reproductive rates and speed up genetic progress. These procedures include synchronization of estrus in cycling females, and induction of estrus accompanied by ovulation in heifers that have not yet reached puberty or among cows that have not returned to estrus after calving.

The following protocols and terms will be referred to throughout this manuscript.

<u>*Protocols:*</u>

PG: Prostaglandin $F_{2\alpha}$ (PG; Lutalyse®, Estrumate®, ProstaMate®, InSynch®).

MGA-PG: Melengestrol acetate (MGA; 0.5 mg/hd/day) is fed for a period of 14 days with PG administered 17 to 19 days after MGA withdrawal.

GnRH-PG (Select Synch): Gonadotropin-releasing hormone injection (GnRH; Cystorelin®, Factrel®, Fertagyl®, OvaCyst®) followed in 7 days with an injection of PG.

MGA-GnRH-PG (MGA® Select): MGA is fed for 14 days, GnRH is administered 12 days after MGA withdrawal, and PG is administered 7 days after GnRH.

7-11 Synch: MGA is fed for 7 days, PG is administered on the last day MGA is fed, GnRH is administered 4 days after the cessation of MGA, and a second injection of PG is administered 11 days after MGA withdrawal.

<u>*Protocols for fixed-time AI:*</u>

MGA® Select: MGA is fed for 14 days, GnRH is administered 12 days after MGA withdrawal, and PG is administered 7 days after GnRH. Insemination is performed 72 hours after PG with GnRH administered at AI.

7-11 Synch: MGA is fed for 7 days, PG is administered on the last day MGA is fed. GnRH is administered 4 days after the cessation of MGA, and a second injection of PG is administered 11 days after MGA withdrawal. Insemination is performed 60 hours after PG with GnRH administered at AI.

CO-Synch + CIDR: GnRH is administered at CIDR insertion on day 0, followed 7 days later with CIDR removal and PG. Insemination is performed 66 hours after CIDR removal and PG, with GnRH administered at AI.

<u>*Terms:*</u>

Estrous response: The number of females that exhibit estrus during a synchronized period.

Synchronized period: The period of time during which estrus is expressed after treatment.

Synchronized conception rate: The proportion of females that become pregnant of those exhibiting estrus and inseminated during the synchronized period.

Synchronized pregnancy rate: Proportion of females that become pregnant of the total number treated.

To avoid problems when using estrus synchronization, females should be selected for a program when the following conditions are met: 1) Adequate time has elapsed from calving and the time synchronization treatments are implemented (a minimum of 40 days postpartum at the beginning of treatment is suggested); 2) Cows are in average or above-average body condition (scores of at least 5 on a scale of 1 to 9); 3) Cows experience minimal calving problems; 4) Replacement heifers are developed to prebreeding target weights that represent at least 65 percent of their projected mature weight; and 5) Reproductive tract scores (RTS) are assigned to heifers no more than two weeks before a synchronization treatment begins (scores of 3 or higher on a scale of 1 to 5) and at least 50 percent of the heifers are assigned a RTS of 4 or 5 (Patterson et al., 2000a).

DEVELOPMENT OF METHODS TO SYNCHRONIZE ESTRUS

The development of methods to control the estrous cycle of the cow has occurred in six distinct phases. The physiological basis for estrus synchronization followed the discovery that progesterone inhibited ovulation (Ulberg et al., 1951) and preovulatory follicular maturation (Nellor and Cole, 1956; Hansel et al., 1961; Lamond, 1964). Regulation of estrous cycles was believed to be associated with control of the corpus luteum, whose life span and secretory activity are regulated by trophic and lytic mechanisms (Thimonier et al., 1975; Patterson et al., 2003). The Progesterone Phase included efforts to prolong the luteal phase of the estrous cycle or to establish an artificial luteal phase by administering exogenous progesterone. Later, progestational agents were combined with estrogens or gonadotropins in the Progesterone–Estrogen Phase. Prostaglandin $F_{2\alpha}$ and its analogs were reported in 1972 to be luteolytic in the bovine (Lauderdale, 1972; Rowson et al., 1972; Liehr et al., 1972; Lauderdale et al., 1974) and ushered in the PG Phase. Treatments that combined progestational agents with PG characterized the Progestogen-PG Phase. All of these protocols addressed control of the luteal phase of the estrous cycle since follichlular waves were not recognized at the time.

Precise monitoring of ovarian follicles and corpora lutea over time by transrectal ultrasonography expanded our understanding of the bovine estrous cycle and particularly the change that occurs during a follicular wave (Fortune et al., 1988). Growth of follicles in cattle occurs in distinct wave-like patterns, with new follicular waves occurring approximately every 10 days (6-15 day range). We now know that precise control of estrous cycles requires the manipulation of both follicular waves and luteal lifespan (GnRH-PG Phase).

A single injection of gonadotropin-releasing hormone (GnRH) to cows at random stages of their estrous cycles causes release of luteinizing hormone leading to synchronized ovulation or luteinization of most large dominant follicles (≥ 10 mm; Garverick et al., 1980; Bao and Garverick, 1998; Sartori et al., 2001). Consequently, a new follicular wave is initiated in all cows within 2 to 3 days of GnRH administration. Luteal tissue that forms after GnRH administration is capable of undergoing PG-induced luteolysis 6 or 7 days later (Twagiramungu et al., 1995). The GnRH-PG protocol increased estrus synchronization rate in beef (Twagiramungu et al., 1992a,b) and dairy (Thatcher et al., 1993) cattle. A drawback of this method, however, is that approximately 5 to 15% of the cows are detected in estrus on or before the day of PG injection, thus reducing the proportion of females that are detected in estrus and inseminated during the synchronized period (Kojima et al., 2000). This information stimulated research in the Progestogen-GnRH-PG Phase.

Synchronization of Estrus and Ovulation with the GnRH-PG-GnRH Protocol

Administration of PG alone is commonly utilized to synchronize an ovulatory estrus in estrous cycling cows. However, this method is ineffective in anestrous females and variation among animals in the stage of the follicular wave at the time of PG injection directly contributes to the variation in onset of estrus during the synchronized period (Macmillan and Henderson, 1984; Sirois and Fortune, 1988). Consequently, the GnRH-PG-GnRH protocol was developed to synchronize follicular waves and timing of ovulation. The GnRH-PG-GnRH protocol (Figure 1) for fixed-time AI results in development of a preovulatory follicle that ovulates in response to a second GnRH-induced LH surge 48 hours after PG injection (Ovsynch; Pursely et al., 1995). Ovsynch was validated as a reliable means of synchronizing ovulation for fixed-time AI in lactating dairy cows (Pursley et al., 1995; Burke et al.,1996; Pursley et al., 1997a,b; Schmitt et al., 1996). Time of ovulation with Ovsynch occurs between 24 to 32 hours after the second GnRH injection and is synchronized in 87 to 100% of lactating dairy cows (Pursley et al., 1997a). Pregnancy rates among cows that were inseminated at a fixed time following Ovsynch ranged from 32 to 45% (Pursley et al., 1997b; 1998). The Ovsynch protocol, however, did not effectively synchronize estrus and ovulation in dairy heifers (35% pregnancy rate compared with 74% in PG contols; Pursley et al., 1997b).

Protocols for fixed-time insemination were recently tested in postpartum beef cows. Pregnancy rates for Ovsynch treated beef cows were compared with those of cows synchronized and inseminated at a fixed time following treatment with Syncro-Mate-B (Geary et al., 1998a). Calves in both treatment groups were removed from their dams for a period of 48 hours beginning either at the time of implant removal (Syncro-Mate-B) or at the time PG was administered (Ovsynch). Pregnancy rates following fixed-time AI after Ovsynch (54%) were higher than for Syncro-Mate-B (42%) treated cows. One should note that on the day following fixed-time insemination, cows were exposed to fertile bulls of the same breed; no attempt was made to determine progeny paternity. Additionally, we do not know the incidence of short cycles among cows that were anestrus prior to treatment and that perhaps returned to estrus prematurely and became pregnant to natural service.

Recently, variations of the Ovsynch protocol (CO-Synch and Select Synch) were tested in postpartum beef cows (Figure 1). It is important to understand that treatment variations of Ovsynch currently being used in postpartum beef cows have not undergone the same validation process that Ovsynch underwent in lactating dairy cows. At this point we do not know whether response in postpartum beef cows to the protocols outlined in Figure 1 is the same or different from lactating dairy cows due to potential differences in follicular wave patterns. Differences in specific response variables may include: a) the relative length of time to ovulation from the second GnRH injection; b) the anticipated range in timing of ovulation; and c) the degree of ovulation synchrony that occurs.

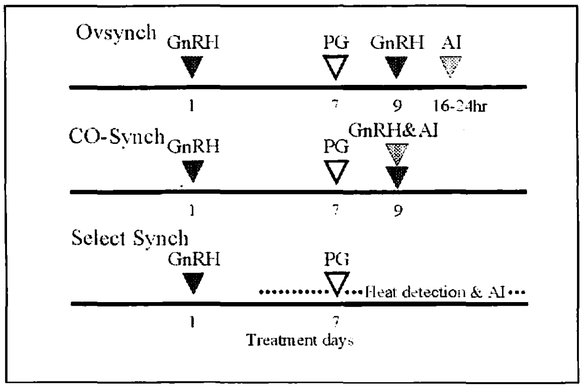


Figure 1. Methods currently being used to synchronize ovulation in postpartum beef cows: Ovsynch, CO-Synch and Select Synch.

Two variations from Ovsynch being used most extensively in postpartum beef cows are currently referred to as CO-Synch and Select Synch. CO-Synch (Geary et al., 1998b) is similar to Ovsynch in that timing and sequence of injections are the same and all cows are inseminated at a fixed time. CO-Synch differs from Ovsynch, however, in that cows are inseminated when the second GnRH injection is administered, compared to the recommended 16 hours after GnRH for Ovsynch treated cows. Select Synch (Geary et al., 2000) differs too, in that cows do not receive the second injection of GnRH and are not inseminated at a fixed time. Cows synchronized with this protocol are inseminated 12 hours after detected estrus. It is currently recommended for Select Synch treated cows that detection of estrus begin as early as 4 days after GnRH injection and continue through 6 days after PG (Kojima et al., 2000). Select Synch, similar to Ovsynch, was less effective than the melengestrol acetate (MGA)-PG protocol in synchronizing estrus in beef heifers (Stevenson et al., 1999).

MGA-Based Programs

This manuscript reviews methods to control estrous cycles of cows or heifers using MGA in breeding programs involving artificial insemination. Three methods will be outlined for using the MGA program to facilitate estrus synchronization in beef heifers or cows. The choice of which system to use depends largely on a producer's goals. Melengestrol acetate is the common denominator in each of the systems presented here. MGA is an orally active progestin. When consumed by cows or heifers on a daily basis, MGA will suppress estrus and prevent ovulation (Imwalle et al., 2002). MGA may be fed with a grain or a protein carrier and either top-dressed onto other feed or batch mixed with larger quantities of feed. MGA is fed at a rate of 0.5 mg/animal/day in a single daily feeding. The duration of feeding may vary between protocols, but the level of feeding is consistent and critical to success. Animals that fail to consume the required amount of MGA on a daily basis may prematurely return to estrus during the feeding period. This can be expected to reduce the synchronization response. Therefore, adequate bunk space must be available so that all animals consume feed simultaneously.

Animals should be observed for behavioral signs of estrus each day of the feeding period. This may be done as animals approach the feeding area and before feed distribution. This practice will ensure that all females receive adequate intake. Cows and heifers will exhibit estrus beginning 48 hours after MGA withdrawal, and this will continue for 6 to 7 days. It is generally recommended that females exhibiting estrus during this period not be inseminated or exposed for natural service because of the reduced fertility females experience at the first heat after MGA withdrawal.

Method 1: MGA + Prostaglandin

This method involves the combination of MGA with prostaglandin $F_{2\alpha}$. Prostaglandin $F_{2\alpha}$ (PG) is a luteolytic compound normally secreted by the uterus of the cow. Prostaglandin $F_{2\alpha}$ can induce luteal regression but cannot inhibit ovulation. When PG is administered in the presence of a functional corpus luteum (CL) during days 6 to 16 of the estrous cycle, premature regression of the CL begins and the cow returns to estrus.

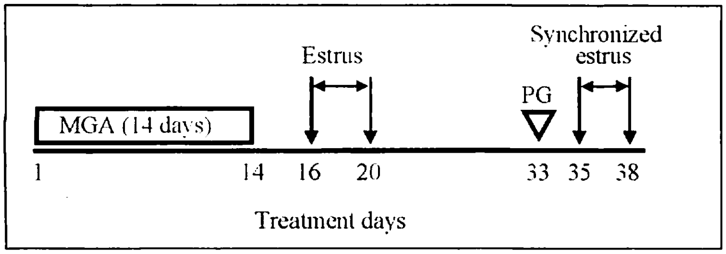


Figure 2. The MGA-PG protocol (adapted from Brown et al., 1998; Deutscher ,2000; Lamb et al., 2000)

In this program, prostaglandin should be administered 19 days after the last day of MGA feeding. This treatment places all animals in the late luteal stage of the estrous cycle at the time of injection, which shortens the synchronized period and maximizes conception rate (Figure 2). Although a 19-day interval is optimal, 17- to 19-day intervals produce acceptable results and provide flexibility for extenuating circumstances (Brown et al., 1988; Deutscher, 2000; Lamb et al., 2000). Four available PG products for synchronization of estrus in cattle can be used after the MGA treatment: Lutalyse®, ProstaMate®, InSynch®, or Estrumate®. Label-approved dosages differ with each of these products; carefully read and follow directions for proper administration before their use.

Method 2: MGA® Select

The MGA® Select treatment (Wood et al., 2001; Figure 3) is useful in maximizing estrous response and reproductive performance in postpartum beef cows. The MGA® Select protocol is a simple program that involves feeding MGA for 14 days followed by an injection of GnRH on day 26 and an injection of PG on day 33. The addition of GnRH to the 14-19 day MGA-PG protocol improves synchrony of estrus, while maintaining high fertility in postpartum beef cows.

We conducted experiments during the spring 2000 and 2001 breeding season to compare the 14-19 day MGA-PG protocol with or without the addition of GnRH on day 12 after MGA withdrawal and 7 days prior to PG in postpartum suckled beef cows (Patterson et al., 2001; Figure 4).

The following tables provide a summary of the results from the study conducted during the 2001 breeding season. Table 2 provides a summary of the number of cows within age group by treatment, the average number of days postpartum and body condition score on the first day of MGA feeding, and the percentage of cows that were cycling prior to the treatment with MGA began. Cyclicity status was determined based on two blood samples for progesterone obtained 10 days before and on the first day of MGA.

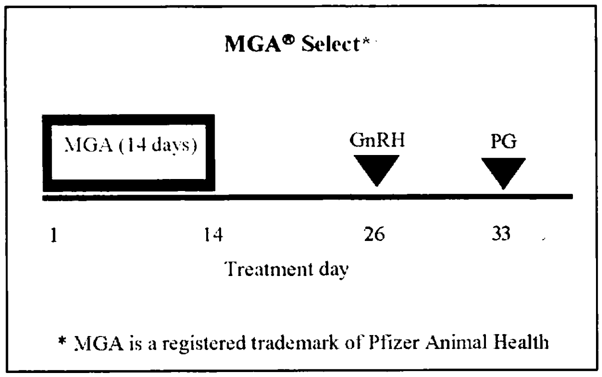


Figure 3. The MGA® Select protocol (Wood et al., 2001). MGA is fed for a period of 14 days followed in 12 days (day 26) by an injection of GnRH, and PG 19 days after MGA withdrawal (day 33).

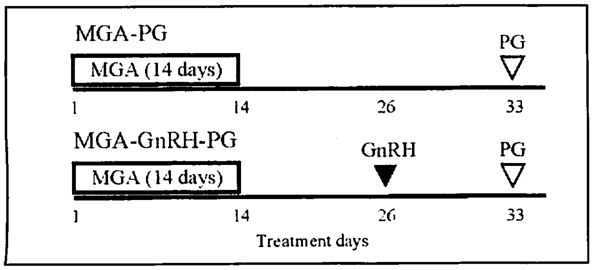


Figure 4. Cows were fed MGA for 14 days; 19 days after MGA withdrawal PG was administered to all cows. GnRH was administered to ½ of the cows 7 days prior to PG (Patterson et al., 2001).

Table 2. Number of cows within age group per treatment, days postpartum, body condition and cyclicity status at the time treatment with MGA began[1] (Patterson et al., 2002).

Treatment	Age group (yrs)	No.of cows	Days postpartum	Body condition score	Cycling (%)
MGA-PG	2, 3 & 4	52	47	5.2	35
	5+	48	39	5.2	15
	Total	100	44	5.2	40
MGA Select	2, 3 & 4	53	47	5.3	38
	5+	48	40	5.3	13
	Total	101	44	5.3	53

[1]Average number of days postpartum on the day treatment with MGA began. Body condition scores were assigned one day prior to the day treatment with MGA was initiated using a scale 1 = emaciated to 9 = obese. Cyclicity was determined from 2 blood samples for progesterone obtained 10 days and 1 day prior to the day treatment with MGA was initiated.

Table 3 provides a summary of estrous response, synchronized conception and pregnancy, and final pregnancy rates for cows assigned to the two treatments. Estrous response was significantly higher among MGA®Select treated cows compared with the MGA-PG treated cows. Synchronized pregnancy rates were higher among the 5-year-old and older cows assigned to the MGA®Select treatment.

METHOD 3: 7-11 SYNCH

We developed an estrus synchronization protocol for beef cattle that was designed to: 1) shorten the feeding period of MGA without compromising fertility; and 2) improve synchrony of estrus by synchronizing development and ovulation of follicles from the first wave of development (Figure 5A; Kojima et al., 2000). This treatment, 7-11 Synch, was compared with the GnRH-PG protocol. Synchrony of estrus during the 24-hour peak response period (42 to 66-hour) was significantly higher among 7-11 Synch treated cows. Furthermore, the distribution of estrus was reduced from 144 hours for GnRH-PG treated cows to 60 hours for cows assigned to the 7-11 Synch treatment (Figure 5B; Kojima et al., 2000). The 7-11 Synch protocol resulted in a higher degree of estrus synchrony (91%) and greater AI pregnancy rate (68%) during a 24-hour peak response period compared to the GnRH-PG protocol (69% and 47%, respectively).

ADDITIONAL CONSIDERATIONS. An additional consideration for Methods 1, 2, and 3 pertains to cows or heifers that fail to exhibit estrus after the last PG injection. In this case, cows or heifers would be re-injected with PG 11 to 14 days after the last injection of PG was administered. These females would then be observed for signs of behavioral estrus for an additional 6 to 7 days. This procedure would maximize efforts to inseminate as many females within the first 2

Table 3. Estrous response, synchronized conception and pregnancy rate, and final pregnancy rate at the end of the breeding period (Patterson et al., 2002). [a,b]Percentages within column and category with unlike superscripts are different ($P<0.05$).

Treatment	Age group (yrs)	Estrous response (no.)	Estrous response (%)	Synchronized conception rate (no.)	Synchronized conception rate (%)	Synchronized pregnancy rate (no.)	Synchronized pregnancy rate (%)	Final pregnancy (no.)	Final pregnancy (%)
MGA-PG	2, 3 & 4	44/52	85	36/44	82	36/52	69	49/52	94
	5+	32/48	67	22/32	69	22/48	46[a]	48/48	100
	Total	76/100	76[a]	58/76	76	58/100	58	97/100	97
MGA Select	2, 3 & 4	46/53	87	33/46	72	33/53	62	51/53	96
	5+	42/48	88	34/42	81	34/48	71[b]	47/48	98
	Total	88/101	87[b]	67/88	76	67/101	66	98/101	97

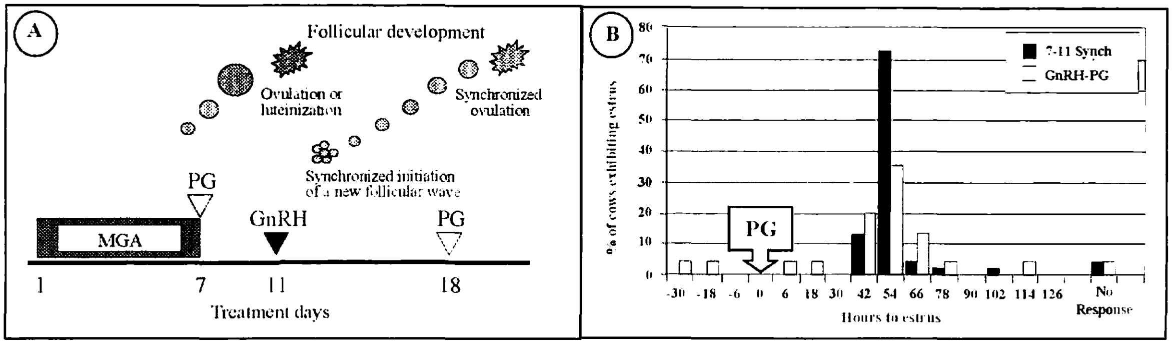


Figure 5A. Illustration of the treatment schedule and events associated with the 7-11 Synch protocol (Kojima et al., 2000). **Figure 5B.** Estrous response of cows treated with the 7-11 Synch or GnRH-PG protocols (Kojima et al., 2000).

weeks of the breeding period as possible. Cows that were inseminated during the first synchronized period should not be re-injected with PG. In addition, the decision to use Methods 2 or 3 in heifers should be based on careful consideration of the heifer's age, weight, and pubertal status (Wood-Follis et al., 2004; Kojima et al., 2001; Federal Register, 1997; Zimbelman, 1963; Zimbelman and Smith, 1966; Patterson et al., 1989).

USING MGA-BASED PROTOCOLS TO SYNCHRONIZE OVULATION PRIOR TO FIXED-TIME AI

Control of the follicular and luteal phase of the estrous cycle and induction of estrous cyclicity in anestrous cows is essential to the development of estrus synchronization protocols that facilitate fixed-time AI (Perry et al., 2002). Beef producers face uncertainty in knowing the percentage of cows that are anestrus in their herds, and which treatment or combination of treatments can be expected to provide the greatest likelihood of pregnancy following administration. The significance of progestin pre-treatment followed by administration of the GnRH-PG protocol and associated effects related to follicular development and subsequent fertility were demonstrated in previous experiments (Perry et.al., 2002; Kojima et al., 2002; Kojima et al., 2003a,b; Stegner et al., 2004a; Stevenson et. al., 2003). Previous research from our laboratory led to the development of the MGA Select and 7-11 Synch protocols. Both protocols effectively synchronize estrus in mixed populations of estrous cycling and anestrous postpartum beef cows (MGA Select, Wood et al., 2001; 7-11 Synch, Kojima et al., 2000). The two protocols differ in length of treatment (MGA Select - 33 days; 7-11 Synch - 18 days) as well as length of the interval to estrus and resulting synchrony of estrus (Figure 6); however, there were no differences reported in pregnancy rates

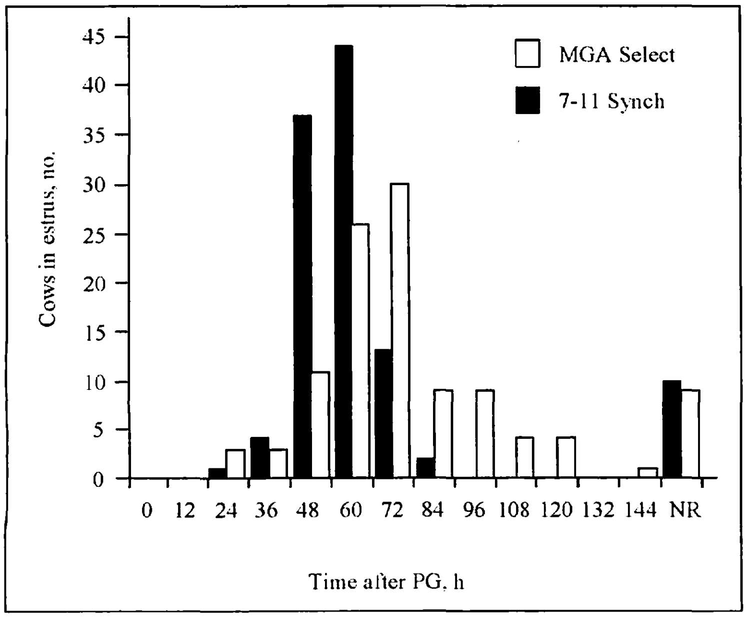


Figure 6. Distribution of estrus for MGA Select and 7-11 Synch treated cows. Non-responders (NR) refers to the number of cows that failed to exhibit estrus during the synchronized period (0 to 144 h). Adapted from Stegner et al. (2004b).

between these protocols among cows inseminated on the basis of observed estrus (Kojima et al., 2000; Patterson et al., 2001; Wood et al., 2001; Stegner et al., 2004b).

The optimum and/or appropriate time to perform artificial insemination at fixed times following administration of these two protocols was reported (Kojima et al., 2003a; Perry et al., 2002; Stegner et al., 2004b); however, a direct comparison of the protocols to evaluate their efficacy for fixed-time AI was not made until recently (Bader et al., 2005). The MGA Select protocol provides an established synchrony of estrus and improves total herd estrous response, particularly among herds with high rates of anestrus (Patterson et al., 2002). Peak estrous response among cows assigned to the MGA Select protocol typically occurs 72 hours after PG (Figure 6; Patterson et al., 2001; Stegner et al., 2004a; Patterson et al., 2002). Pregnancy rates were optimized for cows assigned to the MGA Select protocol when fixed-time AI was performed at 72 hours after PG (Perry et al., 2002; Stegner et al., 2004c), but were reduced when AI was performed at 48 or 80 hours after PG (Stevenson et al., 2003; Stegner et al., 2004c). The 7-11 Synch protocol (Kojima et al., 2000) improves synchrony of estrus over other protocols (Select-Synch, MGA Select) and peak estrous response typically occurs 56 hours after PG (Figure 6; Kojima et al., 2000; Stegner et al., 2004b). Pregnancy rates resulting from fixed-time AI after administration of the 7-11 Synch protocol were optimized when AI was performed 60 hours after PG (Kojima et al., 2003a).

Bader et al. (2005) compared the MGA Select and 7-11 Synch protocols used in conjunction with fixed-timed artificial insemination (Figure 7). The study was conducted at three locations with cows from the University of Missouri Experiment Station. Table 4 summarizes pregnancy rates resulting from fixed-time AI. There was no effect of treatment (P = 0.25), technician (P = 0.81), or sire (P = 0.94) on pregnancy rates resulting from fixed-time AI. Table 5 summarizes pregnancy rates resulting from fixed-time AI on the basis of estrous cyclicity of cows prior to the initiation of treatment. Pretreatment estrous cyclicity did not influence (P = 0.12) pregnancy rates resulting from fixed-time AI. Furthermore, pregnancy rates resulting from fixed-time AI did not differ (7-11 Synch, P = 0.12; MGA Select, P = 0.50; Table 5) between cows that were estrous cycling or anestrus prior to initiation of the MGA Select and 7-11 Synch protocols.

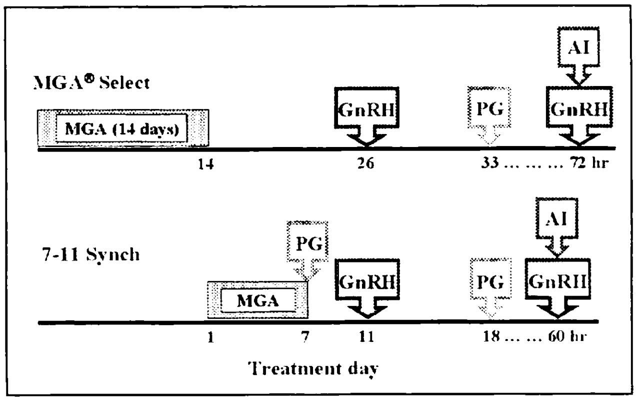


Figure 7. Comparison of the MGA Select and 7-11 Synch protocols in conjunction with fixed-time AI. From Bader et al. (2005).

Pregnancy rates resulting from fixed-time AI utilizing the MGA Select and 7-11 Synch protocols involved in this study are consistent with previously published reports [(MGA Select: Perry et al., 2002; Stegner et al., 2004c); (7-11 Synch: Kojima et al., 2002; Kojima et al., 2003a; Kojima et al., 2003b)]. Furthermore, pregnancy rates resulting from fixed-time AI in this study compare favorably with pregnancy rates after cows were inseminated on the basis of detected estrus using the same protocols to synchronize estrus (Kojima et al., 2000; Patterson et al., 2002; Stegner et al., 2004b).

Perry et al. (2005) reported differences in late embryonic/fetal mortality following fixed-time AI among cows assigned to a CO-Synch protocol. Late embryonic/fetal mortality occurred at higher rates among cows that were induced to ovulate follicles ≤ 11 mm in diameter. Follicles induced to ovulate in this smaller range (≤ 11 mm) were characterized as being less physiologically mature at the time of ovulation, which may subsequently result in reduced oocyte and/or luteal competence. When cows were detected in standing estrus however, follicle size did not affect pregnancy rates or late embryonic mortality (Perry et al., 2005). The author suggested that oocyte and luteal competence may be more dependent on steroidogenic capacity of the follicles from which they were ovulated than follicle size (Perry et al., 2005). A key observation from the preceding study suggests that follicular competence is important for both the establishment and maintenance of pregnancy. Vasconcelos et al. (2001) observed reduced peak concentrations of circulating estradiol, decreased size of the corpus luteum, decreased circulating concentrations of

Table 4. Pregnancy rates after fixed-time artificial insemination and at the end of the breeding season.

Location	Treatment	Pregnancy rate to fixed-time AI[a] No.	(%)	Pregnancy rate at the end of breeding season[b] No.	(%)
1	7-11 Synch[c]	64/104	(62)	98/104	(94)
	MGA Select[c]	68/104	(65)	102/104	(98)
2	7-11 Synch	34/60	(57)	57/59	(97)
	MGA Select	43/62	(69)	60/62	(97)
3	7-11 Synch	30/45	(67)	43/45	(96)
	MGA Select	31/47	(66)	42/47	(89)
Combined	7-11 Synch	128/209	(61)	198/208	(95)
Combined	MGA Select	142/213	(67)	204/213	(96)

[a,b] Fixed-time AI pregnancy rate determined by transrectal ultrasonography 40 to 50 d after AI and final pregnancy rate determined by ultrasonography 45 d after the end of breeding season (From Bader et al., 2005).

progesterone, and lower pregnancy rates to AI when dairy cows were induced to ovulate smaller sized follicles (≤ 14 mm).

Premature ovulation of a dominant follicle results in decreased ovulatory size, reduced luteal function, and compromised pregnancy rates compared to animals induced to ovulate larger, more mature dominant follicles (Mussard et al., 2003). The potential advantage in using either of these protocols (MGA Select, 7-11 Synch) to synchronize estrus prior to fixed-time AI is that mean follicle diameter at the time ovulation is induced (Kojima et al., 2002; Perry et al., 2002; Kojima et al., 2003a,b; Stegner et al., 2004a) exceeds the range described by Perry et al. (2005) and potentially minimizes problems with late embryonic/fetal mortality described by Perry et al. (2005) and Mussard et al. (2003).

Although presence of luteal tissue at PG affected subsequent pregnancy rate to fixed-time AI, the actual concentration of progesterone (P_4) at PG was not important in determining subsequent pregnancy. The difference between treatments in serum concentrations of P_4 at PG stems from the difference in hormonal environments between the two treatments under which the dominant follicle develops (Stegner et al., 2004a.). MGA Select treated cows have higher concentrations of serum P_4 and lower E_2 during the growth phase of the dominant follicle, than cows treated with 7-11 Synch (Stegner et al., 2004a). This hormonal milieu is similar to the mid-luteal phase of the estrous cycle while, 7-11 Synch cows develop a dominant follicle under higher estradiol (E_2) and lower P_4 concentrations similar to the early luteal phase. Pregnancy rates based on pre-treatment estrous cyclicity status (estrous cycling versus anestrus) did not differ between treatments or among locations, which points to the efficacy of both protocols in successfully synchronizing estrus prior to fixed-time AI in mixed populations of estrous cycling and anestrous cows.

Table 5. Pregnancy rates after fixed-time AI based on estrous cyclicity prior to initiation of treatments.

Location	7-11 Synch: Estrous cycling No.	(%)	7-11 Synch: Anestrus No.	(%)	MGA Select: Estrous cycling No.	(%)	MGA Select: Anestrus No.	(%)
1	24/34	(71)	40/70	(57)	20/30	(67)	48/74	(65)
2	9/15	(60)	25/45	(56)	12/16	(75)	31/46	(67)
3	8/10	(80)	22/35	(63)	6/8	(75)	25/39	(64)
Combined	41/59	(69)	87/150	(58)	38/54	(70)	104/159	(65)

From Bader et al. (2005).

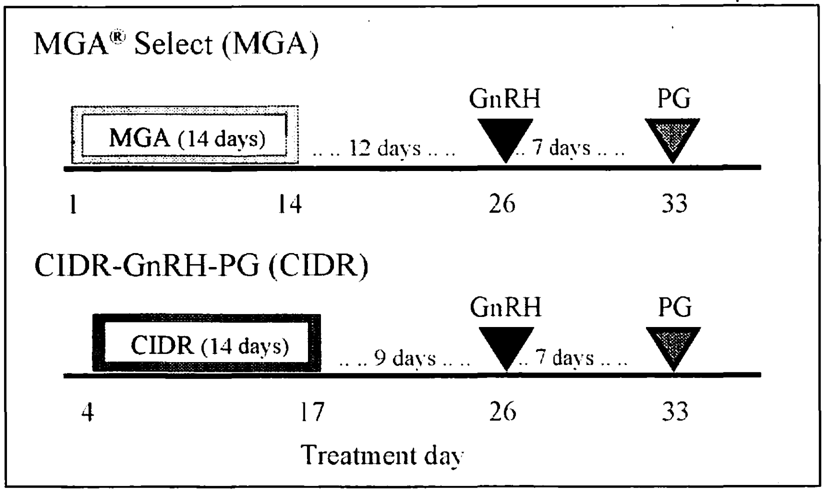


Figure 8. Substituting CIDR inserts for MGA in the MGA Select protocol in beef heifers. From Kojima et al. (2004).

HOW DO MGA- AND CIDR-BASED PROTOCOLS COMPARE?

Substituting EAZI-BREED CIDR inserts for MGA in the MGA Select protocol in beef heifers. We recently designed a study to compare estrous response, timing of AI and pregnancy rate resulting from AI among beef heifers that were presynchronized with MGA or CIDR inserts prior to GnRH and PG (Kojima et al., 2004; Figure 8). Heifers (n = 353) at three locations (location 1, n = 154; 2, n = 113; and 3, n = 85) were randomly assigned to one of two treatments by age and weight. The MGA Select-treated heifers (MGA; n = 175) were fed MGA (0.5 mg/head/day) for 14 days, GnRH (100 µg i.m. Cystorelin) was injected 12 days after MGA withdrawal, and PG (25 mg i.m. Lutalyse) was administered 7 d after GnRH. CIDRs (CIDR; n = 177) were inserted in heifers for 14 days, GnRH was injected 9 days after CIDR removal, and PG was administered 7 days after GnRH. CIDR-treated heifers received carrier without MGA on days that coincided with MGA feeding.

Heifers were monitored for signs of behavioral estrus beginning the day PG was administered. AI was performed 12 hours after onset of estrus and recorded as day of AI (Day 0 = PG). Pregnancy rate to AI was determined by ultrasonography 40 days after AI. Estrous response did not differ ($P > 0.10$) between treatments. Peak AI occurred on day 3 for heifers in both treatments (CIDR 122/177, 69%; MGA 93/175, 53%), and distribution of AI was more highly synchronized ($P < 0.05$) among CIDR- than MGA-treated heifers. Pregnancy rate to AI was greater ($P < 0.01$) in CIDR- (112/177, 63%) than MGA-treated heifers (83/175, 47%), however, final pregnancy rate did not differ ($P > 0.10$) between treatments (Table 6). In summary, replacing feeding of MGA with CIDR inserts improved synchrony of estrus and pregnancy rate resulting from AI in replacement beef heifers (Kojima et al., 2004).

HOW DO MGA SELECT AND CO-SYNCH + CIDR COMPARE WHEN USED IN CONJUCTION WITH FIXED-TIME AI IN POSTPARTUM BEEF COWS?

Previous research in our laboratory demonstrated the efficacy of using the MGA Select protocol to

Table 6. Estrous response, AI pregnancy, and final pregnancy rates.

	Estrous response	AI pregnancy rate	Final pregnancy rate
CIDR	154/177 (87 %)	112/177 (63 %)[a]	164/177 (93 %)
MGA	147/175 (84 %)	83/175 (47 %)[b]	159/175 (91 %)
Total	301/352 (86 %)	195/352 (55 %)	323/352 (92 %)
Difference	+ 3 %	[a,b] P = 0.01 + 16 %	+ 2 %

From Kojima et al. (2004).

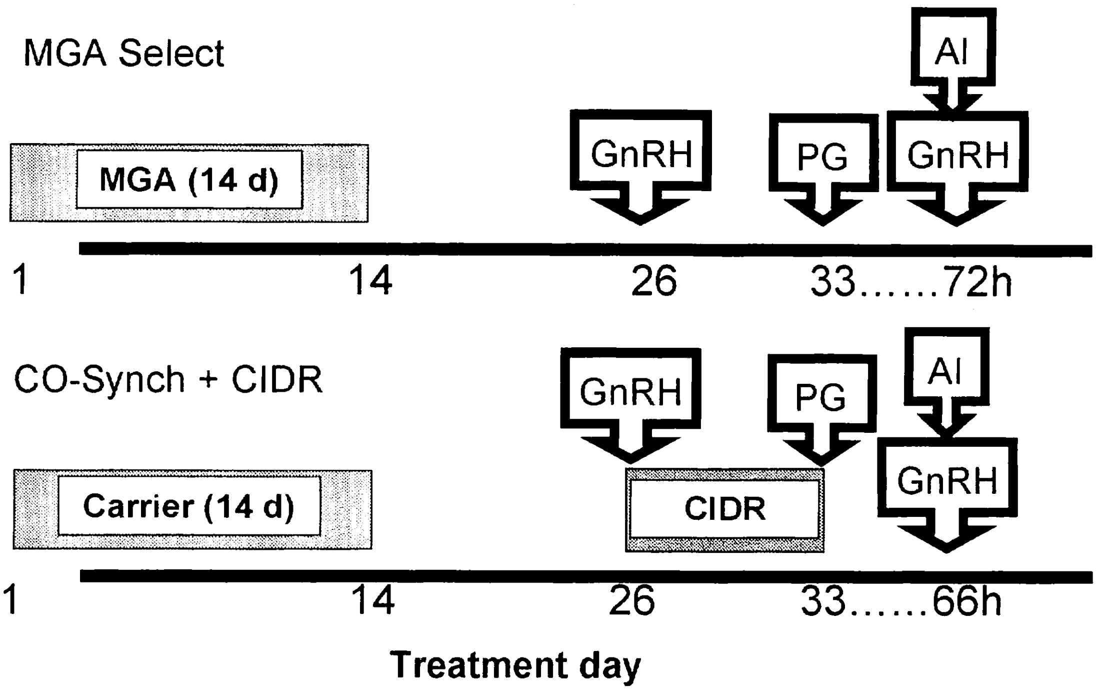


Figure 9. Treatment schedule for cows assigned to the MGA Select and Co-Synch + CIDR protocols. Cows assigned to the MGA Select protocol were fed melengestrol acetate (MGA; 0.5 mg•hd^{-1}•d^{-1}) for 14 d, GnRH was administered 12 d after MGA withdrawal, and PG was administered 7 d after GnRH. Cows were inseminated 72 h after d 33 PG with an injection of GnRH at AI. Cows assigned to the CO-Synch + CIDR protocol were fed carrier for 14 d, on d 26 cows were injected with GnRH and equipped with an EAZI-BREED™ CIDR insert (CIDR), 7 d later CIDRs were removed and PG was administered. Cows were inseminated 66 h after d 33 PG with an injection of GnRH at AI. From Schafer (2005).

synchronize estrus and ovulation prior to fixed-time AI that was performed 72 h after PG (Perry et al., 2002b; Stegner et al., 2004c; Bader et al., 2005). Other research showed an improvement in pregnancy rates resulting from fixed-time AI after treatment with the Co-Synch + CIDR protocol when insemination was performed 66 h as opposed to 48, or 54 h following CIDR removal and PG administration (Bremer et al., 2004). Schafer (2005) designed a study to compare pregnancy rates resulting from fixed-time AI among cows assigned to the MGA Select and CO-Synch + CIDR protocols.

Crossbred, lactating, beef cows (n = 650) at four locations (n = 210; n = 158; n = 88; n = 194) were assigned within age group by calving date (days postpartum, **DPP**) and body condition score (**BCS**; 1 to 9 scale, 1 = emaciated, and 9 = obese) to one of two treatments (Table 7) during the spring 2004 breeding season (Schafer, 2005). Cows assigned to the MGA Select treatment (MGA Select; n = 327) were fed melengestrol acetate for 14 d, GnRH was injected on d 26, and **PG** was injected on d 33. CO-Synch + CIDR treated cows (CO-Synch + CIDR; n = 323) were fed carrier for 14 d, were injected with GnRH and equipped with an EAZI-BREED™ Controlled Internal Drug Release® insert (**CIDR**) 12 d after carrier removal, and PG was injected and CIDR were removed on d 33. Artificial insemination was performed at 72 h after PG for cows assigned to the MGA Select treatment, and at 66 h after PG administration for cows assigned to the CO-Synch + CIDR treatment (Figure 9). Time of PG administration and AI were recorded for each cow. All cows were injected with GnRH at the time of insemination, and AI was performed by one of three experienced technicians. Three AI sires were used at location 1, and one sire was used at locations 2, 3, and 4. One of the sires used at location 1 was the same sire used at locations 3 and 4. The AI sire and

Table 7. Number of cows at each location, days postpartum, body condition score, and estrous-cycling status for cows before initiation of each treatment (mean ± SE). From Schafer (2005).

Treatment	No.	Age, yr	Time postpartum, d[a]	BCS[b]	Cows with elevated progesterone[c]	
					Proportion	%
Location 1						
MGA Select[d]	106	5.3 ± 0.3	46.4 ± 1.4	5.6 ± 0.06	62/106	58
CO-Synch + CIDR[d]	104	5.4 ± 0.3	45.9 ± 1.4	5.7 ± 0.06	50/104	48
Combined	210	5.3 ± 0.2	46.1 ± 1.0[x]	5.7 ± 0.04[x]	112/210	53[x]
Location 2						
MGA Select[d]	80	5.7 ± 0.3	32.7 ± 1.6	6.1 ± 0.07	29/80	36
CO-Synch + CIDR[d]	78	5.7 ± 0.3	32.4 ± 1.6	6.0 ± 0.07	34/78	44
Combined	158	5.7 ± 0.2	32.5 ± 1.1[y]	6.0 ± 0.05[y]	63/158	40[y]
Location 3						
MGA Select[d]	45	5.5 ± 0.4	44.6 ± 2.1	5.2 ± 0.10	16/45	36
CO-Synch + CIDR[d]	43	5.4 ± 0.4	44.1 ± 2.1	5.3 ± 0.10	15/43	35
Combined	88	5.5 ± 0.3	44.4 ± 1.5[xz]	5.3 ± 0.07[z]	31/88	35[y]
Location 4						
MGA Select[d]	96	5.2 ± 0.3	43.8 ± 1.4	5.3 ± 0.07	78/96	81
CO-Synch + CIDR[d]	98	5.3 ± 0.3	41.7 ± 1.4	5.3 ± 0.07	78/98	80
Combined	194	5.2 ± 0.2	42.8 ± 1.0[z]	5.3 ± 0.05[z]	156/194	80[z]
Combined						
MGA Select	327	5.4 ± 0.2	41.9 ± 0.8	5.5 ± 0.03	185/327	57
Combined						
CO-Synch + CIDR	323	5.4 ± 0.2	41.0 ± 0.8	5.6 ± 0.03	177/323	55

[a]Number of days postpartum at the initiation of melengestrol acetate (MGA) feeding for MGA Select-treated cows and carrier feeding for CO-Synch + CIDR-treated cows.

[b]Body condition scores of cows at the time of first blood sample before initiation of treatments (1 to 9 scale, where 1 = emaciated, and 9 = obese).

[c]Estrous cyclicity = the percentage of cows with elevated (≥ 0.5 ng/mL) concentrations of progesterone in serum before treatment. Cows were considered to be cyclic if progesterone was elevated in either of two blood samples collected 8 and 1 d prior to treatment.

[d]See Figure 9 for description of protocols.

[x,y,z]Means with at least one superscript in common within columns and between locations are not different, $P > 0.05$.

technician were assigned to cows within each treatment by cow age, calving date, and BCS. Cows were exposed to fertile bulls for natural service 14 d after AI for a 60 day natural service period at Locations 1, 3, and 4 and for a 45 day natural service period at Location 2.

The number of cows at each location, age, days postpartum, BCS, and estrous cycling status of cows before the initiation of treatments are shown in Table 7. There were no differences between treatments at the respective locations for age, days postpartum, BCS, or estrous cyclicity status at the initiation of treatment; however, there were differences among locations (Table 7). There was no effect of treatment ($P = 0.20$), technician ($P = 0.63$), or sire ($P = 0.11$) on pregnancy rates resulting from fixed-time AI (Table 8). In addition, pre-treatment estrous cyclicity before the initiation of the MGA Select or CO-Synch + CIDR protocols, did not affect (MGA Select, $P = 0.39$; CO-Synch + CIDR, $P = 0.31$; Table 8) pregnancy rates resulting from fixed-time AI. Final

Table 8. Pregnancy rates after fixed-time artificial insemination and at the end of the breeding season. Schafer (2005).

Item	Pregnancy rate to fixed-time AI[a] Proportion	%	Pregnancy rate at end of breeding season[b] Proportion	%
Location 1				
MGA Select[c]	70/106	66	99/106	93
CO-Synch + CIDR[c]	67/104	64	99/104	95
Location 2				
MGA Select	53/80	66	77/80	96[d]
CO-Synch + CIDR	56/78	72	76/78	97[d]
Location 3				
MGA Select	26/45	58	42/45	93
CO-Synch + CIDR	29/43	67	42/43	98
Location 4				
MGA Select	52/96	54	87/96	91
CO-Synch + CIDR	62/98	63	91/98	93
Combined MGA Select	201/327	61	305/327	93
Combined CO-Synch + CIDR	214/323	66	308/323	95

[a] Pregnancy rate to fixed-time AI determined by ultrasound 40 to 45 d after AI.

[b] Pregnancy rate at the end of the breeding season determined 50 to 60 d after the end of breeding season.

[c] See Figure 9 for a description of protocols.

[d] Pregnancy rate at the after 45 d breeding season.

pregnancy rates did not differ ($P = 0.25$) between treatments (Table 8).

The MGA Select protocol results in a consistent synchrony of estrus with the peak estrous response typically occurring 72 h after the administration of PG (Patterson et al., 2002; Stegner et al., 2004a). Furthermore, the MGA Select protocol has consistently produced pregnancy rates to fixed-time AI ≥ 60%, when AI is performed 72 h after PG (Perry et al., 2002b; Stegner et al., 2004c; Bader et al., 2005). The pregnancy rates to fixed-time AI reported in this study following treatment with the MGA Select estrus synchronization protocol are consistent with other published data when insemination was performed at 72 h after PG (Perry et al., 2002b; Stegner et al., 2004c; Bader et al., 2005).

The CO-Synch + CIDR protocol with fixed-time AI performed 60 h after PG resulted in comparable pregnancy rates when compared to CIDR-based protocols that involve estrus detection and AI up to 84 h after PG followed by fixed-time insemination of non-responders at 84 h (Larson et al., 2004). Other studies reported pregnancy rates to the CO-Synch + CIDR estrus synchronization protocol were optimized when insemination was performed at 66 h after PG compared to AI performed at 48 or 54 h (Bremer et al., 2004). Consideration of these various studies led to the decision to inseminate cows at 66 h following administration of the CO-Synch + CIDR protocol in this experiment. The results that were obtained in this study are comparable to the study by Bremer et al. (2004), and support the concept that there is a critical window of time over which insemination should be performed.

Successful application of these protocols requires

Table 9. Pregnancy rates after fixed-time artificial insemination based on estrous cyclicity before initiation of treatments. From Schafer (2005).

	MGA Select[a]				CO-Synch + CIDR[a]			
	Estrous cycling[b]		Anestrous[b]		Estrous cycling		Anestrous	
Location	Proportion	%	Proportion	%	Proportion	%	Proportion	%
1	38/62	61	32/44	73	30/50	60	37/54	69
2	20/29	69	33/51	65	25/34	74	31/44	70
3	11/16	69	15/29	52	8/15	53	21/28	75
4	41/78	53	11/18	61	50/78	64	12/20	60
Combined	110/185	59	91/142	64	113/177	64	101/146	69

[a]See Figure 9 for a description of protocols.
[b]See Table 9 for a description of estrous cyclicity.

careful consideration of the advantages and disadvantages that accompany each of them. Based on these data both protocols appear to work effectively in mixed-populations of estrous cycling and anestrous cows despite differences recently reported by Perry et al. (2004). The fertility after treatment was shown to produce pregnancy rates resulting from fixed-time AI consistently ranging from 54 to 72%. The CO-Synch + CIDR protocol may have broader application in comparison to the MGA Select protocol due to shorter treatment duration (< 10 d vs. 36 d), especially in herds with more widespread calving periods. Successful results with either protocol require proper application of each step of the respective treatment. The consistent results that were obtained with the CO-Synch + CIDR protocol may be due to more precise control of progestin treatment among cows that received CIDR inserts compared to more variable MGA intake patterns of cows assigned to the MGA Select protocol.

These results indicate that estrus synchronization with the MGA Select and CO-Synch + CIDR protocols produce comparable pregnancy rates to fixed-time AI when inseminations were performed at 72 and 66 h after PG, respectively. The results reported here present beef producers a choice and

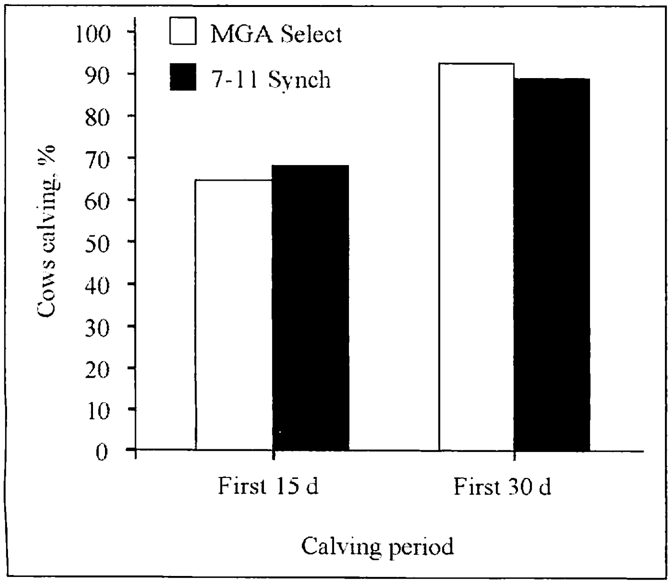


Figure 10. Cumulative calving distribution during the first 15 and 30 days of the calving season for MGA Select and 7-11 Synch-treated cows. [93% of MGA Select and 89% of 7-11 Synch treated cows calved within 30 days from the onset of the calving period]. From Stegner et al. (2004b).

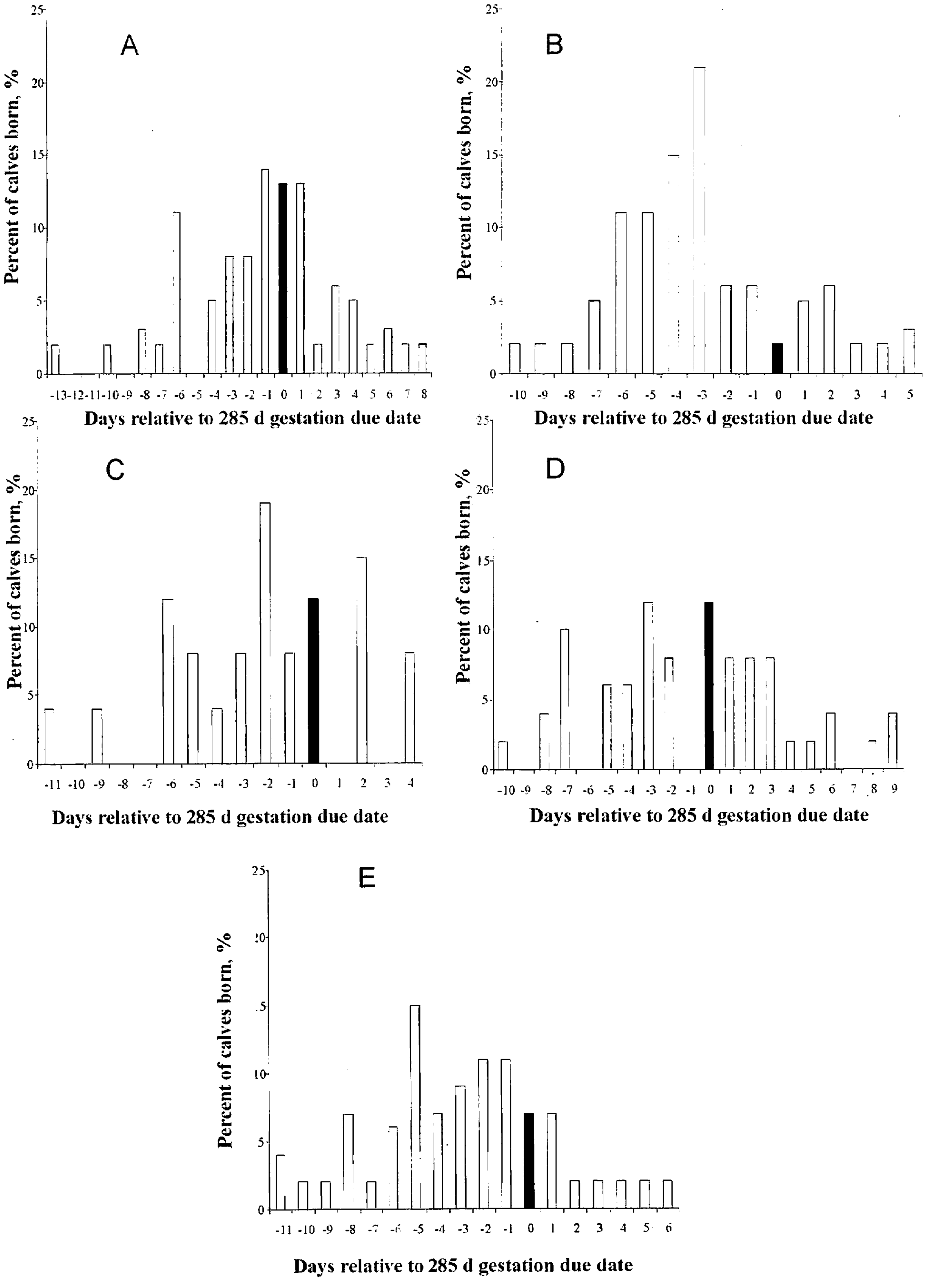


Figure 11. Calving distribution for cows that conceived to fixed-time AI at each location. Calving dates among cows that conceived on the same day to the respective sires (A, B, C, D, and E) were 21, 16, 16, 20, and 18 days. Sire B at Location 1 and sire E at Location 3 were the same sire. The shaded bar in each graph represents an anticipated 285 day gestation due date. From Bader et al. (2005).

means for expediting genetic improvement and reproductive management.

Management Considerations Related to Estrus Synchronization and Fixed-Time AI
Stegner et al. (2004b) discussed the advantages and disadvantages related to practical application and successful administration of the MGA Select and 7-11 Synch protocols. The advantages shown here and reported in other studies include the following: 1) MGA is economical to use (approximately $0.02 per animal daily to feed); 2) each protocol works effectively in mixed populations of beef cows that were estrous cycling or anestrus at the time treatments are imposed; and 3) pregnancy rates resulting from insemination performed on the basis of detected estrus or at predetermined fixed times are comparable and highly acceptable.

Stegner et al. (2004b) noted, however, that the feasibility of feeding MGA to cattle on pasture is limiting in some production systems and is viewed as a disadvantage. Furthermore, the MGA Select protocol requires feeding and management of cows for 33 d, whereas the 7-11 Synch protocol involves an 18 d period. Conversely, the 7-11 Synch protocol requires that animals be handled four times, including AI, compared to the MGA Select protocol, which requires three handlings.

The calving distribution is illustrated in Figure 10 for cows that were assigned to the MGA Select and 7-11 Synch protocols and inseminated on the basis of detected estrus from the study by Stegner et al. (2004b). A high proportion of calves were delivered within the first 15 and cumulative 30 days of the calving season for each protocol, with no differences between treatments. The cumulative number of cows that calved within the first 30 days of the calving period was 93% and 89% for the MGA Select and 7-11 Synch groups, respectively. The calving distribution of cows assigned to each of these protocols must be carefully considered. One of the obvious benefits of estrus synchronization is a shortened calving season that results in more uniform calves at weaning (Dziuk and Bellows, 1983). Reduced length of the calving season translates into a greater number of days for postpartum recovery of the cow to occur prior to the subsequent breeding season. Herd owners must be aware of the risks associated with a concentrated calving period, including inclement weather or disease outbreaks, which separately or together may result in a decrease in the number of calves weaned.

These data, however, support the use of estrus synchronization not only as a means of facilitating more rapid genetic improvement of beef herds, but perhaps, more importantly, as a powerful reproductive management tool. Profitability may be increased by reducing the extent to which labor is required during the calving period, and increasing the pounds of calf weaned that results from a more concentrated calving distribution and a resulting increase in the age of calves at weaning.

More recently, calving dates for cows that conceived on the same day to fixed-time AI were recorded to address concerns that pertain to the subsequent calving period (Bader et al., 2005). Calf birth dates were recorded for cows that conceived to fixed-time AI (Figure 11) at each location. The resulting calving distribution for cows that conceived to the respective sires at each of the locations in the two treatments is shown in Figure 11. Analysis of calving distribution for individual sires differed (Table 10; $P < 0.05$). Calving distribution among cows that conceived to fixed-time AI for Location 1 (sires A and B) was 21 and 16 days, respectively. Distributions for Location 2 (sires C and D) were 16 and 20 days, respectively. The calving distribution among cows at location 3 (sire E), was 18 days. Sire B at Location 1 and sire E at Location 3 was the same sire. Cows that conceived on the same day gave birth to calves over a 16 to 21 day period, dependent upon the respective sire.

Calving distribution for cows involved in the study by Schafer (2005) are illustrated in Figure 12. These data also represent calving profiles among cows that became pregnant on the same day using cows that became pregnant on the same day using semen from single sires as indicated by the respective panels. These distributions indicate that successful use of fixed-time AI will not result in an overwhelming number of cows calving on the same day(s). This furthermore suggests that current management practices will not need to be greatly altered to accommodate the early portion of the calving season. Conversely, these data demonstrate that successful application of estrus synchronization protocols that facilitate fixed-time AI support improvements in whole-herd reproductive management and expanded use of improved genetics.

Consider the Impact of Estrus Synchronization on Calving Distribution

Economic considerations related to use of estrus synchronization and choice of the various protocols to use in beef heifers and cows was reviewed by Johnson and Jones (2004). Hughes (2005) data indicates that opportunities to increase profits for cow-calf operations lie in managing females from the later calving intervals forward toward the first and second 21-day calving intervals. Hughes (2005) reports that added pounds are the economic reward to tightening up the calving interval. The CHAPS benchmark values utilize IRM-SPA guidelines for operating high production herds. These guidelines suggest that 61% of your calves should be born by day 21, 85% by day 42 and 94% by day 63. Hughes (2005) goes on to say that today's high market prices are generating big economic rewards to intensified management, but more specifically "management as usual" may be what is amiss for many cow calf producers.

Figure 13 illustrates cumulative calving percentages for the University of Missouri Thompson farm over a 10 year period. The graph compares the percentages of calves born during years when only natural service was used, followed by estrus synchronization and AI performed on the basis of observed heat, and finally fixed-time AI. The graph illustrates the respective distributions on the basis of days in the calving season. Figure 14 illustrates the combined calving data for 3 of the 4 locations in the study by Schafer (2005). Data from the fourth location was not included in the summary since cows that failed to conceive to AI were sold prior to the calving period. Finally, Figure 15 illustrates the calving profile for cows at the Forage Systems Research Center in Linnueus, MO, over a two year period. This herd maintains a 45 day breeding season and until the spring of 2004 estrus synchronization and AI had not been utilized. Figure 15 illustrates the calving profile of cows that calved during the spring of 2004 as a result of natural service during the 2003 breeding season, and the calving profile for cows that calved during the spring of 2005 as a result of fixed time AI performed during the 2004 breeding season (Schafer, 2005).

These data collectively demonstrate that estrus synchronization can be used effectively to influence calving distribution during the subsequent calving period, which in turn impacts economics of the herd at weaning time. Consider for a moment the data illustrated in Figure 15. Estrus synchronization resulted in an increase of 7 days postpartum among cows at the start of the breeding period at this location, which theoretically translates into an increase in calf age at weaning in one year of seven calf days.

Summary and Conclusions

Expanded use of AI and/or adoption of emerging reproductive technologies for beef cows and heifers requires precise methods of estrous cycle control. Effective control of the estrous cycle requires the synchronization of both luteal and follicular functions. Efforts to develop a more effective estrus synchronization protocol have focused on synchronizing follicular waves by injecting GnRH followed 7 days later by injection of PG (Ovsynch, CO-Synch, Select Synch). A factor contributing to reduced synchronized pregnancy rates in cows treated with the preceding protocols is that 5 to 15% of cycling cows show estrus on or before PG injection. New protocols for inducing and synchronizing a fertile estrus in postpartum beef cows and replacement beef heifers in which progestins are used sequentially with the GnRH-PG protocol provide new opportunities for beef producers to synchronize estrus and ovulation and facilitate fixed-time AI.

Table 11 provides a summary of various estrus synchronization protocols for use in postpartum beef cows. The table includes estrous response for the respective treatments and the synchronized pregnancy rate that resulted. These data represent results from our own published work, in addition to unpublished data from DeJarnette and Wallace, Select Sires, Inc. The results shown in Table 11 provide evidence to support the sequential approach to estrus synchronization in postpartum beef cows we describe.

These data suggest that new methods of inducing and synchronizing estrus for postpartum beef cows and replacement beef heifers now create the opportunity to significantly expand the use of AI in the U.S. cowherd.

Table 11. Comparison of estrous response and fertility in postpartum beef cows after treatment with various e synchronization protocols.

Treatment	Estrous response		Synchronized pregnancy	
AI based on detected estrus				
2 shot PG	241/422	57%	147/422	35%
Select Synch	353/528	67%	237/528	45%
MGA-PG 14-17 d	305/408	75%	220/408	54%
MGA-2 shot PG	327/348	93%	243/348	70%
MGA-PG 14-19 d	161/206	78%	130/206	63%
MGA® Select	275/313	88%	195/313	62%
7-11 Synch	142/155	92%	101/155	65%
AI performed at predetermined fixed times with no estrus detection				
MGA® Select				
7-11 Synch	Fixed-time AI @ 72 hr		482/763	63%
CO-Synch + CIDR	Fixed-time AI @ 60 hr		446/728	61%
	Fixed-time AI @ 66 hr		214/323	66%

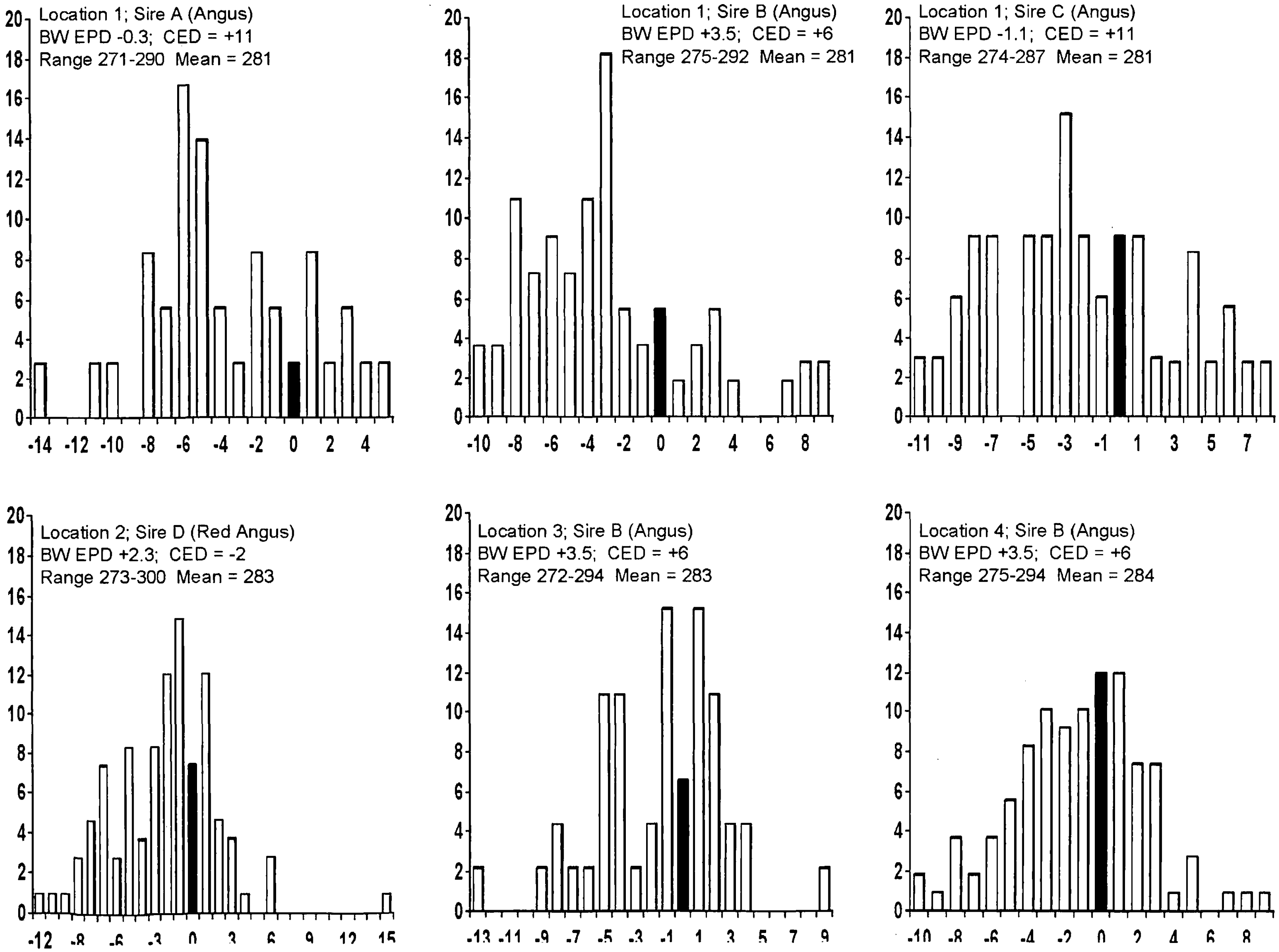


Figure 12. Calving distribution for cows that conceived to fixed-time AI at each location from the study by Schafer (2005). The shaded bar in each graph represents an anticipated 285 day gestation due date.

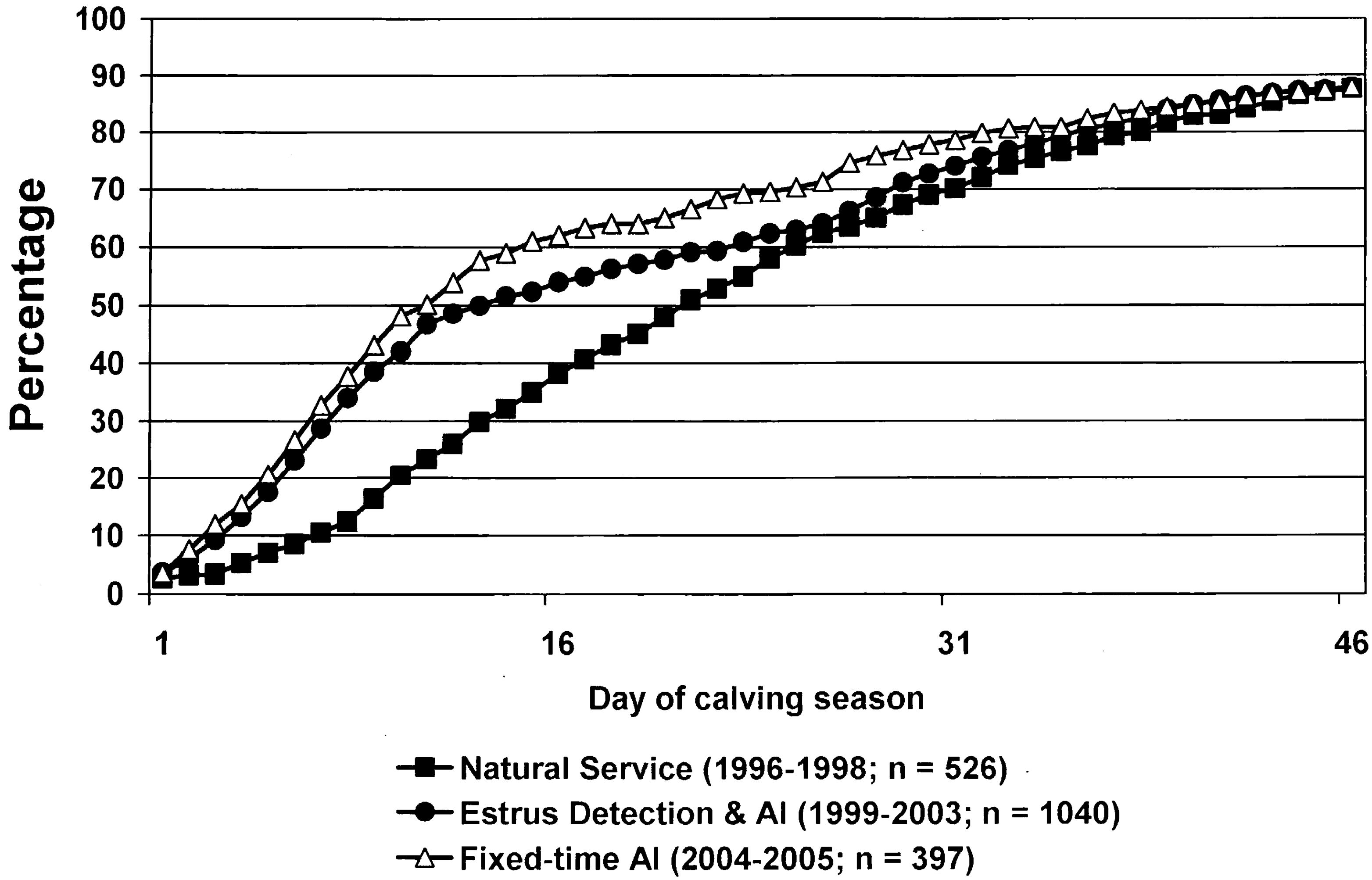


Figure 13. Cumulative calf crop for cows at the University of Missouri Thompson Farm combining years involving natural service, estrus synchronization and AI performed on the basis of observed heat, and fixed-time AI (Schafer and Patterson,unpublished data).

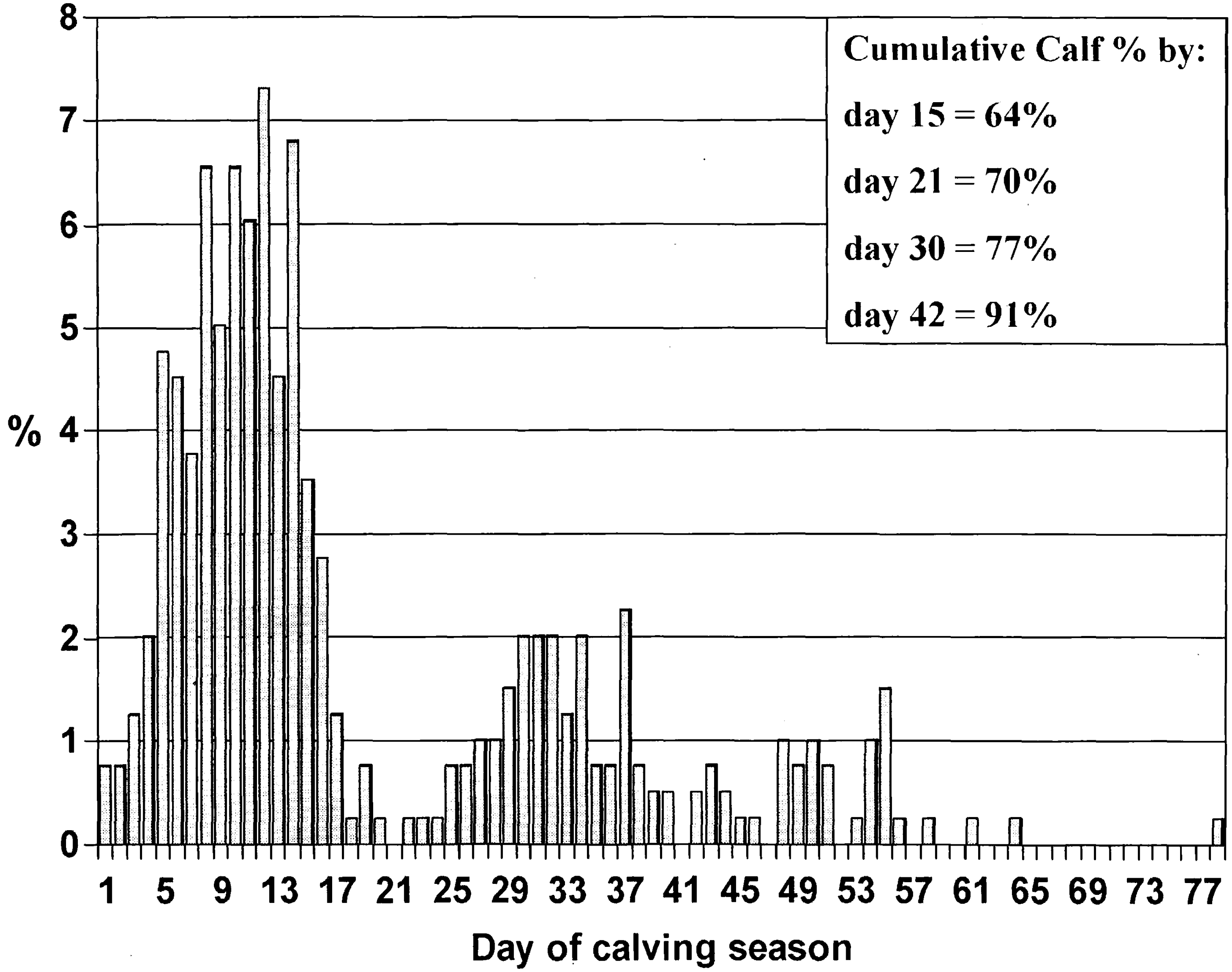


Figure 14. Combined calving data for 3 of the 4 locations in the study by Schafer (2005).

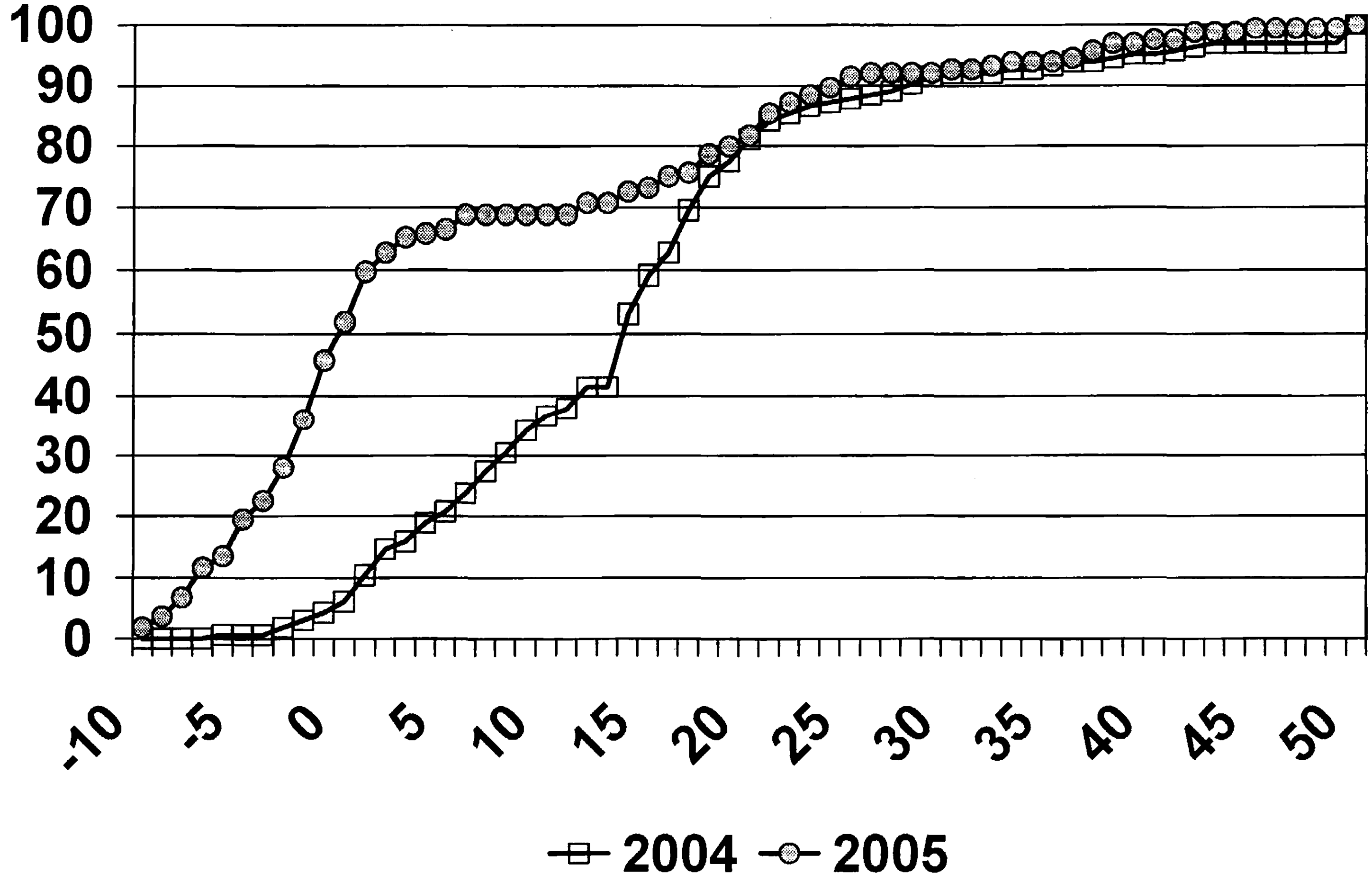


Figure 15. Calving profile for cows at the Forage Systems Research Center in Linnueus, MO. over a two year period. This herd maintains a 45 day breeding season and until the spring of 2004 estrus synchronization and AI had not been utilized.

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Defining your Goals and "Opportunities for Profitability"

Thursday, July 7th

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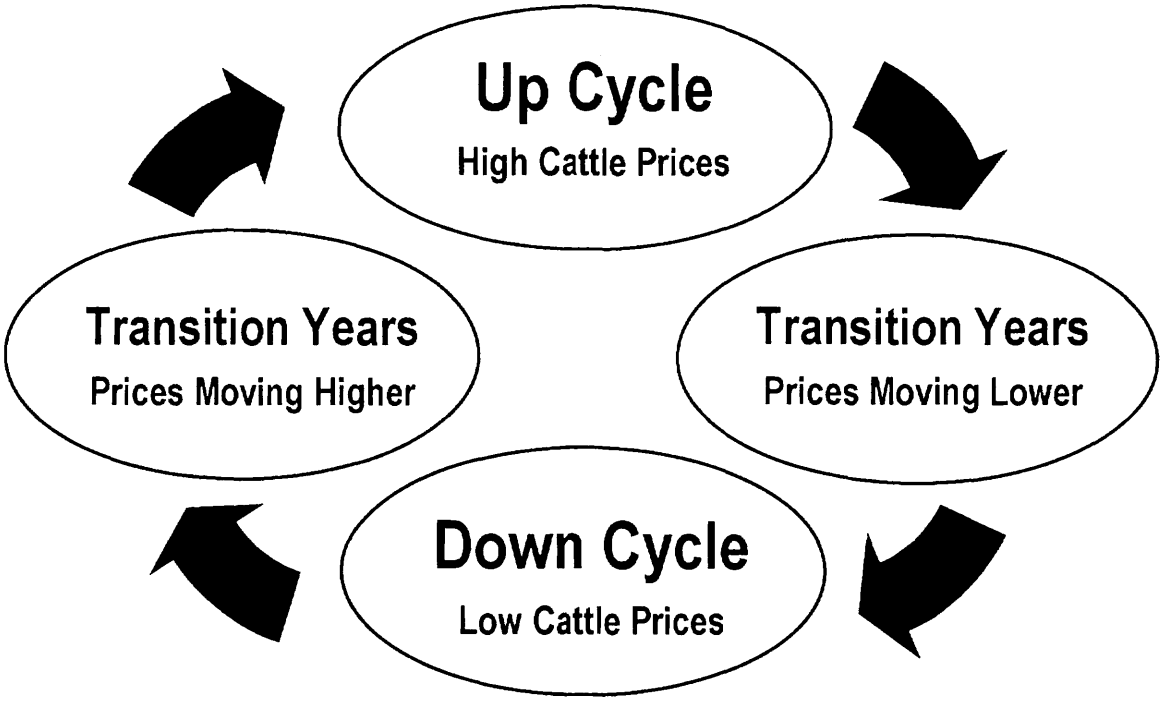
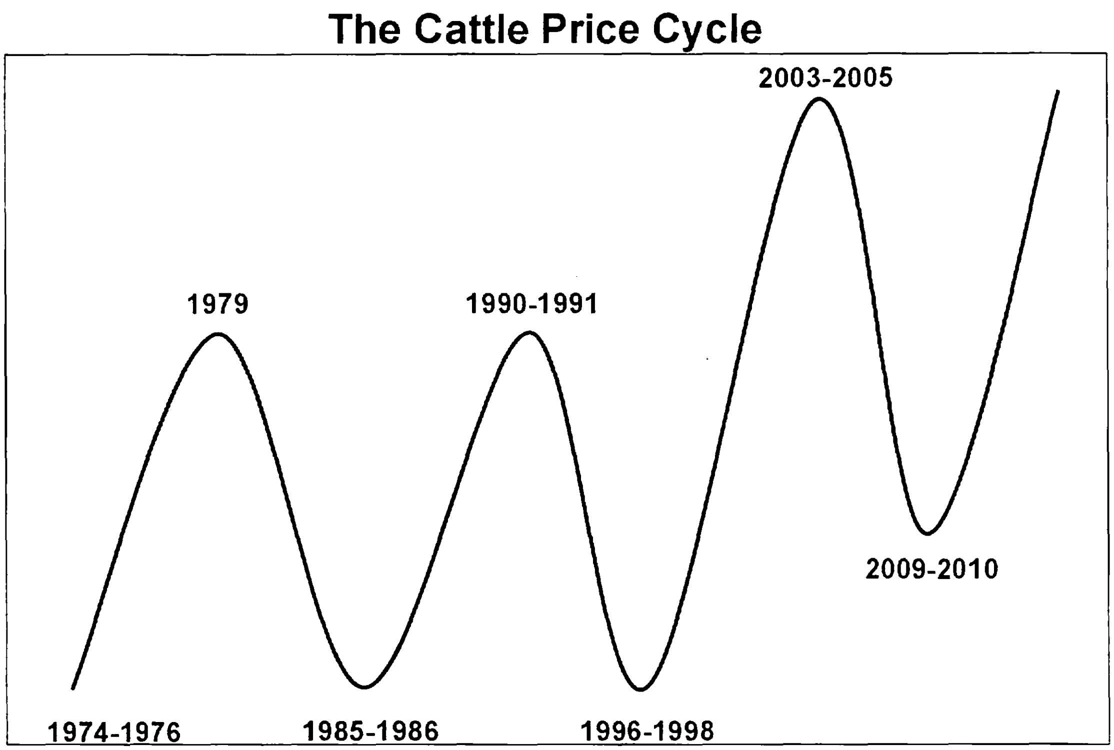
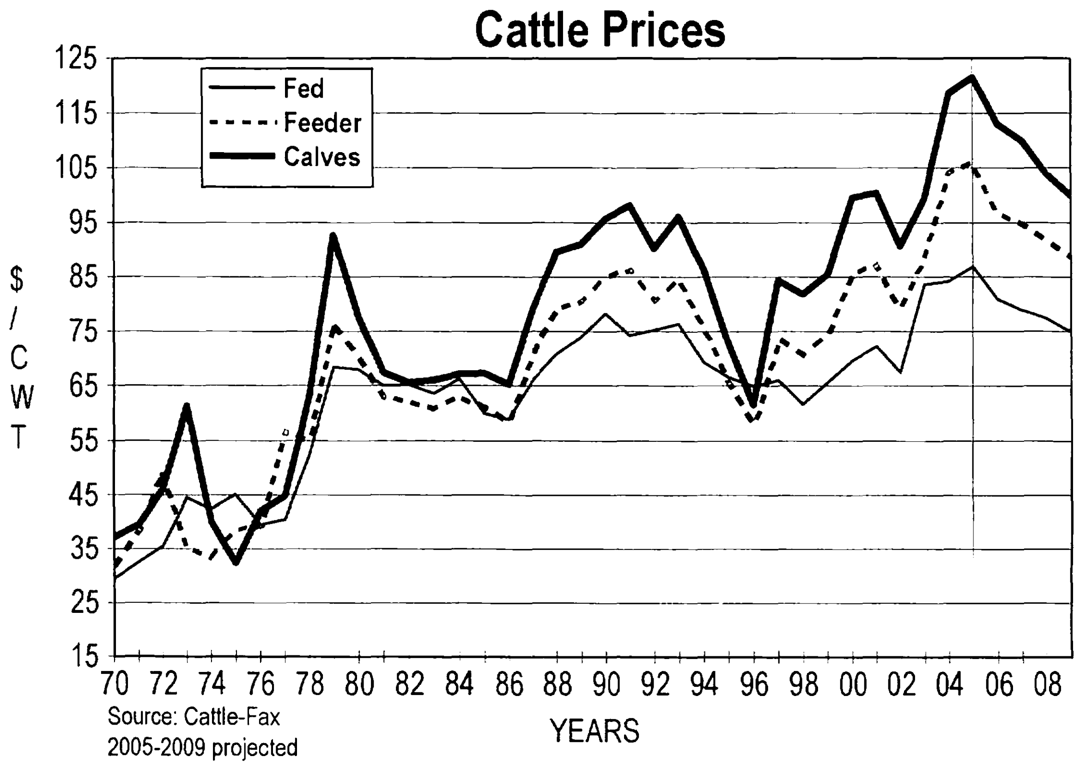
FOUR PHASES OF THE CATTLE CYCLE



Profit Trends By Industry Segment During The Four Phases Of The Cattle Cycle

	Cow / Calf	Stocker	Feedlot
(1) Up Cycle:	Significant Profits	Moderate Profits	Modest Profits
(2) Downward Transition:	Declining Profitability	Significant Losses	Significant Losses
(3) Down Cycle:	Significant Losses	Narrow / Negative Margins	Narrow / Negative Margins
(4) Upward Transition:	Improving Profitability	Significant Profits	Significant Profits


The Cattle Price Cycle
2003-2005
1979
1990-1991
2009-2010
1974-1976
1985-1986
1996-1998


Cattle Prices
125
115
105
95
85
75
65
55
45
35
25
15
$ / CWT
Fed
Feeder
Calves
70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 00 02 04 06 08
YEARS
Source: Cattle-Fax
2005-2009 projected

April 29, 2005
Issue 17
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CATTLE-FAX update

Structural changes in cow/calf business

Cow/calf business consolidating

Structural change and consolidation continues in the cow/calf segment. According to The Census of Ag, the number of beef cow operations declined about five percent from 1987 through 2002. During the same time, the size of the average cow herd increased 27 percent (from 33 head to 42 head in 2002). These trends are not surprising and mirror those occurring in nearly all beef industry segments.

Beef Cow Operations by Size Groups				
	1987		2002	
	Number	Percent	Number	Percent
0-49	690,875	82.1	632,810	79.5
50-99	87,763	10.4	89,874	11.3
100-199	39,754	4.7	45,354	5.7
200-499	18,677	2.2	23,126	2.9
500-999	3,463	0.4	4,002	0.5
1000 hd or more	1,246	0.1	1,270	0.2
Total	841,778	100.0	796,436	100.0

There have been some interesting trends relative to which size groups of operations are growing and which are declining. This comparison will utilize the 1987 and 2002 census of agriculture report. Even though there are fewer total cow calf operations, 91 percent of all operations still have less than 99 cows. The number of cows represented by the larger size groups has increased significantly.

The number of beef cow operations with 100 or more cows has increased a whopping 17 percent since 1987 and the number of operations with more than 200 cows has increased 21 percent (from 23,386 to 28,398 operations). According to the same data, there are now 5,272 cow/calf operations in the U.S. with more than 500 beef cows, an increase of 563 operations since 1987.

The number of beef cows represented in operations with more than 200 head has increased 15 percent and this group is expected to continue to grow. Operations have been forced to grow in order to spread fixed costs more efficiently. Economics and the changing business environment will continue to encourage consolidation and concentration at all levels. The cow/calf industry will not be immune to these forces during the next 5 to 10 years. — *Randy Blach*

Currentness

Steer carcass weights were 780 pounds — up 5 pounds from a year ago.

50 percent lean trim at record highs

Fifty percent lean beef trimmings are solely derived from slaughter steers and heifers. This fairly fatty trim is then mixed with lean beef trimmings from U.S. cow beef or imported lean trim to produce the 70-90 percent lean ground beef that we consume in the United States. Through April 2005, total U.S. beef production from steers and heifers is two percent below last year and four percent below the 2000-2004 average. Lower beef production so far in 2005 and seasonally strong demand has helped to keep fed cattle prices and 50 percent lean trim prices at record high levels.

For the week ending April 22, 2005, the average fed cattle price was $94.00 and the average 50 percent lean trim price was $98.30 (as quoted by Urner Barry). The figure above shows that the monthly average 50 percent lean trim price has not traded above the fed cattle

continued on page 3

This week in brief

Market highlights

There was a softer tone to the market this week with regard to fed cattle trade. Nebraska and Colorado started the trade on Wednesday at $147-152 with the bulk of the cattle at $148 on a dressed basis and $92-93 live. Southern trade didn't occur until late in the day Friday at primarily $93 live. Cut-out values through Thursday saw Choice gain $4.64 to end at $163.10 and Select $4.95 higher at $147.02. Movement of beef was moderate but much below last weeks levels. The Ch/Se spread continues to remain seasonally wide and should continue through the early summer months. Feeder cattle prices remained strong this week and trended $1-2 higher, while calves were mostly steady to $1 better. Cows were steady to $2 weaker and bulls steady.

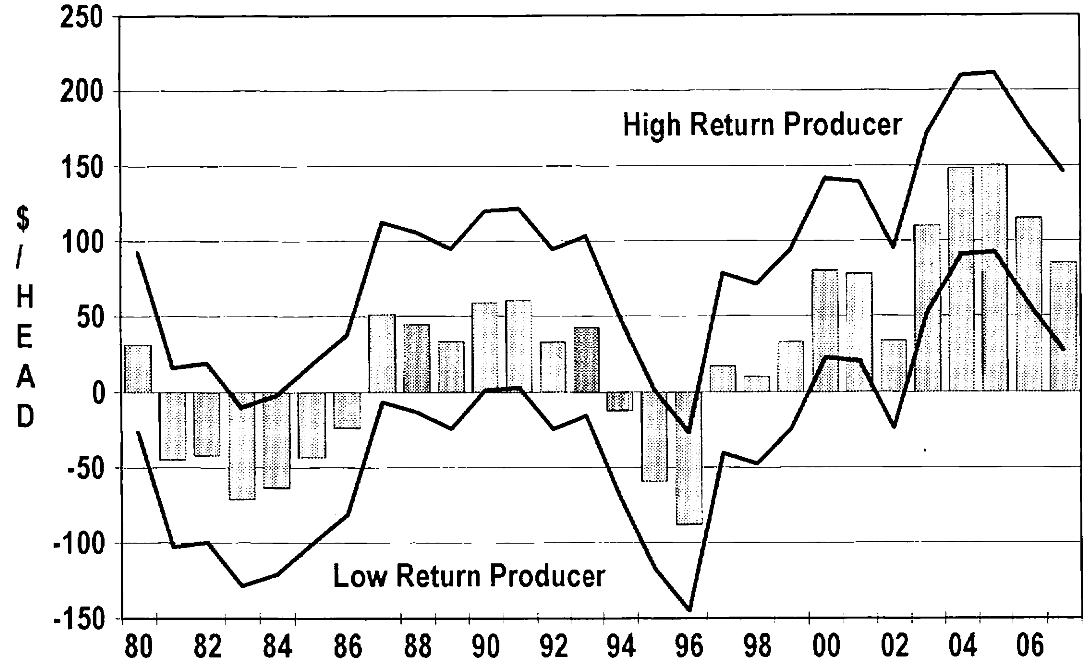
U.S. considers technical issues on Japan border resolved

The head of a visiting U.S. delegation seeking to end Japan's ban on U.S. beef imports because of mad cow disease said Tuesday he believes technical discussions between the two countries are over with the United States having presented data on measures to ensure product safety. The U.S. has now 'provided more than adequate information' to Japan through experts' meetings and visits by Japanese experts to verify beef safety measures implemented in the country during the past 16 months of the import ban. The United States is scheduled to host another verification visit by Japanese experts in the second week of May.

Typical increase of over 50,000 head per week

Did you know that the 10-year average increase in weekly average steer and heifer slaughter from April to May is over 50,000 head per week? The average increase over the past 10 years is 54,000 head per week. The largest increase occurred in 2002 at 96,000 head per week. However there have been 2 years, 1995 and 2000, where weekly average slaughter levels were actually larger in April than May. If this typical increase takes place this year, average slaughter levels will approach 650,000 per week during May.

Cow/Calf Returns



Source: Cattle-Fax, 2005-2007 projected

Cow / Calf Producer Profitability

	2000	2001	2002	2003	2004
Profitable	90%	83%	70%	90%	93%
Near Breakeven	8%	9%	17%	8%	6%
Not Profitable	2%	8%	13%	2%	1%

HIGH- RETURN vs. LOW-RETURN PRODUCERS

	HIGH	LOW
Calf Breakeven	$53/cwt	$86/cwt

Difference $151Per Cow

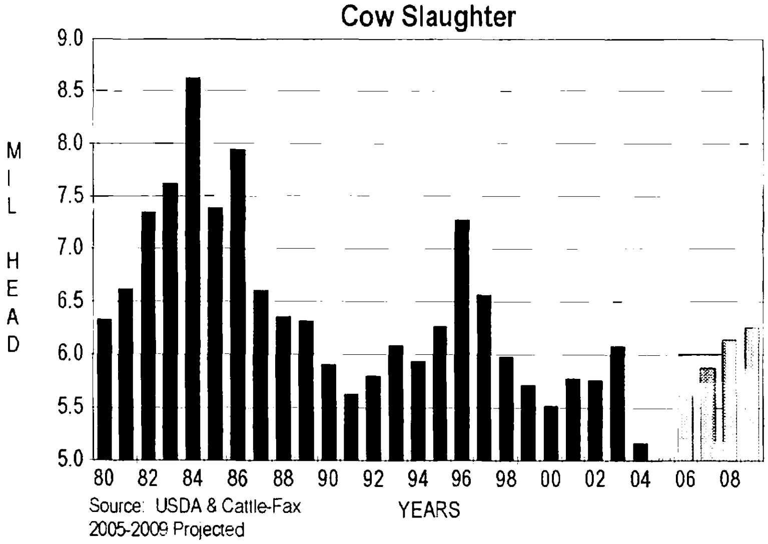
HIGH- RETURN vs. LOW-RETURN PRODUCERS

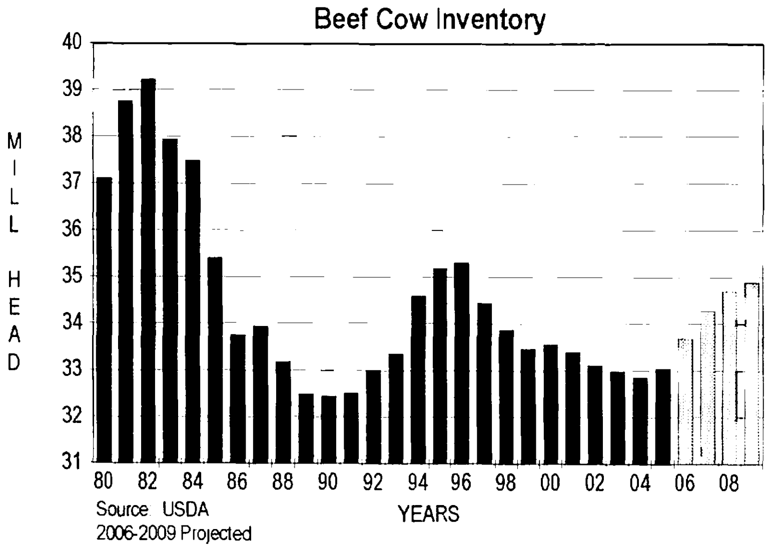
	HIGH	LOW
Annual Cow Cost	$259/head	$357/head

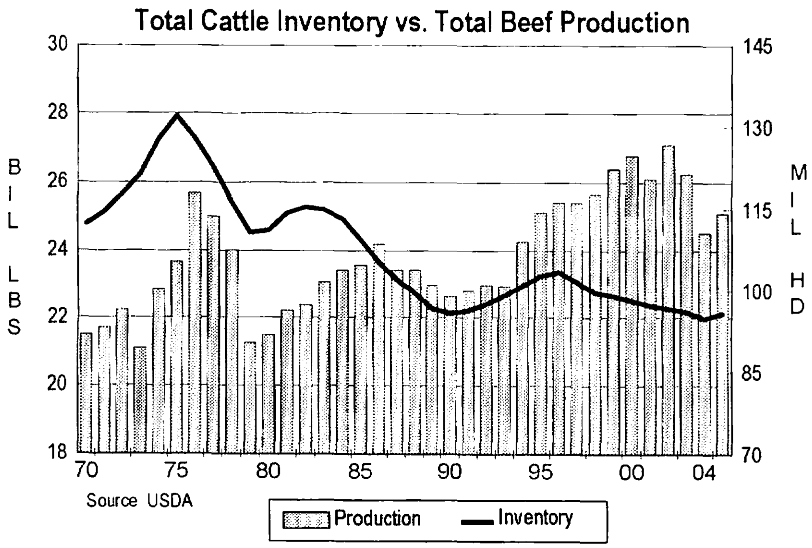
Difference $98 Per Cow

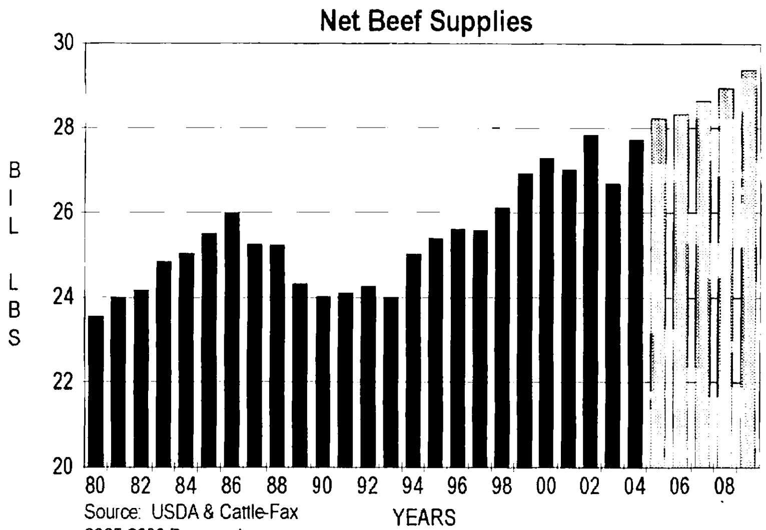
HIGH-RETURN vs. LOW-RETURN: $151 per head

	Dollars	Percent
Cow Costs	$98	65%
Production	$53	35%

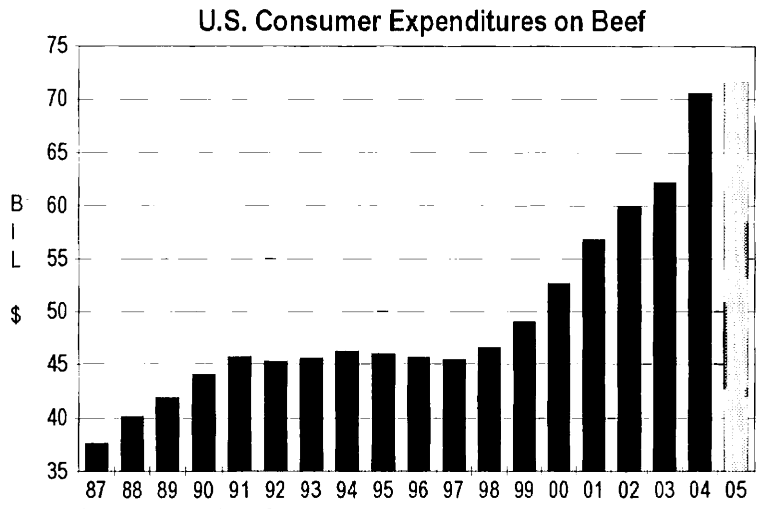

Cow Slaughter
M I L L H E A D
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
80 82 84 86 88 90 92 94 96 98 00 02 04 06 08
Source: USDA & Cattle-Fax
2005-2009 Projected
YEARS


Beef Cow Inventory
M I L L H E A D
40
39
38
37
36
35
34
33
32
31
80 82 84 86 88 90 92 94 96 98 00 02 04 06 08
Source USDA
2006-2009 Projected
YEARS

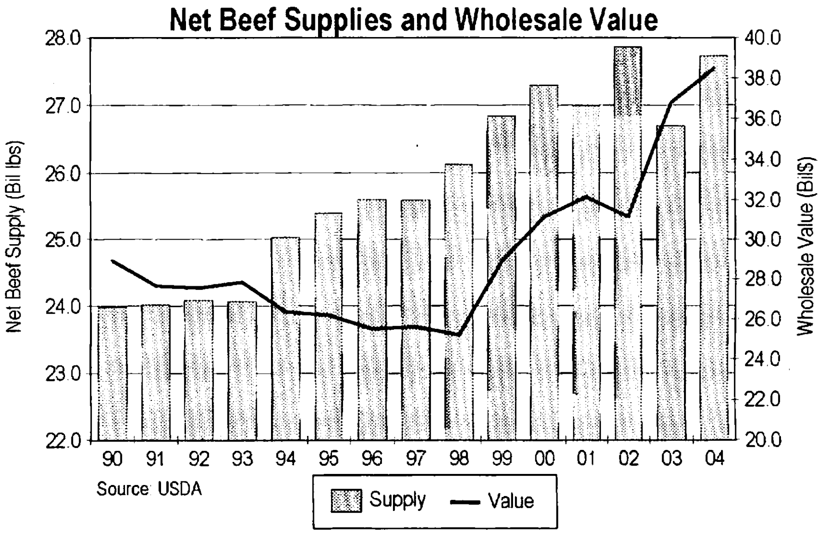

Total Cattle Inventory vs. Total Beef Production
B I L L B S
30
28
26
24
22
20
18
145
130
115
100
85
70
M I L H D
70 75 80 85 90 95 00 04
Source USDA
Production
Inventory



Source: USDA & Cattle-Fax
2005-2009 Projected

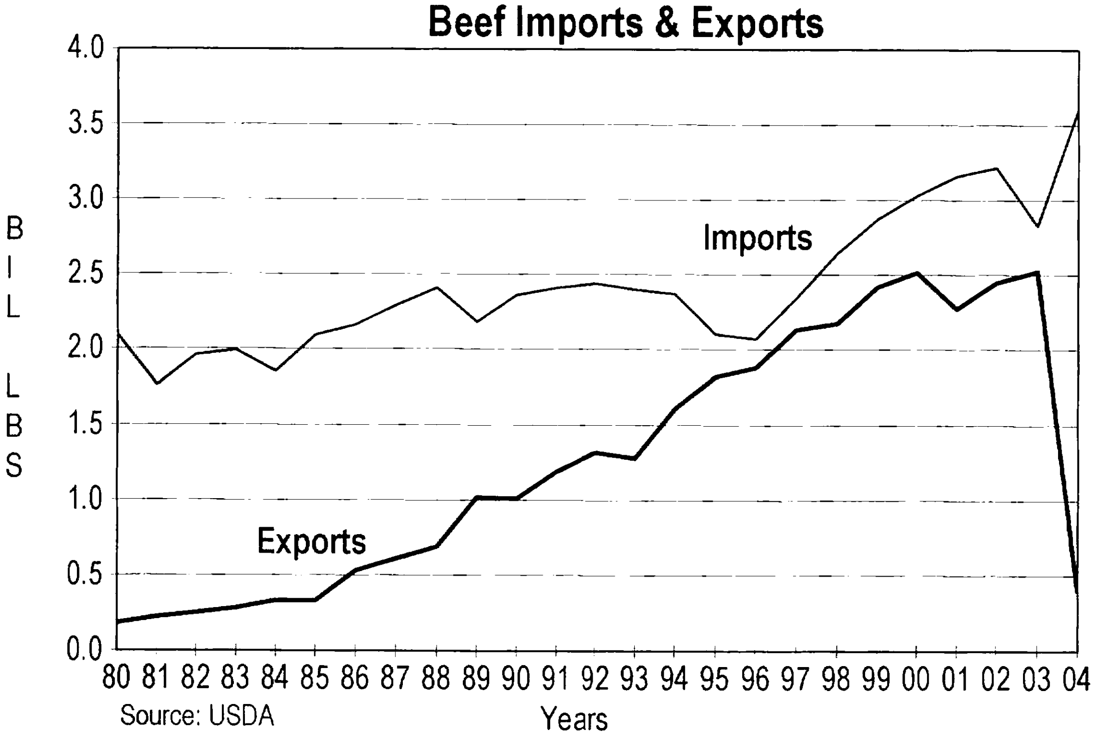


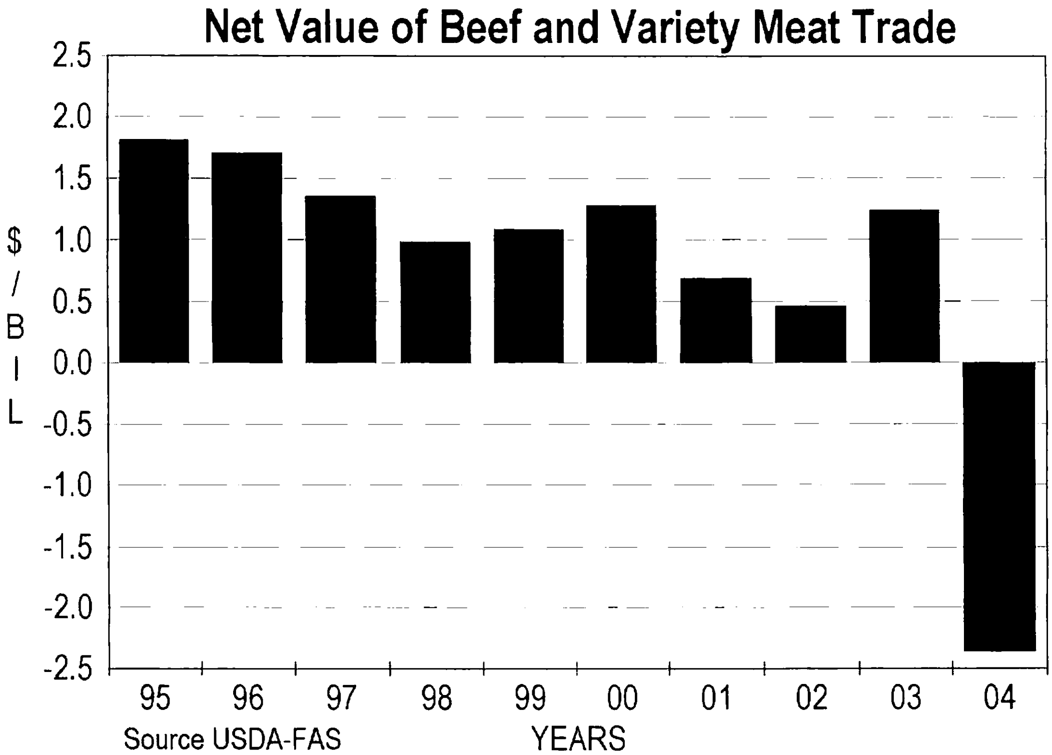
Source: USDA & Cattle-Fax
Domestic disappearance valued at all-fresh retail price, 2005 projected

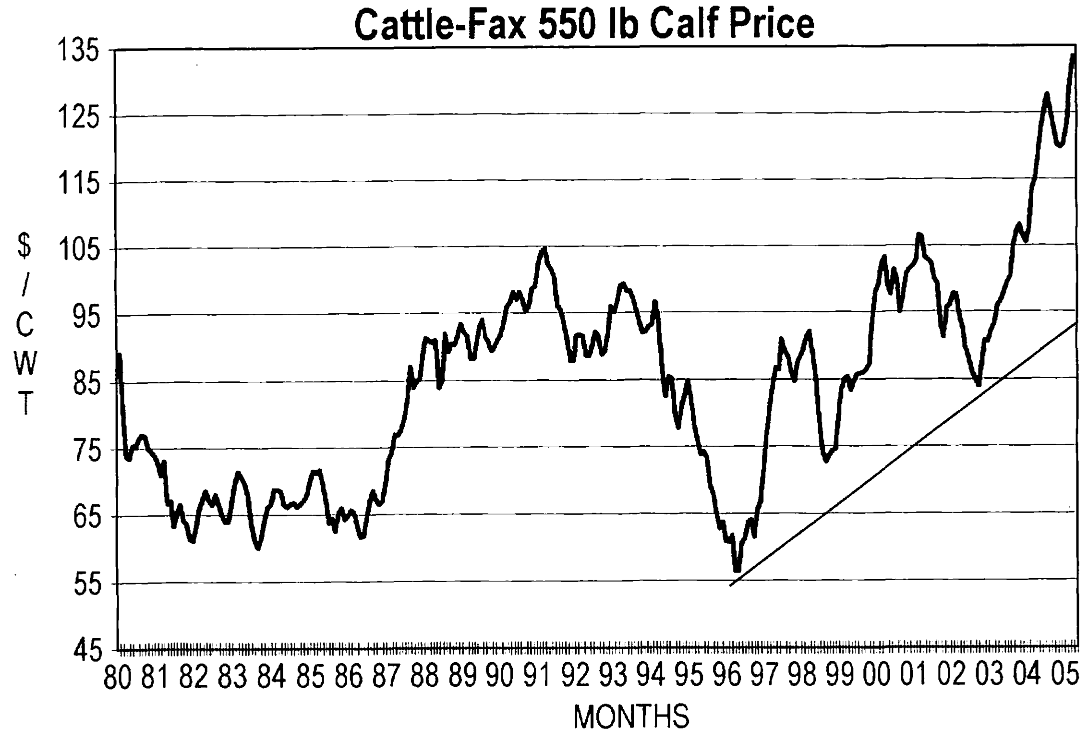


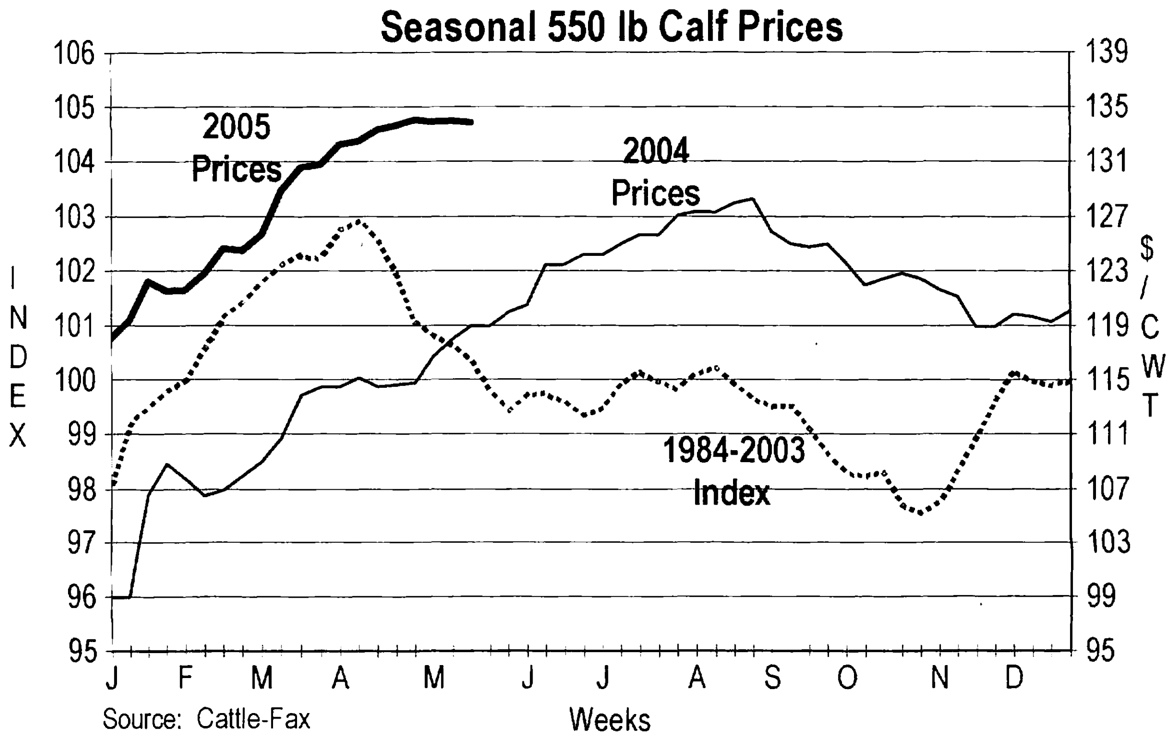
Source USDA

56


Beef Imports & Exports
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
B I L L B S
Imports
Exports
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
Source: USDA
Years

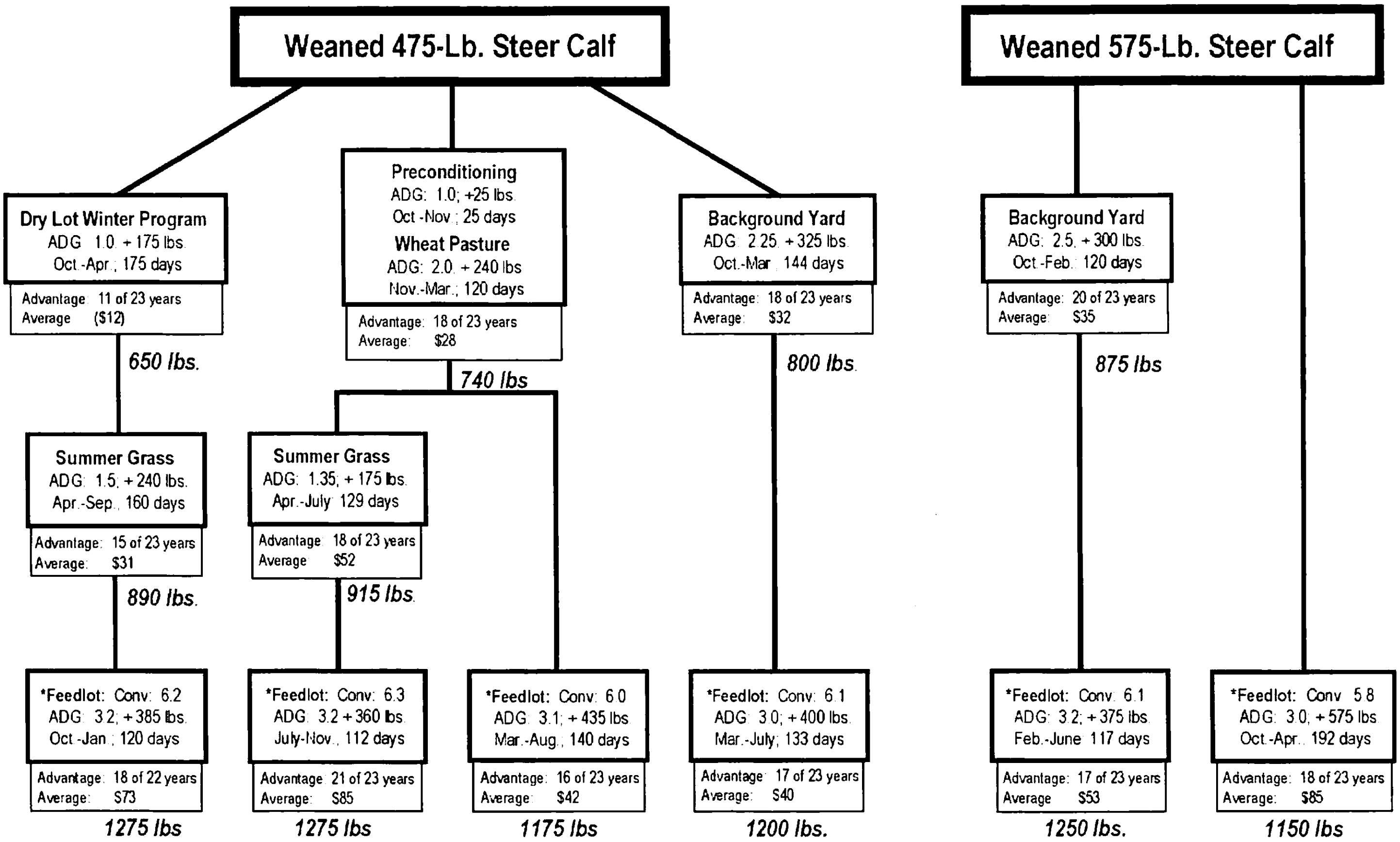

Net Value of Beef and Variety Meat Trade
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
$ / B I L
95 96 97 98 99 00 01 02 03 04
Source USDA-FAS
YEARS



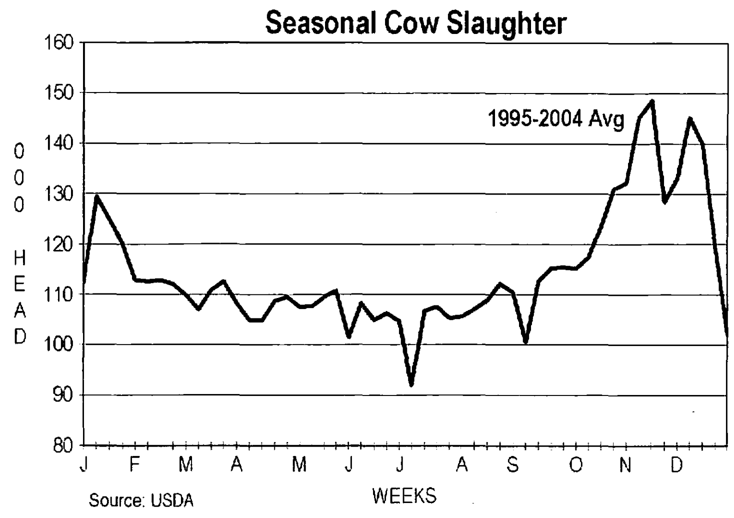


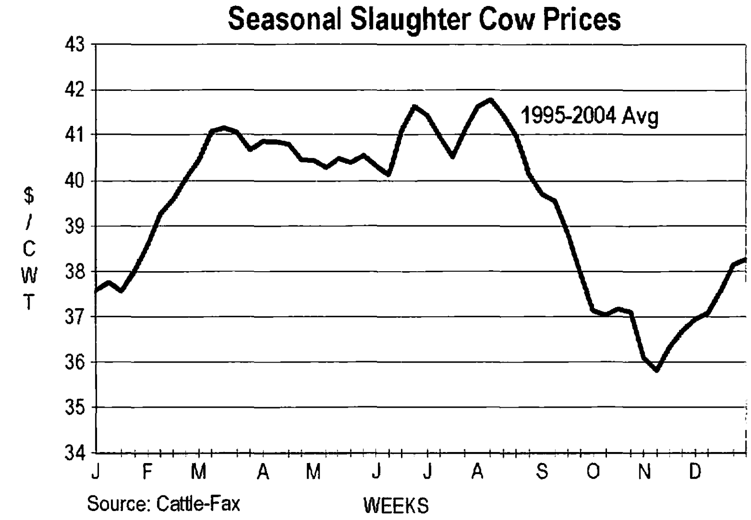
Source: Cattle-Fax

Spring-Born Steer Calves
Retained Ownership Alternatives



* *Feedlot conversions are measured on a dry-matter basis*





Slaughter Cow Extended Ownership

Cull Cow

ADG: 1.5
Nov.-Feb.; 95 days

Advantage : 23 of 23 yrs
Average: $64

1125 lbs.

Profile of Livestock & Producer Operations

	Total # of Producers/ Operators	# of LG Producers	LG Producers as % of Total	% of Production from LG Producers
Broilers Top 20				85%
Hogs >2000 hd	98,460	7,125	7%	69%
Dairy >200 cows	105,250	8,005	8%	48%
Beef Cattle				
Feedlots >1000 hd	104,471	2,071	2%	85%
Cow/Calf >200 cows	804,000	28,000	3.5%	33%
>100 cows		72,891	9%	51%

Concentration in the Food and Beef Industries

		Market Share
Cow/Calf Producers	Largest 9%	51%
Feedlot Operators	Largest 2%	85%
Packing Companies	Top 5	78%
Supermarket Chains	Top 10	55%
Food-Service Distributors	Top 10	45%
Restaurant Chains	Top 10	30%

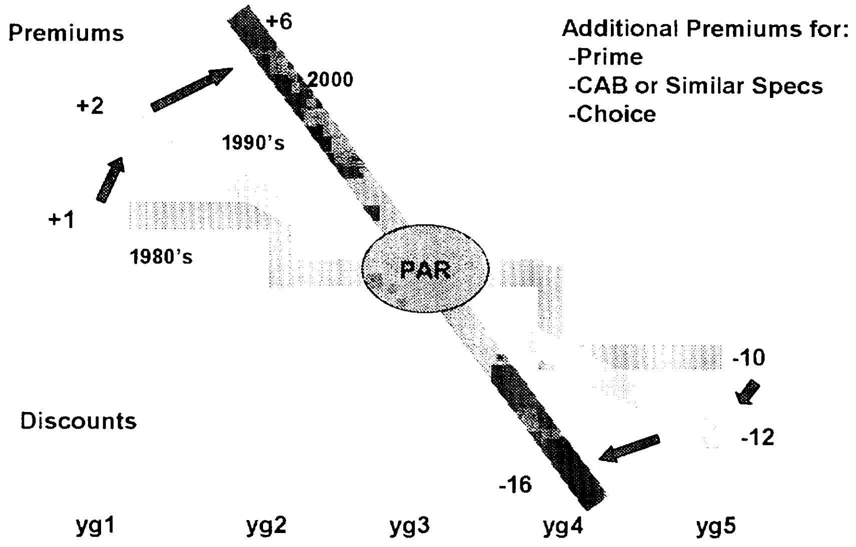
Source: Cattle-Fax 2

005

Top 25 Feeding Companies Feed 40% of the Cattle Now!

By 2006 = ?

Value Discovery Changing

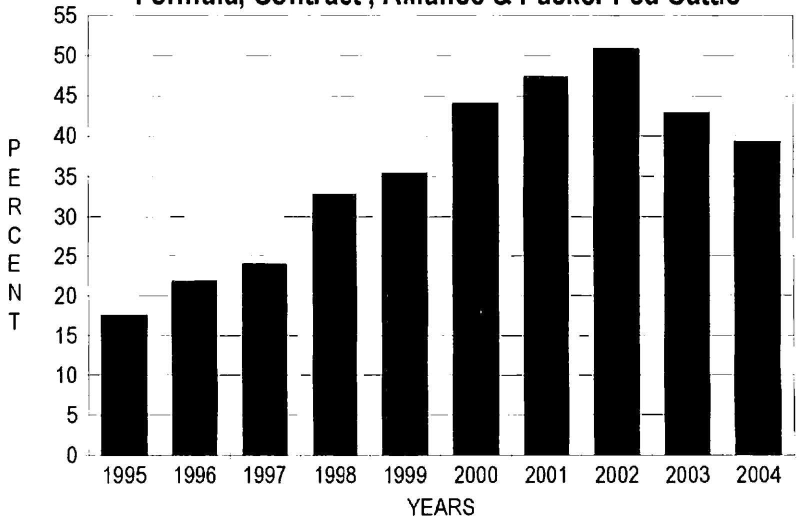


New Opportunities

- **Source Verified**

- **Age Verified**

Percentage of Fed Cattle Movement from: Formula, Contract, Alliance & Packer Fed Cattle



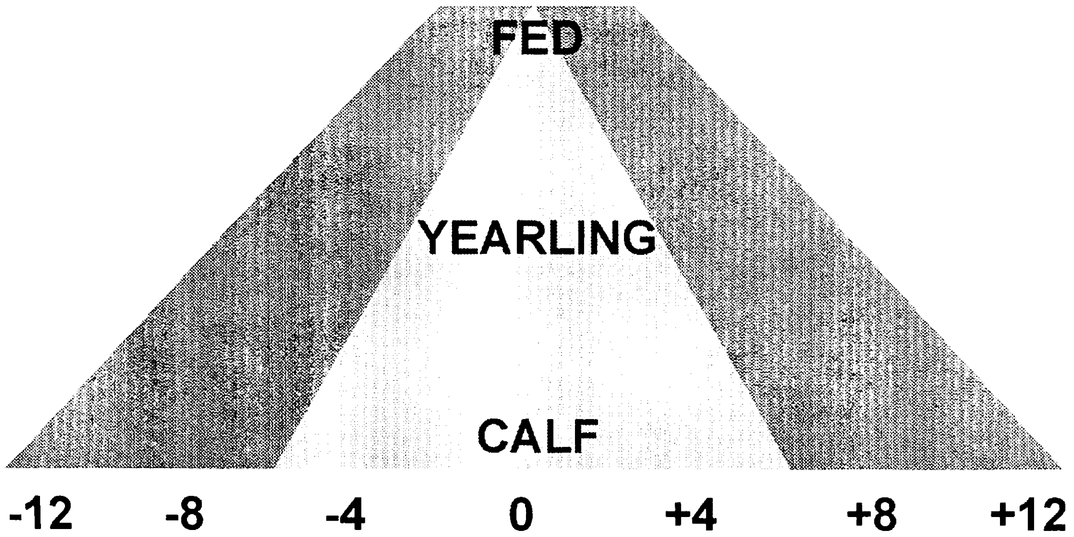
Pricing Method: Pricing on value of beef and the by-products produced

Message: "Some cattle are better than others"

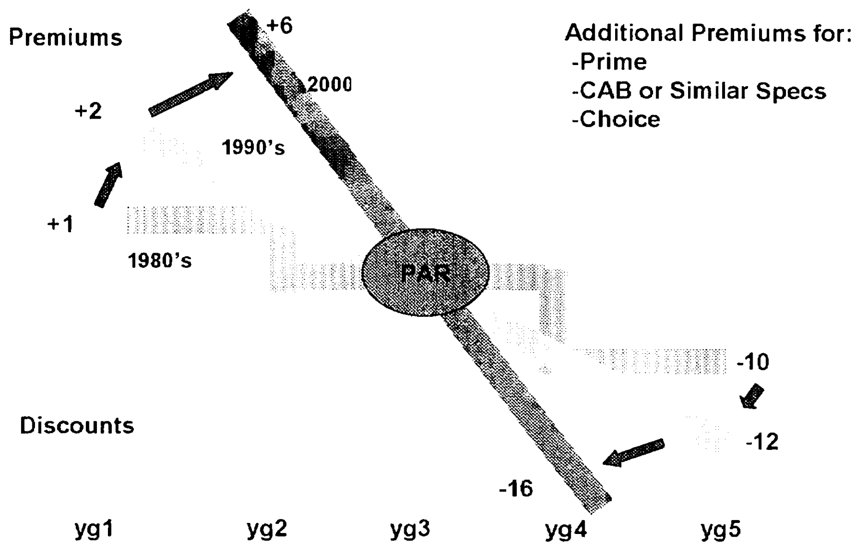
Result: Produce more of the better cattle

FUTURE CATTLE MARKET

Increased Value Differentiation At All Levels

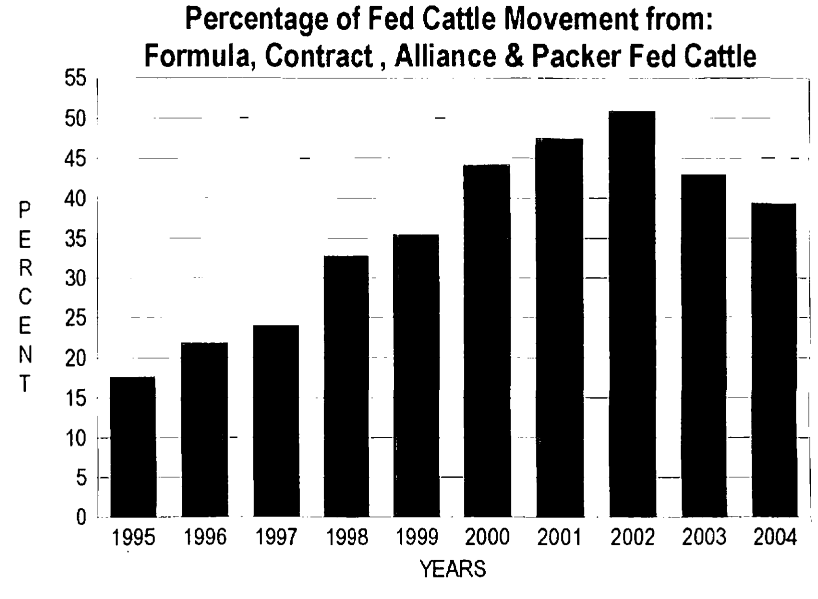


Value Discovery Changing

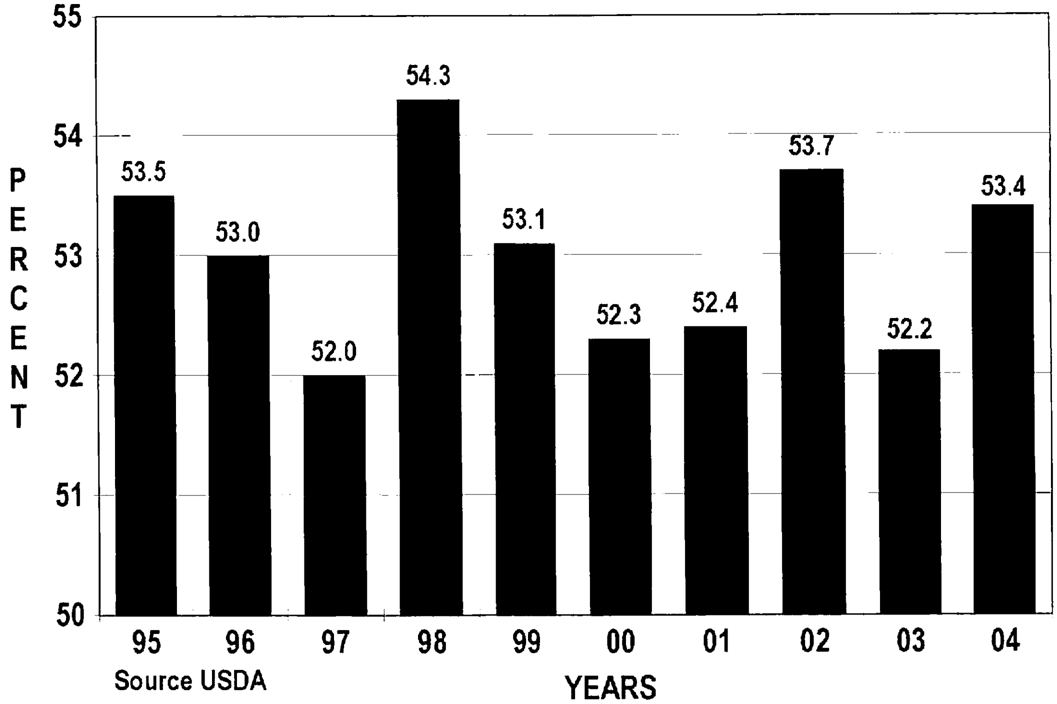


New Opportunities

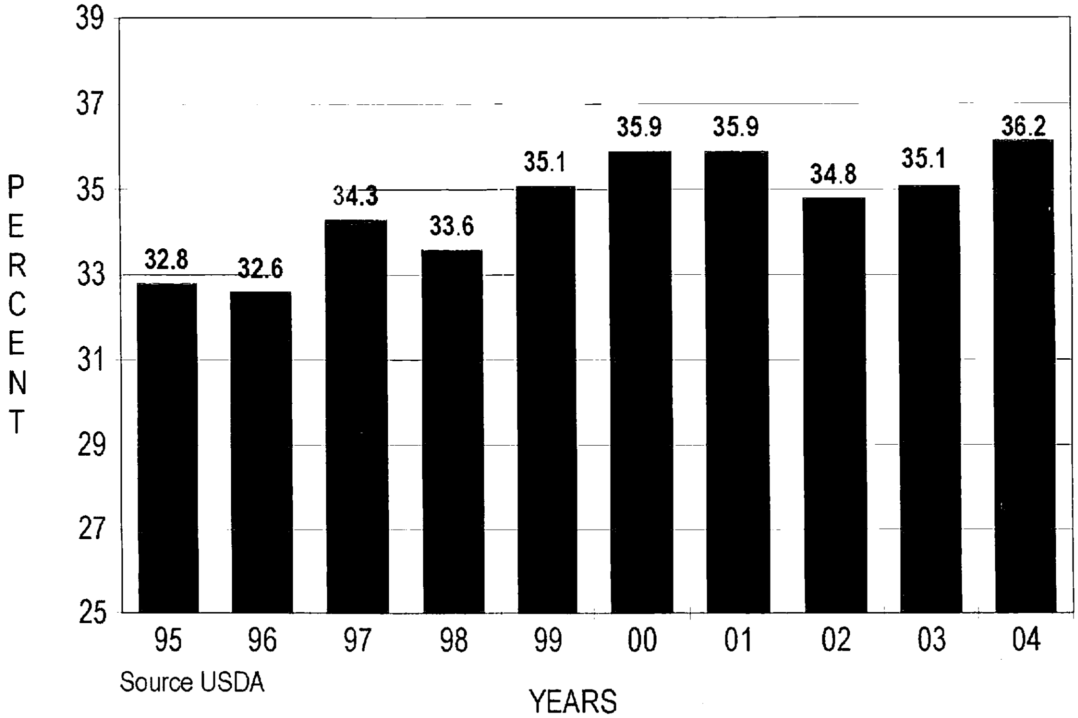
- **Source Verified**
- **Age Verified**

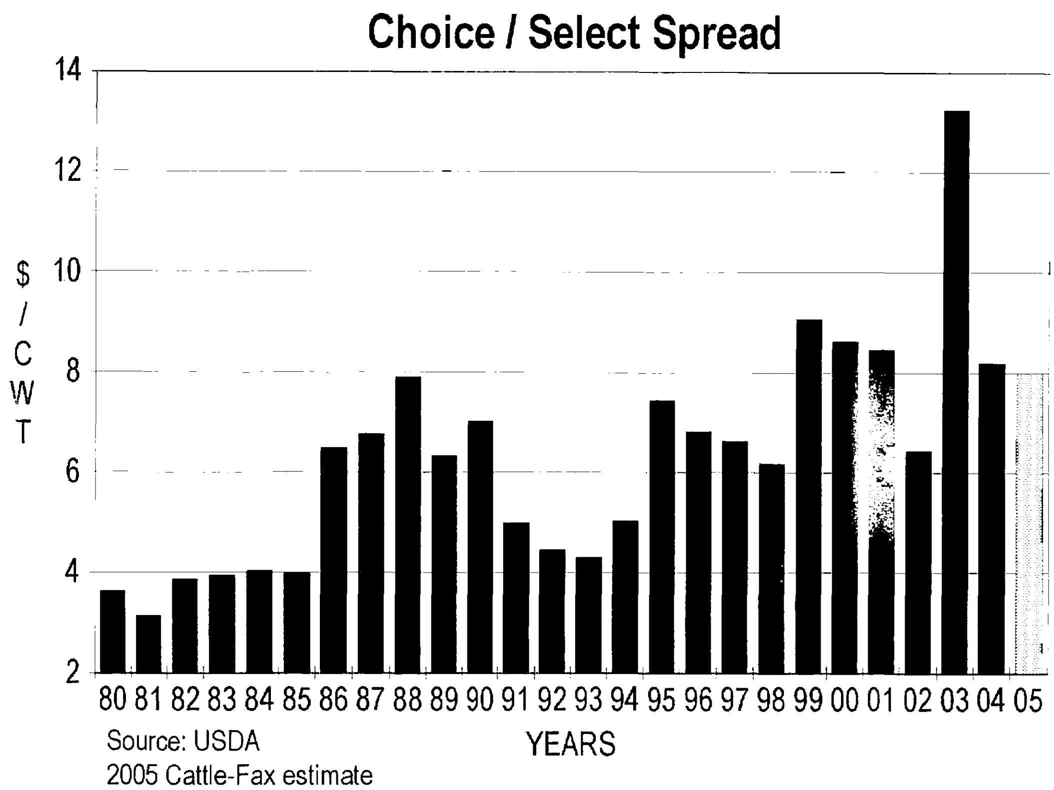


USDA % Choice

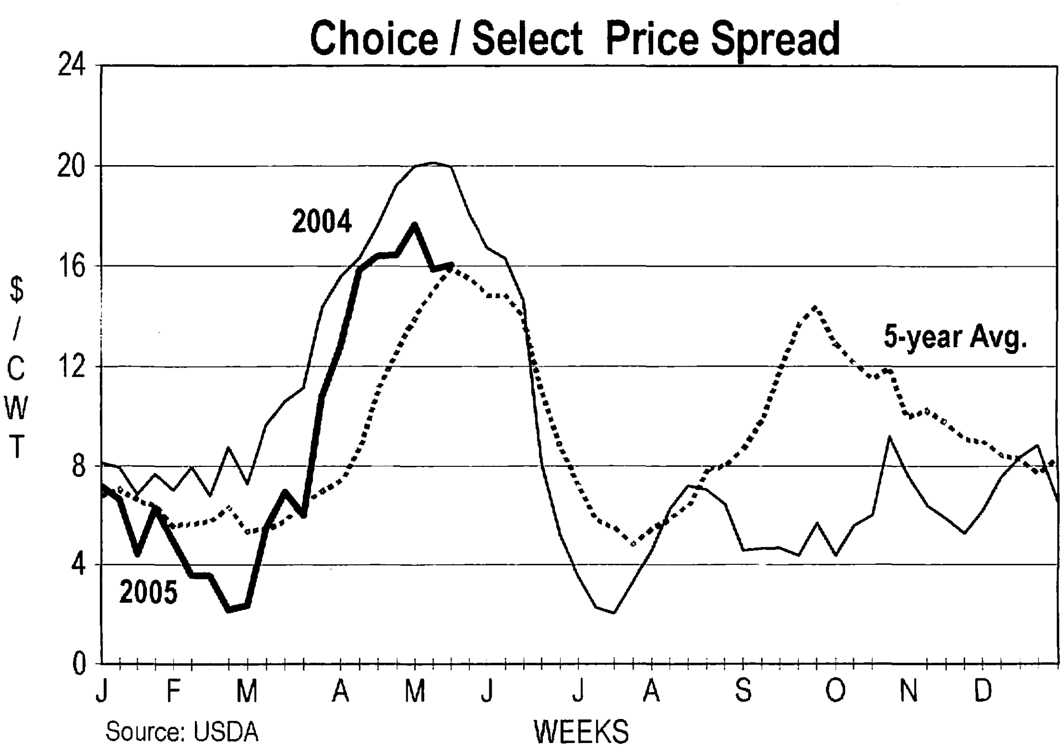


USDA % Select

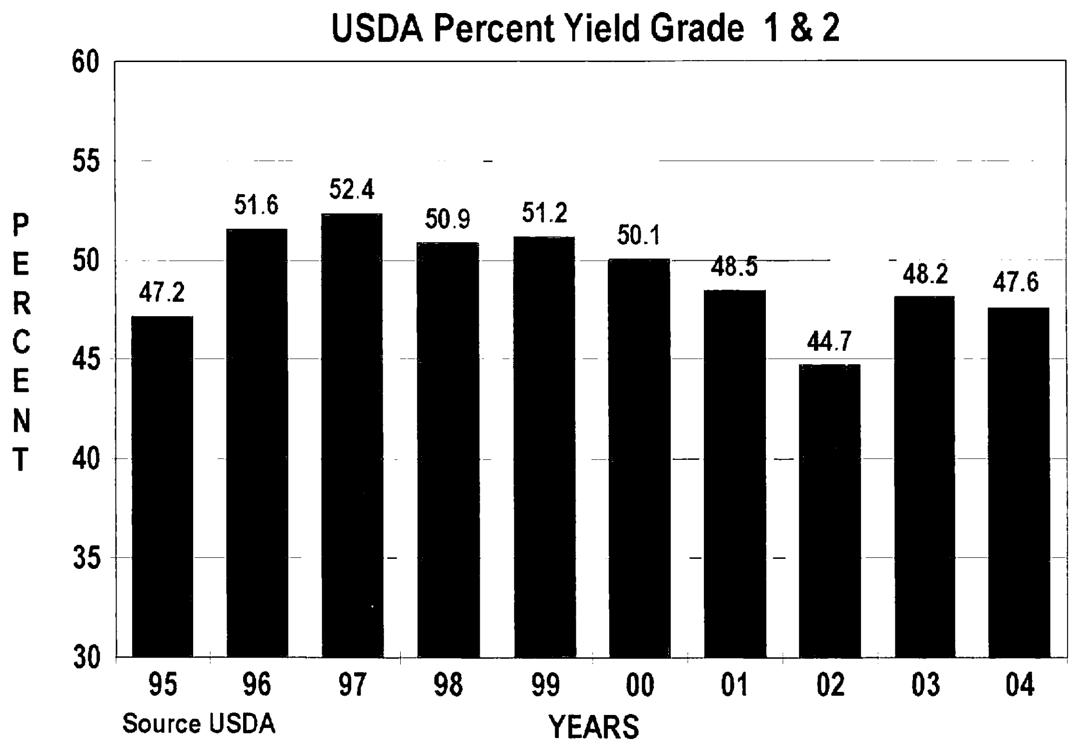


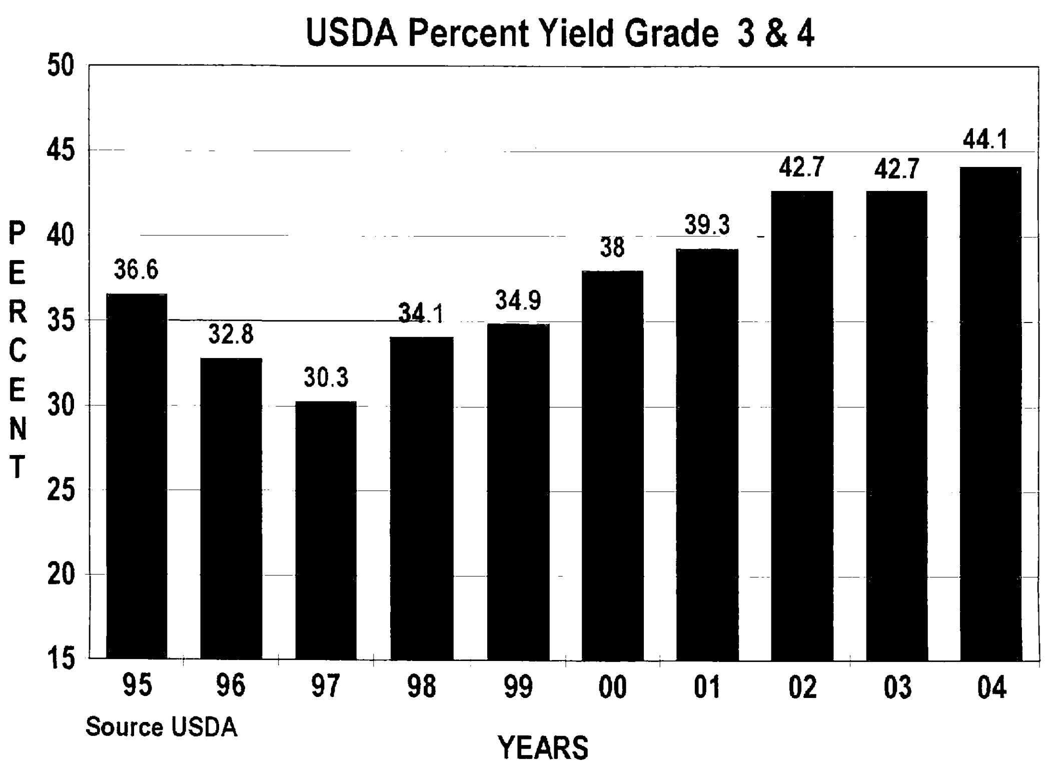


Choice / Select Spread
$ / CWT
14
12
10
8
6
4
2
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05
Source: USDA
YEARS
2005 Cattle-Fax estimate



Choice / Select Price Spread
$ / CWT
24
20
16
12
8
4
0
2004
2005
5-year Avg.
J F M A M J J A S O N D
Source: USDA
WEEKS


USDA Percent Yield Grade 1 & 2
60
55
50
45
40
35
30
P E R C E N T
47.2
51.6
52.4
50.9
51.2
50.1
48.5
44.7
48.2
47.6
95
96
97
98
99
00
01
02
03
04
Source USDA
YEARS


USDA Percent Yield Grade 3 & 4
50
45
40
35
30
25
20
15
P E R C E N T
36.6
32.8
30.3
34.1
34.9
38
39.3
42.7
42.7
44.1
95
96
97
98
99
00
01
02
03
04
Source USDA
YEARS

U.S. Beef Market

- 28 Million Fed Cattle Annually
- 540,000 Harvested per Week
- 26 Billion Pounds Beef Production
- 500 Million Pounds per Week

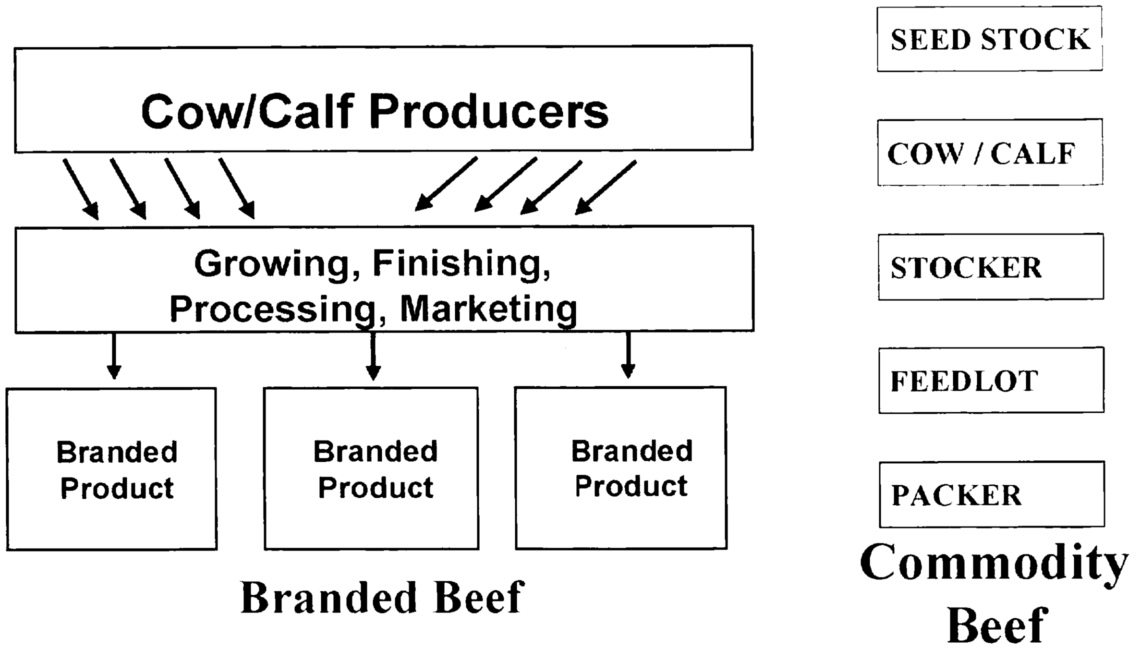
Branded Beef Production (excluding store brands)

- Less than 10 Percent of Total
- Growing Market Trend
- Natural Trend Growing but Small Percent of Total Market

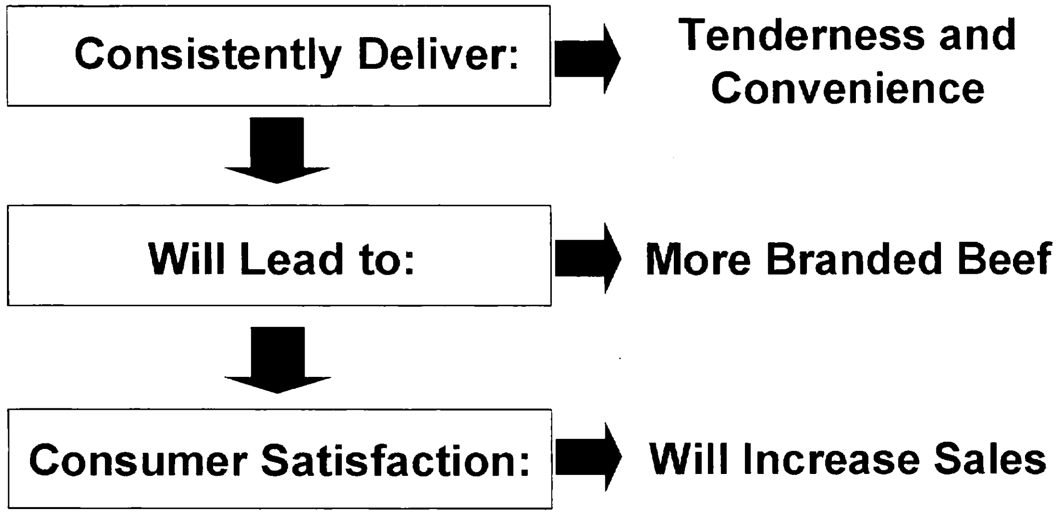
Challenges with Branded Programs

- Carcass Utilization
- Lack of Food Service Market Penetration
- Cost of Production vs. Price of Product

Where do You Fit ?



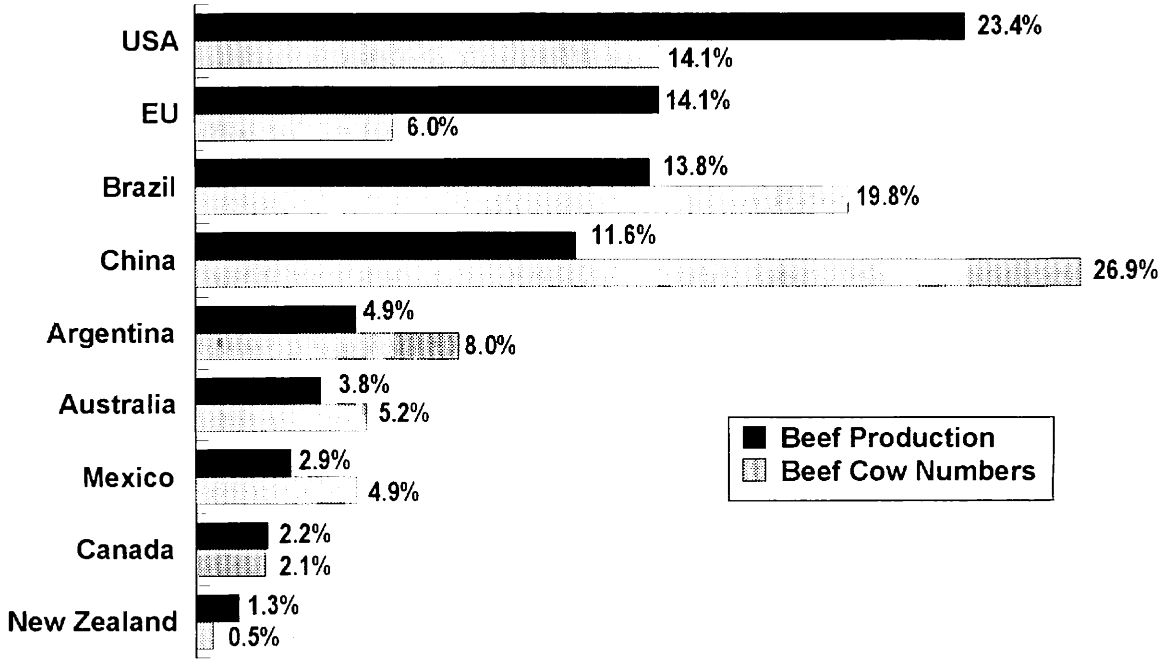
Opportunity



Value of Market Access

		12/22/2004	Difference
	$/hd	$/hd	$/hd
Chuck Short Ribs	24.30	10.43	-13.87
Short Plate	54.77	43.50	-12.21
Chuck Roll	68.21	62.85	-5.36
Tongue	12.43	2.49	-9.95
Liver	4.28	1.81	-2.48
Total			-$42.93/hd
Fed Steer Price	$92.62/cwt.	$89.59/cwt.	

Percentage of World Market



Source: FAS

The Bottom Line

Does It

Increase

Profit

$$\text{Value} = \frac{\textit{Benefits}}{\text{Cost}}$$

Major Trends and Opportunities

- Globalization – Increased Competition
- Retail and Food Service Consolidation
- Beef Safety – Accountability
- Increased Product Branding and Differentiation.
- Accelerated Development - New consumer friendly and convenience orientated beef products.
- Further Advances in Value Determination for fed cattle.
- Capital Requirements – Who can afford to play?
- Risk Management and Forward Pricing Tools?
- Productivity / Technology

How Do We Get There From Here? Bridging the Gap.

Dr. Vern L. Pierce, Beef Economist
University of Missouri

The future of the beef industry is clearer than most think, at least to me! It is clear that it will look nothing like it does today and it will be led by different people or at least entirely different philosophies.

While the endgame is more clear than the course to get there, I believe there are three major opportunities, or even principles, that will help a forward thinking person or organization be in front.

1. Recognize that we have, perhaps, the closest thing to a free market as anyone.

You know the scenario. The local cattle producers are meeting this week in town to hear a speaker that has come in to discuss the changing beef system and how people can develop a strategy to be part of that system. Most people come to really hear what the speaker has to say and figure out how they will have to change to fit there beef operation into the new system. The questions are challenging for the speaker as the audience tries to get as much information out of him as possible so they can develop a good plan for their business. Of course, not everything the speaker has to say will work but there are some good morsels there for the picking to be sure.

Then it happens-it's the "anti-packer guy". This ole boy gets on his high horse and, regardless of whether the question fits into the topic of conversation that night, asks the speaker the question that turns the educational event into a bounty hunt. "Yeah, but.." the question usually begins, "All this wouldn't be necessary if the packers would give us what we deserve and if the government would just guarantee us a free enterprise market."

Let's take a look at that philosophy. The standard Merriam-Webster dictionary defines "free enterprise" as follows: *freedom of private business to organize and operate for profit in a competitive system.*

Note that the definition doesn't say anything about guaranteeing that any particular business will be profitable. Several Centuries ago, Adam Smith, an economist penned the expression and concept of the "invisible hand." It works in the beef industry as well today as it did for all "free markets" back then. In the context of today's beef business this theory says that you, or any one else, is welcome to participate in the beef business at any level you wish. You are welcome to have a business as small or as large as you wish. You should try to sell your products for as high a price as your buyers will pay and you should pay no more for your inputs than you absolutely have too. You will need to be able to recognize when the needs of your customers change and it will be your responsibility to adapt. The only catch is that everyone else gets to play the same game. Mr. Smith would have gone on to say—if the marketing system changes and you find that your old way of doing business does not provide you with the income that you desire then you are welcome to leave the industry —thank you very much.

I have read all of the studies that have been done trying to determine if the packers are controlling the market place. The studies are inconclusive. However, I would like to put your mind at ease by solving the mystery. YES! Indeed the packers are paying the feeders for the cattle a price that is as low as they possibly can and still get the cattle. They are not paying a premium to get commodity cattle from one feeder when they can bid the price down and get essentially the same cattle down the road. In addition, they are selling the beef they get from those cattle for as high a price as they can get from the retailers. By the way, if you recall, this is called a "free market" and it is available to them as well as you. As you know, with the recent downfall of Future Beef, this "free market" does not guarantee the packer a profit either.

The retailers get to play the same game. They will charge a price for retail beef about as high as they can and still sell the meat to the consumers. If the price goes too high the consumers will walk to the pork cooler. If the price is too low the retailers will sell all the meat they have and leave some profits on the table. On the other side of the business they will pay feeders a price for commodity beef as low as possible. The money that is left is the free market profit. They don't get a guarantee and neither do beef producers. Unless of course, we want to argue that the government should control the market which is the opposite of where we started by asking for a free market.

Granted, there is a possibility for abuse in the free market and the government is there for that situation. Perhaps, however, we have used a fear of market power of some as an excuse for lack of entrepreneurship for others. As an industry we tend to gather up to point fingers at others rather than point a finger in the direction we wish to go.

Perhaps the greatest threat to the beef industry is the beef industry

In the beef business we are proud of our traditions. Producers learn from an early age that hard work and, well more hard work will get you every edge there is available. Even more importantly, hard work is always honorable. We teach eachother the way it is in the business in terms of who is expected to succeed and who is not. Then, as the next generation comes through, we are shocked that the same people are farther ahead in the game.

Have you ever wondered whether some things stay the same because that is the way we expect them to be? Some would say that is called tradition. I think it is a little closer to home than even tradition. Take that word AGRI-CULTURE apart once and you will see what I mean. The traditions and lifestyles that we enjoy are part of our culture. We just need to realize when to leave the old culture behind and find the new. We all grew up learning what the acceptable rules were in our homes and in our communities. This was dictated by the culture of our heritage and the principles of our parents. If you grew up in the agriculture world you also began to see some of the culture show its face if you ever tried to question the way something was done.

"That's not the way we do things around here, son" was one of the first things I heard when I asked someone in the beef industry about rethinking the way they marketed cattle. When I pushed the issue, they pushed harder. The culture of the beef industry has run deep into every stage of our business from the cow-calf producer all the way through to and including the retail store. It is only when a few people step out in front and show a different way of doing things and insist on not backing down when the pressure hits that the culture is challenged and positive change begins.

Think about the way "we" taught consumers to eat our beef products. We taught them that beef comes in white styrofoam trays with cellophane plastic over the top. Be careful when you tip the package in case the blood run off leaks onto your pants in the grocery store. We taught consumers that beef really tastes great – every once in awhile when you get lucky and find just the right cut of meat and get even more lucky to cook it just right. We taught them that we were going to work very hard on our farms and ranches and they should appreciate our effort and pay us more for the meat they enjoyed eating—well mostly enjoyed eating. We taught them that we were going to label our product just the way we liked thank you very much and that included a subjective measure of quality using a grading system that the USDA, not consumers, choose to differentiate our products. We taught consumers that beef was really good and they needed to keep coming back and trying it again even if the last steak they bought was tough and chewy. "Trust us", we taught them, "the next one will be better." Well we tried to teach them these things anyway – that WAS our culture. Then a few people began to try something different and, well, have you seen the retail beef case lately?

That old culture of the beef industry continues down through the system though doesn't it? The system has taught cow-calf producers that they really are doing a great job if they get a good price at the commodity sale this fall. We taught them that a single price given to them on a single day for a years worth of work was a signal about whether they had the whole system right or wrong this year. We taught them that someone who would see their cattle running by them for 30 seconds really did know best when it came to evaluating the real value of the cattle before them and the quality of feed and husbandry that went into those cattle. We taught cow-calf producers to go back and figure out what was good and not so good about their calves based only on this one price signal from the sale. Well we tried to teach them these things anyway – that WAS our culture. Then a few people tried something different.

We taught those who bought in the commodity system that they were to buy cattle that had problems, pay as little as they could, group the cattle together, fix the problem, and then market the cattle for a profit. Of course, neither the buyer nor the original producer would ever know what, if anything, was really wrong with the calves or whether the grower corrected the problems. We taught the feedlot managers that over time they really should not expect to make any money as an industry and they should save up during the good times as the bad part of the cycle was coming. We taught our extension education industry to hound us constantly about knowing our cost of production and then we secretly laughed when they gave us speeches to do just that because we knew we never would—but the free steak was good that night-well actually it was a little tough, but it was free! Our culture taught us that when the checks were not bouncing the farm must be making money.

Then something happened. The culture began to change. It started slow as some in the retail sector began to notice that the fresh meat aisle was the only one in the store without branded products. The retail culture, you see, is that retail shelf space is limited and the more times you can empty and fill that space the more money the store makes. They noticed that branded products which offer quality and consistency throughout the store were attracting consumers as repeat buyers once the consumer found the brand he wanted and could rely on the quality to be the same each time.

It started in the poultry business, continued through pork and finally hit beef. Our culture in the beef system began to change. The check-off was born and invested in finding products that consumers would like and for which they would be willing to pay a premium They funded programs that finally broke our culture down and recognized that the word "consumer" is not singular. There are many types of consumers with many tastes and preferences. As our culture changes we will teach cow-calf producers that they can make a good living if they learn as managers to manage information more and fence repairs less. We will teach them that using information will increase profits faster than better hay management. We will teach the livestock markets that they have a vital role in the new market place in facilitating the transaction of cattle between buyers and sellers and there value will come from facilitating the transfer of information more than there skills on the auction block. We will teach the packers that as the information flows back through the system along with corresponding prices for differentiated quality that producer will raise their respect rather than their suspicions. The culture of agriculture is changing and the beef system is finally on board ?

2. The Gap for individuals is entrepreneurship.

The basis of the generic beef cattle business has always been a massive commodity system providing processors in every part of the country with an animal supply that is cyclical and inconsistent in quality. Against this background, former USDA Secretary Dan Glickman said, "The days when most farmers could make ends meet by simply bringing bulk commodities to market are over." Managing the farm operation requires the establishment of a set of farm policies just like the government. The question for individuals is not rocket science- Have you formed a farm policy, or business plan, which will guide your operation toward finding the most money possible, then setting a course to earn and capture that money for your operation? It is time for your own farm policy. What will it take in your cattle operation to maintain your family and living style 10 years from now? The cold economics lesson from Adam Smith says that if you can't maintain a profitable business then the free market will find someone else who can.

Vertically coordinated value-added systems attempting to capitalize on a changing consumer demand have emerged. These are emerging as new and separate entities from traditional markets as well as from livestock markets that are adding value to their customer's product by helping them develop vertical marketing relationships. This is one way that progressive managers are taking the advice of Adam Smith by redefining how they do business in a changing "free market." There are many others ways of course and they key is to recognize your strengths and find a way to make money in the marketplace. I don't think complaining at meetings will help your checkbook balance.

The concept of vertical relationship marketing is not new. We have seen a substantial increase in the presence of these types of groups in recent years. However, like every other new innovation that has come along, it also requires a new understanding of some part of the business. How is it possible to pick the right alliance to join in with? How will your returns and costs be different? Will this change add to your bottom line or just the top line? The answer to these and other questions can only come from how you decide to fit into the new beef production and marketing system. That answer comes from how you shape your new farm policy.

Managing your farm with an objective in mind is really easier than without one. Of course, most of us have the objective to make more money. But how? Just waiting for it isn't going to make it happen. The answer comes from identifying where you believe you can best serve the industry as the returns to a value based marketing system come to those who provide the most value or service to the system. To determine this, consider what it is that you are or can be best at doing in the beef system. I guarantee you that if your answer is that you just like to be with the cows there are problem days ahead. I mean really think about what part of the business you can do better, cheaper, and more efficiently than others. At the same time think about what you are really not very good at. The manager that will be able to thrive in the future in our changing beef system described by Secretary Glickman will be the one that can expand his business in the first area and contract it in the second.

Learn what to focus off!

It is never difficult to learn more about that which we are interested. The one who likes nutrition so will hardly pass up an article in a trade journal sharing some of the latest knowledge about feeding. Our genetics friends will read every sire summary cover to cover trying to find the best bull to use. Finally, our business friends will learn all he can about money – how to make it and how to keep it.

Of course, It is fine to continue to learn about what we are interested in, however, I challenge you to make a list of all the skills that you think a good cattle businessmen should have. Next check off on that list the skills that you have. The remaining list is where you need to focus. Chances are the list will reveal what you already know are your biggest business management weaknesses. Don't just go to an extension meeting on Wednesday night because you have that evening available. Choose educational and reading opportunities that help you check off more items on your list. Think about it this way, if a young man just out of high school where to come to you and ask what skills you would advise he should have to be one of the decision makers in the new beef chain, what would you say? Think about the list you might sit down and sketch out for him. The skills you need to survive as a businessman in this changing structural environment are those you just shared with the young man. If you already believe that this list you gave him has all the skills needed to survive then just check off the skills you have mastered – the remainder is what you need.

3. The Gap for organizations is leadership.

Visionary leaders take their organizations forward in a particular direction not always because of some of its members but often in spite of them.

Who Shredded My Lettuce?

You might have heard of the widely popular New York Times best seller, "Who Moved My Cheese." If you haven't heard of it go and buy it and read it. It is a small book that will take about a hour to read. It is a parable really, a story about 4 mice and how they deal with change when their cheese supply disappears. One of them complains about how it shouldn't have been moved while another goes out and finds another source of food. Their other two friends fall somewhere in between. It is a great story that will make you think about change. Change is inevitable you know (except from a vending machine). The story however, has at least one weakness for some readers who cannot make the leap from being mice to being producers. Here is a story of two lettuce producers that might have taken place about 10 years ago.

Bob and Rex had adjoining farms on which lettuce had been grown for the local coop for several decades. They both had about the same number of acres and, apparently, about the same level of wealth. Bob had always thought of the operation as a business. While he loved the land and all that rural life had to offer his family. He knew that the days of not having to worry about a market place would soon be over. Rex was a third generation farmer. He did go off to college at his fathers' advice to learn a vocation in case the farm couldn't always support their family.

Lettuce has certain market periods when there is a large supply coming to market because most of the producers sell their crop at the same time. Bob and Rex would always see each other at the lettuce buying station and would, along with the other producers, complain that the price was too low and how the lettuce baggers were making all the money. Rex's usual complaint went something like this, "Look, I get fifteen cents a head for my lettuce and it sells for seventy-five cents in the store—you do the math on who is getting all the profit. It's those baggers and the government won't do a thing about it."

Meanwhile at the bagging plant, Bob takes a tour of the process to see what happens to his lettuce after it leaves the operation. During the tour, Bob notices several trucks that don't belong to the bagging plant backing up to the truck ramps near the cooler. He recognizes the name on the side of the truck is from one of those companies that make the shredded lettuce for salads and tacos that can be bought at the grocer. He watches as the buyer for the value added lettuce company carefully looks through the cooler and finds the quality that he is looking for and selects about 10 percent of the cooler to go to his company for shredding and bagging. Bob stops and thinks out load to no one in particular, "do you mean these guys just come in here and buy bulk commodity lettuce by the head from the cooler and then go shred it and put it in a bag and sell it for about six times what the commodity lettuce sells for in the store?" The proverbial light bulb comes as Bob walks away saying "I want a piece of that!"

Bob stops and talks to one of the bagging plant managers on the way out of the plant to confirm what he had just witnessed. "Yes," the manager said, "that is exactly what happens and we have several more of those companies that come in and buy the higher quality lettuce. We also have some of those salad bar and steak restaurants come in and buy some of the lower quality stuff. The rest goes into our generic bag of whole head lettuce and off to the grocery store. We then blend all the money from the high end sales, the low end sales and what we sell to the grocers for and blend that price into what we can pay you at the buying stations for the commodity stuff." Can I let you in on a little secret, the manager continued, "We have noticed that those value added buyers are starting to develop relationships with the producers directly through some kind of alliance they call it. Well, if that continues then all the good stuff will never end up in my cooler. I won't get that premium price for my lettuce and that will lower the blended price I can offer producer for their lettuce. I have a plan though, are you interested?"

It didn't take Bob long to sign up. The deal was that Bob would start to sort his lettuce according to growing condition, variety, and other quality factors and promise to sell all of his harvest to the bagging plant directly. His lettuce would not go through the buying station anymore. In return, Bob would get a guaranteed base price plus quality premiums for each head that met standards that were set by the bagger. Bob became the spokesperson for the bagger and recruited several others of his friends. Rex would not budge. "That doesn't sound right," Rex said, "You have to watch those baggers every minute. My daddy didn't trust them and I am not either. In fact I said something at a meeting the other day about these new programs and I think the government is going to shut'em down." Bob moved on to other producers.

The next year, Bob and his new alliance partners kept better records about the varieties of lettuce that they planted and when they planted each variety. Part of the deal with the bagger was that he could lower his costs of buying lettuce at the buying station if he knew when the new "alliance lettuce" was going to be ready for market. He had to pay his employees on the chill floor weather they were working at full capacity or not. The bagger figured he could pay a premium to Bob and his friends if they could time when their lettuce came to market during the times when the commodity lettuce was in short supply.

As it turns out, over the next few years the alliance that the bagger had started grew in popularity among some of the producers. It was true that most of the money for the processing, shredding, marketing, advertising, and retailing went to the businesses upstream form the producers. However, they also noticed that the price of lettuce sold at the buying stations was lower that what they were selling their product for. They also noticed that some of the buying stations had become part of the new system helping the bagger recruit and develop ways to sort and keep records on the lettuce. Most of those were still in business. Most of the others were not.

It was the last sale date for the buying station that Bob and Rex had always gone to. Bob hadn't sold his lettuce there for several years now but went to the sale that day for nostalgic reasons. That buying station was a part of the lettuce history. He and his friends used to sit with their dads on sale days in the audience and watch as each head was sold to some unknown buyer. That was all over today as that buying station was purchased by some website that planned to close it the next week. And look, there was Rex in the café eating a piece of pie and what was he saying? "Look, I get fifteen cents a head for my lettuce and it sells for seventy-five cents in the store—you do the math on who is getting all the profit. It's those baggers and the government won't do a thing about it."

Rex went on to become a leader in the lettuce improvement federation and drained all of the resources of the federation fighting change. Most were afraid to challenge him on his ideas because he pulled so much weight in the organization. Most of the young leaders knew that he was wrong and knew that the federation was not helping the industry by sticking with these old value systems.

Eventually, the more aggressive thinkers just stopped coming to the meetings because they were tired of the same old arguments. Since the opposition began to decline, Rex decided he was right. The organization folded a couple of years later.

Never think that a few dedicated individuals can change the world! Indeed, it's the only thing that ever has – Margaret Meade.

Introduction to Indexes

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Why do we need indexes?
The complications of multiple-trait selection and animal breeding decisions may be best summarized by Dr. Lanoy N. Hazel in the opening paragraph of his landmark paper on the topic of selection indexes published in the journal *Genetics* in 1943:

> The idea of a yardstick or selection index for measuring the net merit of breeding animals is probably almost as old as the art of animal breeding itself. In practice several or many traits influence an animal's practical value, although they do so in varying degrees. The information regarding different traits may vary widely, some coming from an animal's relatives and some from the animal's own performance for traits which are expressed once or repeatedly during its lifetime....These factors make wise selection a complicated and uncertain procedure; in addition fluctuating, vague, and sometimes erroneous ideals often cause the improvement resulting from selection to be much less than could be achieved if these obstacles were overcome.

Hazel points to the complexities of selection of individuals when many traits are observed and when the 'information' or performance record of an individual and its ancestors, collateral relatives and progeny may vary considerably. Indeed, the overall net merit of the individual, considering several traits of economic importance, provides a superior selection criterion than other forms of selection including single trait selection and multiple trait selection via independent culling levels (Hazel and Lush, 1943).

Hazel's pioneering work solidified the idea of a breeding objective or goal using a quantitative method. The aggregate genotype described by Hazel was a linear function (selection index) of observations such that the observations of each trait were weighted by the relative economic value of that trait. The result was a single value for each animal that represented an objective valuation of the overall satisfaction with that animal. In production agriculture, our level of satisfaction with an animal or system is generally measured in profit. The selection index provided a natural connection between the net merit of an animal's genotype and its relationship with profit.

As beef producers, we know that more than one trait exhibited by beef cattle contribute to profit at the enterprise level. Clearly, a cow-calf producer that sells calves at weaning depends on more than just the average weaning weight of calves for profitability. Simple ranch accounting suggests that reproduction rate, calf survivability, cow maintenance feed costs, length of productive life and others influence the total pay weight of weaned calf produced and the cost required to produce that weight. Likewise, the producer that sells calves at harvest relies on more than just marbling score or quality grade to pay the bills. Reproductive rate of the cow herd, maintenance costs, longevity, not to mention carcass weight, are all factors affecting profitability. Thus, breeding objectives should include all the traits that are of economic relevance.

The original work by Hazel and later the work of Henderson (1951), who incorporated the use of EPD into selection indexes, stimulated a great deal of activity in the area of genetic prediction. Significant time and monetary resources have been devoted by producers, breed associations, beef improvement organizations, public sources, and academics to produce the sophisticated genetic predictions at our disposal today. However, comparatively little work has been devoted to full implementation of multiple-trait predictions into the multiple-trait prediction tools (Bourdon, 1998) envisioned by the originators. While the EPD produced today are of sufficient precision and accuracy, they are presented without context. Bourdon goes on to state that, "There is no easily accessible, objective way for breeders, particularly breeders in the beef and sheep industries where ownership is diverse and production environments vary a great deal, to use these predictions intelligently." Academic animal breeders are encouraged to solve this problem. The solution to the problem of intelligent use of multiple-trait EPD is to integrate genetic predictions with multiple-trait selection strategy usable on a large scale (Bourdon, 1998).

Index Basics

The idea of the selection index has seen a number of improvements since its conception over sixty years ago. In general, index construction begins with determination of the breeding objective or goal. Next, generate a list of the traits that affect attainment of the goal and then determine the relative economic importance of each trait in the list. The traits measured are then used to predict the economic merit of each animal available for selection as a parent. An overview of the construction of indexes is provided below.

In its simplest form, the selection index (Hazel, 1943) defines an animal's economic merit as a parent in terms of the function (often called the breeding objective):

$$H_i = a_1 BV_{i1} + a_2 BV_{i2} + \ldots + a_n BV_{in},$$

where,

H_i = the aggregate economic merit of an animal, i, as a parent,
a_j = the relative economic weight of trait j, $j = 1 \ldots n$, where n = the total number of traits
BV_{ij} = the breeding value of animal i for trait j.

Since the true breeding values of individuals are never known, predictions of genetic merit maybe substituted. Then, candidates are ranked on a prediction of (**H**) called (**I**), the *index value* defined as (Henderson, 1963):

$$I_i = a_1 EPD_{i1} + a_2 EPD_{i2} + \ldots + a_n EPD_{in},$$

where,

I_i = the predicted aggregate economic merit of an animal, i, as a parent,
a_j = the relative economic weight of trait j, $j = 1 \ldots n$, where n = the total number of traits
EPD_{ij} = the Expected Progeny Difference of animal i for trait j.

Henderson's inclusion of EPD in the selection index provided an efficient methodology for the incorporation of large amounts of pedigree and performance on relatives of selection candidates into the selection index. Further, the index is then unbiased as the genetic predictions themselves are unbiased since they are derived from Best Linear Unbiased Predictions (BLUP) procedures.

Genetic predictions for all traits included in the breeding objective are not available in many cases. In this case, a subset of traits is included in the index as suggested by Schneeberger et al. (1992):

$$I_i = b_1 EPD_{i1} + b_2 EPD_{i2} + \ldots + b_n EPD_{in},$$

where,

I_i = the predicted aggregate economic merit of an animal, i, as a parent,
b_j = the predicted relative economic weight of trait j, $j = 1 \ldots n$, where n = the total number of traits
EPD_{ij} = the Expected Progeny Difference of animal i for trait j.

A widely cited example of a selection index designed for the improvement in the efficiency of beef production was published by Dickerson et al. (1974). This index was formulated as:

$$I = YW - 3.2 * BW$$

where,

I = the predicted aggregate economic merit of an animal,
YW = 365 day yearling weight,
BW = Birth weight.

To investigate the response to selection based on an index, a selection study using the index proposed by Dickerson et al. (1974) and a randomly selected control line was under taken using a composite population of cattle at the USDA ARS Fort Keogh Livestock and Range Research Laboratory in Miles City, MT. Results of the study demonstrated that selection using the index produced little effect on maternal traits but produced significant improvement in the index and post-natal growth in spite of the antagonism faced when selecting for decreased birth weight (MacNeil, 2003).

Establish the breeding objective

The first step in development of a selection index is to clearly define what the goal of the genetic improvement is. A verbal description, rather than a mathematical one, may provide easy way to initiate the process. An example could be, 'Maximize profit from the sale of weaned calved produced on a extensively managed ranch in an arid environment where replacement females are retained and developed from the calf crop.' This statement of goals points out that maximization of profit (and only profit) is the objective of selection. Further, it suggests a few traits such as weaning weight, maternal traits, and heifer fertility that should be included in the objective.

Identify Economically Relevant Traits

A description of the breeding objective like the one above will help identify economically relevant traits, those traits that have a affect on profit. Some of these traits will be ones that impact revenue generation and others that typify the incurrence of costs. In cases where economically relevant traits can be identified, but a genetic prediction is not available, then indicator trait(s) with genetic predictors should be included in the breeding objective. Indicator trait EPD should not be included in the breeding objective if the economically relevant trait EPD is available as doing so decreases the accuracy of the index and subsequent selections (Golden et al., 2000).

Determine the Relative Economic Values

In many ways, the formation of the breeding objective and the listing of traits to be included in the index are much simpler tasks than computation of the relative economic values which are the weighting factors for traits in the index. The adoption and implementation of indexes of aggregate economic merit has been limited by the absence of economic values and, as such, the current genetic evaluation falls short of the grand vision developed over 60 years ago (Goldon et al., 2000).

Economic values or weights (the a's or b's in the above equations) reflect the change in profit when a trait is changed a single unit, holding all other traits in the list constant. One approach to obtain the relative economic values is to obtain the partial derivatives of the profit equation with respect to each trait in the objective, and the derivatives are evaluated at the mean value of all other traits. A profit equation is a single function designed to represent the relationship that exists between the animals' performance in economically relevant traits and firm level profit (Bourdon, 1998). MacNeil (1998) described the profit function as a highly aggregated simulation model.

Although much of the early literature surrounding selection indexes utilized only linear profit functions or breeding objectives, methods developed in the 1970s and 1980s included the ability to evaluate non-linear profit functions. The ability to consider non-linear profit functions was an important development as it addresses the issue of diminishing returns common in many biological and economic systems.

An alternative method for computation of economic weights is the use of bioeconomic simulation. A bioeconomic simulation model is a collection of a large number of equations (typically nonlinear) that simulates biological relationships, management systems, and determines profitability. The bioeconomic simulation is typically superior to the single profit equation methods in its precision predicting relative economic values. The improved precision is due to bioeconomic simulations higher degree of biological detail accounting for the 'convoluted' effects that changes in the genetic component of an animal's performance can have on profit (Bourdon, 1998). Further, Bourdon points out that despite the complexity and difficulty of parameterization of a large bioeconomic model, the model can provide a very informative and useful tool for both genetic selection decisions, but also exploration of alternative management strategies.

Generalized Indexes

Recently there's been a flurry of activity by researchers and breed associations to develop a variety indexes. A majority of these indexes are end-point or marketing point focused. These generalized indexes are applied on a breed-wide basis. Generalized indexes are appropriate whenever breeding objectives are consistent across large segments of an animal population. Bourdon (1998) cautions, however, that the usefulness of 'one-size-fits-all' indexes maybe questionable for species like beef cattle where production environments, management, mating systems, and marketing strategies vary considerably. The relative economic values appropriate for a specific operation and the industry average may be dramatically different. Use of inappropriate relative economic values will undoubtedly produce erroneous results. Additionally, operations that depart significantly from the parameter assumptions used in formation of generalized indexes are not likely to obtain satisfactory results. Even though this first implementation of indexes may not be extremely accurate, they do provide an educational tool and for many producers generalized indexes are an improvement over the implemented ad hoc selection method.

The Future of Selection

Since the generalizations made in formation of 'one-size-fits-all' indexes may lead to inappropriate decisions, development of site specific indexes becomes necessary. The customized index should be tailored to fit the specific economic, environmental, marketing and management constraints of an individual farm or ranch. The use of profit function derived index weights may provide the most approachable method for customization. Unfortunately, the level of aggregation utilized may lack the precision necessary for reliable site specific recommendations. Development of bioeconomic simulation software which is more precise and that is easy to parameterize and deploy appears to offer the best hope for implementation of multiple-trait selection technologies. Sire selection by simulation of the firm as suggested by Bourdon (1998) outlines a methodology for effective multiple-trait selection that goes beyond traditional selection indexes and provides for testing of look ahead mating system alternatives.

The speakers that follow will discuss a number of the current implementations of selection indexes and other selection tools. Their talks will give a view of the future may hold for multiple-trait selection decisions.

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Breeding Objectives for Terminal Sires For Use in U.S. Beef Production Systems[1,2]

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ABSTRACT

Breeding objectives facilitate implementation of consistent selection toward a specified goal. In a business context, profit maximization is often that goal. Thus, the aim of the research reviewed here was to develop economic breeding objectives for terminal sires. It is argued that commercial production systems provide the framework from which to develop breeding objectives for seedstock. Breeding objectives were developed for Angus, Charolais, Hereford, Limousin, and Simmental using economic input consistent with future projections of the respective breed organizations. The biological and economic framework was an aggregated model of an integrated beef production system that was employed in simulating commercial beef production in situations typical of the U.S. Use of crossbreeding was assumed, except in the objective developed for Angus. For each breed, economic values for survival, growth, feed intake, and carcass related phenotypes were calculated by approximating partial derivatives of profit with respect to each of the phenotypes. In general, results indicate a need for consistent multiple trait selection with joint consideration of both fitness and production traits and with differential emphasis on their components.

INTRODUCTION

Genetic predictions in the form of estimated breeding values (EBV) or expected progeny differences (EPD) provide breeders and commercial beef producers with opportunities to choose among candidates for selection based on their genetic merit. However, a precise definition for "genetic merit" has been illusive. In a business context, profit maximization has been a long standing goal and it is suggested that genetic merit be defined by the profitability of future progeny. Further, it is argued that since the seedstock sector exists primarily to provide germplasm for commercial producers that the relevant measure of profitability is the profitability of commercial production (Harris and Newman, 1994).

Selection for a single trait likely leads to undesirable correlated responses as a result of various genetic antagonisms among traits (MacNeil et al. 1984, Scholtz, et al. 1990a). These correlated responses likely compromise any improvement in profitability that might result from single trait selection. Thus, with a goal of improving profitability, a strategy for multiple trait selection is necessary. However, selection for production alone tends to decrease fitness (Roberts, 1979; Meuwissen et al., 1995). Thus, a comprehensive and consistently applicable breeding objective, related to traits that influence profitability in commercial production, is needed for multiple trait selection to be most effective (Harris and Newman, 1994).

Commercial beef production is generally most economically efficient when heterosis is captured (MacNeil and Newman, 1991). This efficiency arises from a potential to increase weaning weight per cow exposed by approximately 26% (MacNeil et al.,

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[2] Mention of a proprietary product does not constitute a guarantee or warranty of the product by USDA, Montana Agric. Exp. Sta., ARC Animal Improvement Institute or the authors and does not imply its approval to the exclusion of other products that may also be suitable.

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1988) while only increasing feed energy requirements by 1% (Brown and Dinkel, 1982). Comparing heterosis estimates from experiments crossing inbred lines with heterosis estimates from crossbreeding experiments clearly indicates more heterosis will result from use of multiple breeds (Dickerson, 1973). Use of multiple breeds also allows breeders to capture benefits from complementarity (Cartwright, 1970). In addition, and of particular interest in the developing world, is the opportunity to use locally adapted (low input) maternal breeds and improve characteristics of the harvested progeny by using terminal sires (Scholtz, 1988; Scholtz, et al., 1990b).

Thus, the present objective is to discuss the development of breeding objectives for terminal sires of several breeds. Parallel approaches are applicable in defining objectives for specialized dam lines and general purpose germplasm.

Materials and Methods

A modified version of the simulation model described by MacNeil et al. (1994) was used in these investigations. The model is highly aggregated and reliant on user inputs for the phenotypic characterization of the germplasm used and economic characterization of the production environment. It simulates a production system that is constrained in size by a fixed energetic resource being available for cow-calf production. Owing to the substantial economic benefits that result from exploiting heterosis in beef production, use of crossbreeding is assumed. Phenotypic characterizations of breed resources, originating primarily from the germplasm evaluation and utilization programs conducted by USDA-ARS at Clay Center, NE (Gregory et al., 1991a,b and 1994a,b; Cundiff et al., 2004;) used in this study for traits of economic importance are given in Table 1.

In the U.S. situation, phenotypes for: cow weight, milk production, male and female fertility, calf survival, weaning weight (direct effects), postweaning average daily gain, postweaning feed intake, days fed, dressing percentage, USDA Yield Grade, and marbling score were assumed to determine profitability, in the U.S. situation. Number of calves produced was a function of male fertility, female fertility, and calf survival. Due to a lack of breed characterizations for male fertility, the composite trait pregnancy rate (male fertility x female fertility) was used to set the input for the respective fertility traits with male fertility assumed constant at 98%. Weaning weights were established as a base for the production environment.

The feedlot phase was divided into three periods. The first period (backgrounding) was terminated at a weight-constant endpoint of 386 kg. The second (growing) and third (finishing) periods were of 50 and 100 days duration, respectively. Energy density of rations fed increased with period, as did average daily gain. Feed conversion (feed/gain) decreased with periods. Carcasses are characterized on the tri-variate normal distribution of weight, marbling score, and cutability and their valuation results from price discrimination based on carcass weight, USDA Yield Grade, and USDA Quality Grade (Table 2). All carcasses were assumed to be of A maturity. Variable and fixed costs of cow-calf production were monitored. In the feedlot, fixed costs per day and feed costs were accumulated. Profit was computed as the difference between total carcass value and total cost. For the production systems that are simulated, genes of a terminal sire breed influence progeny that are harvested, but not attributes of producing females. Thus, only the phenotypes for: calf survival, weaning weight, postweaning average daily gain, postweaning feed intake, dressing percentage, USDA Yield Grade, and marbling score contribute to the breeding objective.

Economic values for survival, growth, feed intake, and carcass related phenotypes were calculated by approximating partial derivatives of profit with respect to each of the phenotypes. For each breed, a baseline economic analysis was conducted with breed characterizations given in Table 1 and economic factors affecting carcass value given in Table 2. Then, in separate simulations, the phenotypes for each of the economically relevant traits of the terminal sire breed were changed by one unit. The difference between simulated profit with a phenotype perturbed and profit in the baseline

Table 1. Phenotypic means of traits in the breeding objective for terminal sires for various breeds[1].

Breed	SV	WW(d)	ADG	FI	DP	YG	MS
Angus	94	550	3.43	26.8	63.1	3.5	5.4
Charolais	95	616	3.73	28.2	62.4	2.3	4.7
Hereford	93	552	3.43	25.2	62.1	3.3	5.0
Limousin	94	576	3.41	25.3	65.2	1.9	4.4
Simmental	91	612	3.77	25.9	62.6	2.3	4.8

[1] SV = calf survival, %; WW(d) = direct weaning weight, lbs ADG = average daily gain during finishing period, lbs/d; FI = postweaning feed intake during finishing period, lbs/d; DP = dressing percent, %; YG = USDA yield grade; and MS = marbling score (4.0 = slight^0, 5.0 = small^0, etc.).

simulation was taken to be the relative economic value for that trait. Economic values are expressed both on an enterprise basis and per cow joined. An indication of their magnitude relative to expected genetic variation was provided by multiplying the relative economic values by their respective genetic standard deviations. Genetic correlations (r_A) between objectives were calculated as:

$$r_A = a'_1\mathbf{Q}a_2/\sqrt{(a'_1\mathbf{Q}a_1)(a'_2\mathbf{Q}a_2)} \quad \text{(James 1982)}$$

where, a_1 and a_2 = vectors of relative economic values and **Q** = the genetic variance covariance matrix among traits in the breeding objective (Table 3).

Results and Discussion

Technology for construction of selection indexes has existed for more than 60 years (Hazel, 1943) and has seen substantial adoption in other agricultural industries (see review Hazel et al., 1994) and countries (e.g. Ponzoni and Newman, 1989; Newman et al., 1992). Comprehensive analyses of Dickerson et al (1974) produced the widely recognized index (I) for general purpose use of British breeds in beef production: I = YW – 3.2BW; wherein YW = 365-d weight and BW = birth weight. The efficacy of selection index technology in improving profitability of milk production in the dairy industry was reviewed by VanRaden (2004). Amer et al (1998) proposed three indexes for beef bulls to be used in the U.K. as terminal sires.

The perspective taken here is that of a domestic commercial production unit that utilizes a fixed natural resource base for cow-calf production and markets calves produced based on their carcass merit. A similar farm level approach to derive economic values for dairy production was proposed by Groen (1988). In the present research, two-, three-, and four-year-old cows produce replacement females and male calves are fed out and marketed at

Table 2. Breed-specific factors contributing to price discrimination among beef carcasses ($/cwt).

Angus Base carcass price = $121.00					
Trait	Premiums and Discounts				
Carcass weight	< 550 lbs = -$20.00			> 950 lbs = -$20.00	
Quality	Prime	High Choice	Low Choice	Select	Standard
Grade	$9.00	$5.00	$0.00	-$5.60	-$15.00
Yield Grade	1: $4.00	2: $1.50	3: $0.00	4: -$15.00	5: -$20.00
Charolais Base carcass price = $115.00					
Trait	Premiums and Discounts				
Carcass weight	< 550 lbs = -$19.90			> 950 lbs = -$16.80	
Quality	Prime	High Choice	Low Choice	Select	Standard
Grade	$6.50	$1.30	$0.00	-$6.20	-$17.00
Yield Grade	1: $3.10	2: $2.00	3:- $1.00	4: -$14.50	5: -$19.50
Hereford Base carcass price = $121.00					
Trait	Premiums and Discounts				
Carcass weight	< 550 lbs = -$17.50			> 950 lbs = -$12.75	
Quality	Prime	High Choice	Low Choice	Select	Standard
Grade	$7.25	$3.25	$0.00	-$4.50	-$18.00
Yield Grade	1: $3.00	2: $2.25	3: $0.00	4: -$15.00	5: -$20.00
Limousin Base carcass price = $121.00					
Trait	Premiums and Discounts				
Carcass weight	< 550 lbs = -$20.00			> 950 lbs = -$20.00	
Quality	Prime	High Choice	Low Choice	Select	Standard
Grade	$7.00	$2.50	$0.00	-$10.00	-$20.00
Yield Grade	1: $4.00	2: $2.00	3:- $1.00	4: -$15.00	5: -$20.00
Simmental Base carcass price = $121.00					
Trait	Premiums and Discounts				
Carcass weight	< 550 lbs = -$20.00			> 950 lbs = -$20.00	
Quality	Prime	High Choice	Low Choice	Select	Standard
Grade	$9.00	$4.50	$3.70	-$5.60	-$15.00
Yield Grade	1: $4.00	2: $1.50	3: $0.00	4: -$15.00	5: -$20.00

Table 3. Genetic variances (on diagonal), covariances (above diagonal) and correlations (below diagonal) among phenotypes in the breeding objective (ERT[1]).

ERT	SV	WW(d)	ADG	FI	DP	YG	MS
SV, %	8.74	-16.24	-0.04	0.00	0.00	0.10	0.00
WW(d)	-0.20	755.20	2.68	13.95	7.06	0.69	-4.07
ADG	-0.07	0.50	0.04	0.11	0.02	0.02	0.05
FI	-	0.61	0.70	0.69	0.10	-0.06	0.05
DP	-	0.27	0.10	0.13	0.91	0.04	0.11
YG	0.13	0.09	0.29	-0.25	0.14	0.07	0.08
MS	-	-0.21	0.39	0.08	0.16	0.43	0.50

[1] SV = calf survival, %; WW(d) = direct weaning weight, lbs ADG = average daily gain during finishing period, lbs/d; FI = postweaning feed intake during finishing period, lbs/d; DP = dressing percent, %; YG = USDA yield grade; and MS = marbling score (4.0 = slight^0, 5.0 = small^0, etc.).

harvest. Cows that are five-years-old and older are bred to the terminal sire breed and all progeny of the terminal sire breed are fed out and marketed at harvest. This enterprise is assumed to exist and fixed costs are therefore appropriate. It has also been assumed that additional feed may be purchased to support postweaning growth of market animals. Thus, the perspective here is relevant to seedstock selection for commercial production. It has been argued that total cost be expressed per unit of output and that genetic improvement comes from reducing costs per unit of product value rather than changing output or the value of it (Smith et al., 1986).

Presented in Table 4 are economic values for terminal sires of the various breeds. These results are expressed on an enterprise basis rather than per cow exposed or per progeny produced. Following Henderson (1963), if EPD were produced for these economically relevant traits then the economic values given in Table 4 (or a constant fraction of them) would be the appropriate selection index weights. Extending the breeding objectives, either to include genetic evaluations for indicator traits or eliminate some of the economically relevant traits is straightforward, given appropriate estimates of genetic variances and covariances (Schneeberger et al., 1992). In application rescaling the economic values from an enterprise basis to the basis of per cow exposed has some appeal.

Presented in Table 5 are the products of economic values and genetic standard deviations as indicators of the relative magnitudes of the economic values. On average results in Table 5 indicate relatively uniform emphasis to be placed on breeding values for traits affected in part by terminal sires. In comparison to postweaning feed intake, breeding values for postweaning average daily gain and USDA Yield Grade appear to contribute less to profitability. In comparison, breed-specific relative economic values for carcass weight, carcass conformation score, carcass fat score, gestation length and calving difficulty reported by Amer et al (1998) for terminal sires were 15.0, 7.3, 4.4, 3.2, and 7.8, respectively.

Survival of progeny appears to be an important consideration in selection of terminal sires. Mass selection for survival occurs naturally, particularly in harsh environments (Simm, et al., 1996). However, this result occurs despite the relative low heritability (h^2 = 0.02) of survival assumed in this research and there are reports of the heritability of calf survival being more than 3-fold greater (Cundiff et al., 1986). Even given low heritability, Martinez (1982) found mortality of half-sib progeny groups ranged from 3% to 12% for dairy sires with more than 400 offspring. Thus, prediction of differences in genetic merit among sires may warrant further investigation. Such investigation rests on a foundation of whole-herd reporting (i.e. reporting existence of calves that die at

Table 4. Breed-specific relative economic values for phenotypes in the breeding objective[1].

Breed	SV	WW(d)	ADG	FI	DP	YG	MS
Angus	1096.	130.	8956.	-3546.	2938.	-10149.	4761.
Charolais	733.	145.	5564..	-4074.	3319.	-284.	58.
Hereford	784.	138.	6719.	-2644.	2674.	-5896.	4024.
Limousin	736.	146.	7276.	-2552.	2760.	-2986.	5490.
Simmental	868.	102.	4082.	-2646.	1131.	-4120.	1764.

[1] SV = calf survival, %; WW(d) = direct weaning weight, lbs ADG = average daily gain during finishing period, lbs/d; FI = postweaning feed intake during finishing period, lbs/d; DP = dressing percent, %; YG = USDA yield grade; and MS = marbling score (4.0 = slight^0, 5.0 = small^0, etc.).

Table 5. Products of genetic standard deviations and breed-specific relative economic values for phenotypes in the breeding objective[1].

Breed	SV	WW(d)	ADG	FI	DP	YG	MS
Angus	3239.	3573.	1746.	-2952.	2797.	-2742.	3360.
Charolais	2167.	3985.	1085.	-3391.	3159.	-77.	41.
Hereford	2317.	3792.	1310.	-2201.	2545.	-1593.	2840.
Limousin	2175.	4012.	1418.	-2124.	2627.	-807.	3874.
Simmental	2566.	2803.	796.	-2203.	1077.	-1113.	1245.

[1] SV = calf survival, %; WW(d) = direct weaning weight, lbs ADG = average daily gain during finishing period, lbs/d; FI = postweaning feed intake during finishing period, lbs/d; DP = dressing percent, %; YG = USDA yield grade; and MS = marbling score (4.0 = slight^0, 5.0 = small^0, etc.).

birth in addition to reporting phenotypes of live calves). Lacking direct genetic predictors, current efforts to manage genetic differences in survival rests solely on use of indicator traits.

Feed intake also appears to be important as a component in prediction of differences in profit derived from progeny of terminal sires. Kirschten (2005) presents a review of genetic aspects related to efficient feed utilization elsewhere in these proceedings. Sufficient feed intake allows expression of productive functions and thus its consideration may be seen as the first critical step in evaluating consequences of selection (Emmans and Kyriazakis, 2001).

Presented in Table 6 are genetic correlations among the breeding objectives for terminal sires of various breeds.

For each breed of terminal sire, the environment defined in simulating the breeding objective differed. Economic environments were defined by distinct pricing grids and mating systems differed both in maternal breeds used and the way in which the maternal breeds were used. Despite these differences, most of these genetic correlations among breeding objectives for terminal sires approach 1.0. To the degree that they are less than 1.0 they reflect genotype by environment interaction for the composite trait profitability.

Summary

The breeding objectives presented here point to a need for consistent multiple trait selection. It is argued that commercial production systems provide the framework for these developments. In general, the emphasis given to breeding values for traits in the breeding objective is relatively uniform. Differences between production environments may also influence breeding objectives for terminal sires of various breeds.

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Table 6. Genetic correlations among breeding objectives for terminal sires of various breeds.

Breed	Charolais	Hereford	Limousin	Simmental
Angus	0.74	0.97	0.93	0.89
Charolais		0.80	0.74	0.85
Hereford			0.98	0.87
Limousin				0.80

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Multiple Trait Selection for Maternal Productivity: The Hereford Maternal Productivity Index[1]

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Introduction

Maternal productivity in beef cattle generally refers to measurement of outputs in the beef production enterprise. The primary revenue in the cow-calf segment of the industry is from the sale of weaned calves, but revenue is also derived in the salvage value of cull animals. For a more comprehensive measure of maternal productivity, inputs should also be considered, and as such maternal productivity is a composite trait influenced by several underlying cost components such as fertility, survival, maternal genetic potential, and mature size. Maternal productivity and cow efficiency are therefore complex traits that are difficult to measure, predict, and evaluate.

Cow efficiency and maternal productivity are similar traits. In general, cow efficiency is defined as the ratio of outputs to inputs per breeding female maintained within a given year. Maternal productivity can be characterized as a summation of successive cow efficiency measures with added components such as reproductive ability and longevity. Cow efficiency is simply a subset of maternal productivity without the aspect of time or repeated records. Historically, maternal productivity has been measured as a ratio of outputs (e.g., average weaning weights) divided by a measure of cow weights or feed inputs and adjusted for reproductive performance. Several studies have compared cow efficiency, and to a lesser degree maternal productivity, at the breed or crossbred type level. This has led to numerous publications defining or comparing more efficient cow types and the entire area of matching cow type to the resources available in the production unit.

An important aspect that has received little attention is the amount of variation in maternal productivity within a breed or type. Upon review, one finds clear indication of a large amount of variation within cow types for most of the component traits of maternal productivity. This means two things: 1) that one should expect a large range in maternal productivity within cow type, and 2) there is likely an opportunity to select and further enhance maternal productivity within a breed.

More recent advancements in genetic evaluation methodology provide alternatives for evaluation of traditional ratio-type and composite traits. Examples include EPD for stayability where stayability is defined as the probability that a female will wean some number of calves (i.e., survive into profitable parities) given that she becomes a dam. While genetic evaluations for these traits may be difficult to interpret, they are the forerunners of more user-friendly evaluations. Multiple trait index selection procedures allow for combining genetic evaluation and economic information for the evaluation of composite traits involving several underlying components. Application of these procedures and development of others need to be examined for accurate genetic evaluation of maternal productivity. In addition, genetic associations between maternal productivity and other economically important reproductive, production, and carcass traits are generally unknown. Knowledge of these associations is required before genetic improvement programs for maternal productivity can be implemented (Koots et al., 1994a,b).

The objectives of this report are to summarize the development of a multiple trait maternal productivity index, to describe its implementation with field data, and to summarize the Canadian Hereford Association maternal productivity index (MPI) national cattle evaluation.

Index Development

Experimental Data. Prediction and genetic evaluation of maternal productivity are difficult because properly designed research data is lacking.

[1] The index development discussed here was taken primarily from: Mwansa, P. B., D. H. Crews, Jr., J. W. Wilton, and R. A. Kemp. 2002. Multiple trait selection for maternal productivity in beef cattle. J. Anim. Breed. Gen. 119:391-399. Financial support for this project was provided by the Canadian Hereford Association and the Agriculture and Agri-Food Canada (AAFC) Matching Investment Initiative (MII).

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Table 1. Summary statistics for maternal productivity component traits[a]

Component trait	N	Mean	SD
Birth weight, kg	3,664	36.2	4.7
Weaning weight, kg	3,664	177.4	27.9
Cow weight at weaning, kg[b]	3,609	496.4	63.2
Stayability, %[c]	751	64.7	47.8

[a] From Mwansa et al. (2002) Table 1.
[b] Weight of the cow when her calf was weaned.
[c] Probability that a female will wean three or more calves given she becomes a dam.

Today's cost of collecting such data in a research setting essentially negates any chance of developing such a project. However, Agriculture and Agri-Food Canada (AAFC) has historical data that was utilized to initially develop the MPI, in collaboration with the Canadian Hereford Association (CHA). The AAFC data were collected as part of a long term Hereford selection project conducted at the Onefour Research Substation near Manyberries, Alberta. Data on 3,664 calves born to 186 sires and 886 dams between 1964 and 1985 were available. A description of the experimental herds used for these analyses was given by Bailey et al. (1991).

Traits. Component traits were included in the MPI on the basis of their potential to contribute to high weaning weight with persistent production over a sustained herd life while considering costs. Cow-calf producers derive a majority of their income from the sale of weaned calves, and both direct (WWT) and maternal (MLK) effects on weaning weight were included on this basis. Cow weight (CWT) was included to partially account for annual maintenance costs associated with raising a calf to weaning age, and stayability (STY) was included to account for reproductive consistency. The definition of stayability was derived from and was similar to that of Snelling et al. (1995).

Parameter Estimation. (Co)variance components and genetic parameters were estimated for the component traits with a multivariate animal model that also included direct and maternal birth weight (BWT_d and BWT_m, respectively) using derivative free REML (Boldman et al., 1995). Appropriate contemporary group classifications were fit as fixed effects for all traits. A full maternal animal model including permanent environmental effects was used for weaning weight. In all analyses, at least three sets of covariance starting values were used, along with convergence defined at the point were the variance of the simplex function was less than 10^{-9} to reduce the probability of local maxima solutions.

Economic Weights. The multiple trait model was based on weaning weight of calves, costs associated with the weight of the cow when her calf was weaned and the impact of genetic change in survival. The combined, or aggregate, genetic value (T) to be improved (i.e., selection objective) was then defined as:

$$T = v_1 BV_{WWT} + v_2 BV_{MLK} + v_3 BV_{CWT} + v_4 BV_{STY}$$

where v_i represent net economic values derived independent of changes in the other components. The MPI is then defined as:

$$MPI = v_1 EBV_{WWT} + v_2 EBV_{MLK} + v_3 EBV_{CWT} + v_4 EBV_{STY}$$

where EBV_i represent the estimated breeding values for the component traits from the multiple trait breeding value estimation.

A gross value of \$2.58 kg^{-1} was used for WWT

Table 2. (Co)variance and genetic parameter estimates among maternal productivity components[a]

	BWT_d	BWT_m	WWT	MLK	CWT	STY
h^2	0.48 ± 0.02	0.11 ± 0.04	0.19 ± 0.04	0.18 ± 0.04	0.50 ± 0.07	0.07 ± 0.09
BWT_d	**8.4**	-0.09 ± 0.16	0.74 ± 0.02	-0.34 ± 0.09	0.67 ± 0.02	-0.82 ± 0.30
BWT_m	-0.4	**2.0**	0.09 ± 0.30	0.19 ± 0.27	-0.02 ± 0.27	0.41 ± 0.16
WWT	20.2	1.2	**88.5**	-0.42 ± 0.22	0.85 ± 0.02	-0.52 ± 0.56
MLK	-9.0	2.4	-3.6	**82.2**	-0.17 ± 0.15	-0.01 ± 0.34
CWT	64.7	-1.1	267.3	-52.0	**1120.5**	-0.48 ± 0.44
STY	-24.0	6.0	-50.0	-1.0	-162.0	**113.0**

[a] Genetic variances are on the diagonal in **bold**, genetic covariances are below the diagonal, and genetic correlations (± SE) are above the diagonal. From Mwansa et al. (2002) Table 2. Weights are in kg.

Table 3. Derived economic weights and influence of component traits[a]

Component	Economic value, \$ (v_i)	Genetic SD (σ_g)	Standardized economic weight[b]	Relative emphasis[c]
WWT, kg	2.58	9.40	24.3	0.30
MLK, kg	2.16	9.10	19.7	0.25
CWT, kg	-0.31	33.50	10.4	0.13
STY, %	2.39	10.60	25.3	0.27

[a] From Mwansa et al. (2002) Table 5.

[b] Standardized economic weight, $E_i = v_i \sigma_{g(i)}$.

[c] Relative influence on the index, $E = (E_i / \Sigma_4 E)$.

(Alberta Agriculture, 1989). No reductions were included for the extra maintenance of cows because CWT was included in the model. Similarly, no adjustments were made for decreased fertility that may be associated with increased calf size because stayability, whose main component is fertility, was included in the model. The major contribution to the maternal component of weaning weight was assumed to be milk yield. Results from Miller et al. (1999) for the effect of milk yield on gross margins (accounting for increased feed requirements) indicated that a net economic value of approximately 84% of the gross value for WWT would be appropriate, leading to a value of \$2.16 kg^{-1} for MLK.

The economic weight for CWT was based on the extra feed required by a heavier cow, reduced by the salvage value of that heavier cow. The estimated feed requirement for a 500 kg cow producing 5 kg of milk per day is 12.3 kg d^{-1} (Alberta Agriculture, 1989). This is approximately [(12.3/500) × 100] 2.46% of body weight. The feed associated with a 1 kg change in cow weight was therefore assumed to be 0.0246 kg d^{-1}. On an annual basis, this was (365 × 0.0246) 8.979 kg yr^{-1}. At \$0.07 kg^{-1} (Alberta Agriculture, 1989), the extra feed cost was \$0.63 $(kg\ yr)^{-1}$. The salvage value associated with cow weight was based on an estimated 25% replacement rate and a salvage value of \$1.28 kg^{-1} (Koots and Gibson, 1998). Salvage revenue was then (0.25 × \$1.28) \$0.32 $(kg\ yr)^{-1}$. Net economic value was then equal to (\$0.32 - \$0.63) \$-0.31 $(kg\ yr)^{-1}$.

The definition of stayability used in this study was the probability that a female would have three or more calves given that she became a dam. An equivalence of stayability to fertility was used to derive the relative economic weight of this component. Fertility rates of 81% for 2-yr-old heifers and 90% for 3-year-old cows (Koots and Gibson, 1998) resulted in the probability of having a third calf of 0.81 × 0.90 = 0.729. Increasing fertility by 1% gives a probability of 0.82 × 0.91, which is an increase in stayability of 1.72% resulting from the 1% increase in fertility. The value of a unit increase in stayability was then estimated as 1.72 times that of one unit increase in fertility. Koots and Gibson (1998), using an economic model which also included cow weight, milk yield and growth rate, estimated a value for cow value of \$14.72 per genetic SD. This economic value was assumed to be equivalent to \$14.72 × 1.72 = \$25.30 per genetic SD of stayability. With the estimated genetic SD reported later in this study, the economic value for stayability was then (\$25.30 / 10.6) \$2.39%$^{-1}$.

Combining EBV and corresponding economic values for each of the component traits into a linear function gives the index:

$$MPI = 2.58\ EBV_{WWT(kg)} + 2.16\ EBV_{MLK(kg)} - 0.31\ EBV_{CWT(kg)} + 2.39\ EBV_{STY(\%)}$$

MPI Characteristics. The MPI was constructed as a weighted linear combination of multiple trait EBV. There was a range from -96 to +89 for animals in the experimental data set. The actual and standardized weights for the EBV are given in Table 3, along with the relative emphasis placed on individual component traits. From parameters and economic weights estimated for the experimental data, the MPI places 30% relative emphasis on WWT, 25% on MLK, 13% on CWT, and 27% on STY. The number of traits considered here and the limit on the scope of the selection program to the production of a weaned calf make comparisons with other studies considering carcass traits (e.g., MacNeil et al., 1994 and Koots and Gibson, 1998) difficult.

Table 4. Summary statistics for field data components of the MPI (n = 487,565[a])

Component[b]	Mean	Minimum	Maximum	Phenotypic SD
BWT, lb	90.25	45	150	11.46
WT205, lb	553.40	162	1082	96.95
CWT, lb	1468.95	772	2120	269.74
STY, %[c]	62.60	0	100	44.45

[a] Total animals in the evaluation. Maximum numbers of animals with records = 256,668.

[b] BWT = birth weight (lb), WT205 = adjusted 205-d weaning weight (lb), CWT = weight of cow at weaning of her calf (lb), STY = stayability = probability that a female will wean three or more calves given that she became a dam (%).

[c] Stayability was adjusted in the case of 2- and 3-year old females to account for their not having had the opportunity to produce three calves. Stayability raw score was multiplied by 100 (%) for the purposes of this table.

MacNeil et al. (1984) found relative economic values that were higher for female fertility than for direct or maternal weaning weights when considering weaning weight as the market endpoint. Cow weight had a negative economic value in that study and the relative value was approximately half that of direct and maternal weaning weights, similar to this study.

Genetic Trend in Components Due to MPI Selection. All component traits in the index would be expected to show positive (i.e., increasing) genetic trend due to sire selection on the MPI. Expected genetic changes are a function of the magnitude and sign of the genetic correlation among the component traits in the index as well as the economic values. The expected genetic change in CWT with simulation (Mwansa et al., 2002) was approximately 24% of the genetic SD, while expected change in WWT was approximately 44%. This comparison shows that although MPI selection would be expected to increase CWT, the magnitude of that change would be moderated relative to increases in growth potential. The extent of change in CWT as a result of the positive genetic correlation with WWT was reduced but not removed by the negative economic weight on CWT.

Simulation of several selection scenarios (Mwansa et al., 2002) was used to quantify expected genetic trend by varying the accuracy of the MPI due to differences in information density. Simulation demonstrated that without sufficient grandprogeny data, little genetic change would be expected in MLK. With more data from grandprogeny, comparable increases in both WWT and MLK would be expected. The simulation(s) indicated that, obviously, appropriate family structures are needed to achieve genetic change in relationship to the relative economic values. The accuracy of the index is reduced significantly with reduced information on grandprogeny. The MPI as described can be implemented flexibly, with economic values changed in computations of index values as economic scenarios change. The assumption of linearity is probably reasonable, as long as economic values are periodically updated. Based on the development of the MPI, the Canadian Hereford Association recommended that pilot and release runs be conducted, evaluated, and released. The remainder of this report is focused on the second release run of the CHA maternal productivity index national cattle evaluation.

The 2003 CHA MPI National Cattle Evaluation

Field Data Considerations. Unlike experimental data from genetic resource herds, national cattle evaluation using field data requires unique consideration of the bias that is often inherent to breed association field data. Data up to January 1, 2003 was used for the most recent MPI evaluation. The Canadian Hereford Association maintains performance and pedigree data in the Total Herd Evaluation (THE) database (www.hereford.ca) which was provided to implement the release run.

Prior to analysis, birth and weaning weights were adjusted for age of dam and (for weaning weight), age at measurement (BIF, 2002). Contemporary groups were formed on the basis of subclasses defined similarly to those used for the Hereford North American Cattle Evaluation (NACE). Contemporary groups for all traits were restricted to have at least 2 records on animals from different sires, as well as other restrictions generally utilized in national cattle evaluation procedures (e.g., BIF, 2002). The component trait models genetic parameters from the study by Mwansa et al. (2002) were assumed constant for the CHA field data, although phenotypic variances appropriate to the CHA field database were re-estimated. Table 4 summarizes the 2003 MPI evaluation relative to the component traits.

Table 5. Summary of MPI component trait EPD (n = 487,565)

Component	Mean	Minimum	Maximum
WWT, lb	2.07	-36.97	54.19
MLK, lb	2.00	-32.24	34.04
CWT, lb	1.24	-104.05	108.09
STY, %	0.27	-11.11	9.53

The usual multiple trait Best Linear Unbiased Prediction (BLUP) procedures were used to compute breeding values (EBV) for the component traits which were then assembled into the MPI as previously described:

$$MPI = 1.17\ EBV_{WWT(lb)} + 0.98\ EBV_{MLK(lb)} - 0.14\ EBV_{CWT(lb)} + 2.39\ EBV_{STY(\%)}$$

where the economic values for the component traits were adjusted for application to WWT, MLK and CWT EBV which were measured and computed in pounds instead of kilograms. Because STY was a probability (range 0 to 1.00), no adjustment was made to the economic value compared to the study by Mwansa et al. (2002).

Component Trait EPD. Although breeding values are used to calculate the MPI, Table 5 summarizes EPD for the component traits. These EPD are comparable to those published as part of the 2003 Hereford NACE, except that the MPI run did not include data from American Hereford Association except for those across-country registered animals with data in Canada. It is important to note that the MPI is a within-country national cattle evaluation at present, but an international MPI evaluation is certainly possible.

Mean EPD in the evaluation are not forced to sum to or average zero, so variability exists with respect to the central tendency of genetic values. The actual MPI values released to the CHA membership (www.hereford.ca) were computed using WWT and MLK breeding values from the Hereford NACE, so some discrepancies are expected between these results and those released.

Maternal Productivity Index and Maternal Productivity Ratio. The MPI computed as described above reflects expected revenue differences among animals in the evaluation. Mwansa et al. (2002) reported a range of -\$96 to +\$89 for animals in the developmental AAFC data set. As shown in Table 6, the range in raw MPI values in the CHA field database was -\$96.10 to +\$119.16, with an average MPI of +\$9.70. At the request of CHA, an MPI ratio was developed to force the average and standard deviation of annual MPI values to be constant at 100 and 25, respectively. Therefore, the maternal productivity ratio (MPR) was defined as:

$$MPR = 100 + (MPI_i - \hat{\mu}_{MPI})\left[\frac{25}{\sigma_{MPI}}\right]$$

where MPI_i is the raw MPI value for animal i, $\hat{\mu}_{MPI}$ is the raw MPI mean (9.70 in the 2003 evaluation), and σ_{MPI} is the raw MPI standard deviation (19.07 in the 2003 evaluation). This computation forces the MPR to have a mean of 100 and a variance of 625 in each evaluation year. Response to reporting MPI and MPR values by CHA has been positive.

Comparison of High Versus Low MPI Groups

Given the breeding objective of the MPI to increase the genetic potential of Herefords to consistently wean heavy calves over a sustained productive life while maintaining input costs, it was of interest to compare the MPI and its component traits between groups with high versus low values with respect to the index (Crews, 2002). The comparisons reported here are based on a pilot MPI evaluation provided to CHA prior to the release of the full 2003 run. The pilot run was based on a slightly different set of animals, which can be considered a subset of the population described above for the 2003 MPI evaluation.

Grouping and Analysis Method. Two MPI groups were defined, where animals with MPI more than two standard deviations above the overall mean (4.48) were classified into the high group (n = 17,328) Animals with MPI more than two standard deviations below the mean were classified into the low group (n = 11,496). Component trait EPD were compared between the groups by expressing within-group mean, minimum,

Table 6. Summary statistics for the raw MPI and MPI ratio (MPR) from the 2003 CHA evaluation

Index	Mean	Minimum	Maximum	SD
MPI	9.70	-96.09	119.16	19.07
MPR	100.00	-38.56	243.37	25.00

and maximum EPD as deviations from the overall mean in standard deviation units to remove scale effects (Crews, 2002)

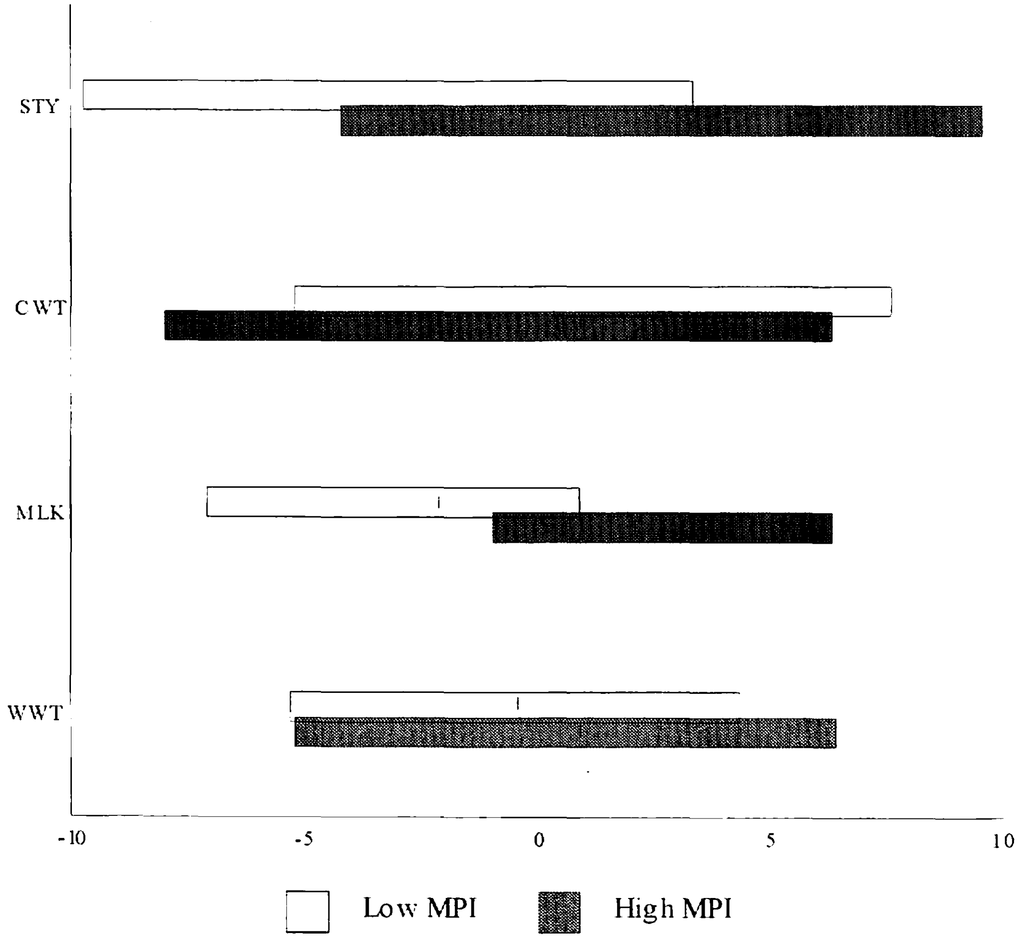
Table 7. Summary c

Trait	Low MPI group (n = 11,496)			High MPI group (n = 17,328)		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
WWT, kg	-1.65	-40.63	35.39	9.12	-39.95	52.21
MLK, kg	-11.32	-37.13	4.51	11.05	-4.98	32.71
CWT, kg	-4.79	-78.08	120.39	17.49	-122.01	101.52
STY, %	-1.83	-15.17	5.02	1.49	-6.63	14.56
MPI, $	-43.81	-127.86	35.00	55.13	44.00	148.69

Table 7 contains a summary of EPD for the component traits of the MPI by group. The ranges and SD of components reflected the phenotypic range and genetic parameters used in the multiple trait evaluation model described previously. Therefore, for example, STY EPD were closer to and more closely distributed around zero than EPD for CWT, which had a higher phenotypic mean, variance, and heritability.

Within the high MPI group, mean component EPD were positive, although the minimum and maximum EPD reflect that animals with both negative and positive EPD were represented in the group. Further, the mean component trait EPD in the low MPI group were uniformly negative. Again, however, the range

Figure 1. Comparison of mean and range of component trait EPD between high and low MPI groups. Standardized range and mean EPD are expressed in standard deviation units for direct (WWT) and maternal (MLK) weaning weight, cow weight (CWT), and stayability (STY).



included both negative and positive EPD. This would be expected because the weights assigned to individual traits were not of the same sign or magnitude. These results suggest that no individual component trait was equivalent to the MPI, and that increasing selection for the MPI would result in selected animals with a wide range of component EPD.

To further compare the groups, scale effects were removed be expressing the mean, minimum and maximum within-group component trait EPD as differences from the overall mean component EPD in standard deviation units (Figure 1).

The difference in standardized means was 1.34, 4.29, 1.39, and 2.14 SD for WWT, MLK, CWT, and STY, respectively. The ranges in standardized EPD, equivalent to the difference between maximum and minimum standardized EPD, were 11.47, 7.24, 14.25, and 13.68 SD for WWT, MLK, CWT, and STY, respectively in the high MPI group. The standardized ranges for the low MPI group were 9.50, 8.00, 12.65, and 13.03 SD for WWT, MLK, CWT, and STY, respectively. These results indicate that from 8 to more than 14 SD of variation existed for the component traits. However, the standardized ranges in component traits were similar between the groups. As shown in Figure 1, 82% of the range in WWT EPD included animals that were assigned to the high and low MPI groups. This overlap in standardized range indicates that direct weaning weight did not effectively separate animals designated as high versus low relative to the index. Similar results were noted for CWT, where 74% of the range in CWT EPD included EPD within the ranges of the low and high groups. Further, there was 39 and 14% overlap in group ranges for STY and MLK EPD, respectively. Therefore, differences in MLK and STY EPD tended to more closely correspond to differences in the MPI compared to the other component traits (WWT and CWT). However, none of the component traits provided animal rankings equivalent to those based on the MPI, which reflects the multiple trait nature of this index. Validation of the MPI with an economic comparison of animals in low versus high MPI groups has yet to be completed.

Conclusions and Implications

A maternal productivity index was developed with the breeding objective to increase the genetic potential of beef cattle to consistently wean heavy calves over a sustained productive life while maintaining input costs. Selection for maternal productivity in beef cattle using the MPI, which incorporates EBV for direct and maternal weaning weight, cow weight, and survival weighted by their independent economic values, would be expected to result in positive genetic change for all component traits. This index would be of general use in varying production environments using economic weights reflecting those particular environments. Genetic values for the component traits varied widely and similarly among animals with different index values, which appeared to be more closely related to genetic differences in maternal weaning weight and stayability than in preweaning growth or cow weight. Results suggest that selection for the MPI would not be equivalent to selection for any of the component traits alone. The components of the MPI were specifically chosen on the basis of ease of implementation for national cattle evaluation and their association with the overall breeding objective, although it has been noted that cow weight is the component phenotype with the most sparse information in field data. Questions still need to be addressed related to adjustment of stayability for length of productive life such that young and older cows are not assigned biased records due to age, and accounting for the repeated records possible with cow weight.

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An Example from the Dairy Industry: The Net Merit Index

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Introduction

Dairy cows produce a lot of milk, but a more important goal of those who milk cows is to make a profit. Selection goals in the dairy industry focus as much on reducing expenses as on increasing income. In the last decade, several important traits have been added to routine genetic evaluations and selection indexes. Dairy cattle breeders now select for longevity, mastitis resistance, fertility, and calving ease in addition to conformation and production.

Because of U.S. exports of dairy semen and embryos and effective progeny-test programs overseas, foreign cattle have become more competitive with U.S. dairy breeds. Today dairy breeders can choose from the best bulls in the world ranked on their combined economic value for the many traits included in the Net Merit index (**NM$**).

Net Merit

Breeders select for traits that can be easily measured, evaluated, and marketed. Until recently, dairy breeders selected mainly for milk and fat production and for various conformation traits that are favored by judges and classifiers. In the late 1970's, dairy breeders also began measuring and selecting for protein production. However, most milk processors did not pay for protein until recently, and grocery stores still label only differences in the fat content and not in the protein content of milk. Jersey breeders successfully lobbied for changes in milk marketing laws to reward higher protein production both within and across breeds.

The first economic index that was introduced by the USDA in 1971 estimated gross income per lactation based on genetic merit for milk and fat yields (Norman and Dickinson, 1971). That index was updated to include genetic merit for protein yield in 1977 (Norman et al., 1979), and an economic index that reflected milk pricing based on cheese yield was introduced in 1984 (Norman, 1986). In 1994, productive life and somatic cell score (**SCS**) were combined with yield traits into NM$ based on economic values that included direct and indirect measures of expense as well as income. In 1999, merit indexes based on cheese and fluid milk pricing were introduced (VanRaden, 2004). The net, cheese, and fluid merit indexes were revised in 2000 to include linear conformation composites (Holstein Association USA, 2005) based on a lifetime (rather than lactation) profit function (VanRaden, 2000). In August 2003, calving ease and daughter pregnancy rate were added to the merit indexes (VanRaden and Seykora, 2003).

Traits

A total of 27 traits are currently measured and evaluated for genetic merit of U.S. dairy animals. Those evaluations represent the genetic merit that an animal is predicted to be able to transmit to its future offspring (predicted transmitting ability) rather than the animal's own genetic merit (breeding value); predicted transmitting ability is equivalent to the expected progeny difference reported for beef cattle. Health, fertility, and longevity evaluations now are widely accepted by dairy breeders in addition to yield and conformation traits.

Lactation yields for milk and fat have been evaluated since 1936 (Kendrick, 1936), and genetic evaluations for protein yield began in 1977 (Norman et al., 1979). Evaluations of component percentages also are released as ratios of fat and protein to milk yield. Testing and sampling from one milking per month is common, and SCS is obtained from almost every sample. Less frequent sampling of components and daily recording of milk by electronic meters are helping to reduce costs on many larger farms. The national cost of collecting production data is about $50 million per year.

Conformation (type) traits are scored visually. Udder traits include udder depth, udder cleft, fore udder attachment, rear udder height, rear udder width, teat placement, and teat length, which are combined into an udder composite. A foot-and-leg composite includes foot angle, mobility, and rear leg angles (side and rear views). A size composite includes stature, strength, body depth, and rump width. No actual body weights are taken or estimated by classifiers, but formulas to predict cow weights from conformation traits were obtained research herd data (VanRaden and Seykora, 2003). Traits final score, rump angle, and dairy form are not used in NM$, but Holstein Association's TPI index includes final score and also selects against dairy form to prevent cows from becoming too thin.

Genetic improvement of dairy cattle for resistance to mastitis, the most costly health problem of dairy cows (Shanks et al., 1982), is possible through selection for fewer somatic cells in milk (Shook and Schutz, 1994). Somatic cell counts, which are recorded through Dairy Herd Improvement testing, are transformed into sample-day log2 SCS, and those scores are used to calculate USDA genetic evaluations for mastitis resistance (Schutz, 1994). Higher evaluations for SCS indicate more mastitis and lower quality payments.

Calving ease (dystocia) of dairy cattle is scored on a scale of 1 (no problem or unobserved) to 5 (extreme difficulty). Because each unit increase in score does not represent the same increase in difficulty, USDA uses a threshold model for genetic evaluations (Van Tassell et al., 2003). Genetic merit for calving ease is reported as the estimated percentage of births that are difficult (calving ease scores of 4 or more) for first-calf heifers. Both service sire and daughter evaluations are released for bulls.

Pregnancy rate measures the percentage of nonpregnant cows that become pregnant for each 21-day opportunity period (each heat cycle). Genetic evaluations for daughter pregnancy rate (cow fertility) are based on days open and indicate the ability of a bull's daughters to cycle, express estrus, conceive, and retain the pregnancy (VanRaden et al., 2004). Genetic rankings for bull fertility (e.g., conception rate) are available from regional data, and much of the research to provide national rankings has been completed (Clay and McDaniel, 2001, Kuhn et al., 2004, Weigel, 2004).

Evaluations of productive life, USDA's measure of longevity for dairy cattle, are based on direct observations of length of productive life and also correlated traits (yield, conformation, SCS, calving ease, and pregnancy rate) measured earlier in life (VanRaden and Wiggans, 1995; VanRaden and Wiggans, 2003). Replacement costs decrease as longevity increases, and cows with high productive life also are healthier (Rogers et al., 1999). The initial emphasis on productive life decreased slightly in 2000 and in 2003 when more of the individual traits that contribute to longevity were added to the merit indexes (VanRaden et al., 2003).

Most artificial-insemination companies also evaluate milking speed and temperament from their own data, but those traits are not available for national selection.

Economic Values

Past selection has focused on gross income instead of profit because prices of income traits are easier to obtain than costs of expense traits. Often, only correlated traits such as cow size are available instead of actual expense traits such as feed consumption. Selection indexes should consider not only the direct values of the measured traits but also correlations of measured traits with any unmeasured expenses or incomes.

Economic values can be obtained as averages of literature estimates if the index includes only a few traits. Economic values of existing traits change as more traits are included, and literature values are less useful because no two studies may include exactly the same set of traits. A profit function is needed then to obtain the value of each trait when many traits are included in the index. NM$ in 1994 used an average of literature estimates for the 5 traits included, but a profit function was used beginning in 2000, when 8 traits were included (VanRaden, 2000).

The percentage of emphasis that is placed on various traits allows for convenient comparisons among selection indexes. A trait's economic value is multiplied by its genetic standard deviation and then is divided by the sum of such products across all traits to give the fraction of total emphasis. Table 1 compares the selection emphasis for traits that are included in NM$ with that for traits in the official indexes of many other countries. Protein and fat yields get about half of the total selection emphasis in most indexes.

Milk component prices differ widely depending on milk use. NM$ includes average expected U.S. prices, but the fluid merit and cheese merit indexes are alternatives for farmers who receive higher incentives for the water or protein content of milk, respectively. Until 1998, the average price from the previous year was used for yield traits in USDA selection indexes for dairy cattle. Since then, future prices are forecast, but this process is not very accurate. Feed costs per pound of protein produced are assumed to be higher than feed costs per pound of fat produced, but this assumption is based only on limited research and on phenotypic rather than genetic correlations. Milk with low somatic cell count now receives price premiums paid by milk processors that often exceed the direct farm expenses from treating mastitis.

Conformation traits may not have direct economic value but are more easily measured and have higher heritability than most direct expense traits. Cows with deep udders require more time and labor to milk. Cows with poor feet and legs do not survive long on concrete flooring. Large cows have more beef income including their own salvage value and heavier calves produced but are less profitable because of the high cost of raising and maintaining the additional cow weight. More research is needed to quantify these expenses.

Cow fertility has a large correlation with productive life and is preferred in selection because data arrive sooner. Longevity and fertility currently receive 11% and 7%, respectively, of total selection emphasis in NM$. Calving ease as a trait of the service sire has been evaluated for Holsteins since 1978 but was not included in NM$ until 2003 when daughter calving ease (the effect of the maternal grandsire) was also added. The two calving ease traits each receive 2% of total selection emphasis in NM$. Several other countries have genetic evaluations for stillbirth and also include this trait in their selection indexes.

Global Selection

The one-way transfer of genetic material from North America to the rest of the world has become a two-way exchange. During the last 15 years, about 400,000 cows with U.S. yield records had foreign sires. Most of those sires were Canadian, but 44,000 cows had sires from The Netherlands and 10,000 had sires from France. Other countries that had sires with more than 1,000 U.S. daughters included New Zealand, Italy, Germany, and Denmark. Currently, 6 of the top 10 sires of progeny-tested sons are foreign, which shows the importance of global selection.

Bull rankings differ by country because international evaluations account for genotype by country interactions and because countries may emphasize different traits. National genetic evaluation methods and selection indexes are documented on national evaluation center web sites and by Interbull (International Bull Evaluation Service, 2004) Centre in Uppsala, Sweden. National selection indexes are updated quite frequently and have become more similar over time. Most countries have decreased their selection on yield traits and increased their selection for health and fertility traits during the last five years.

Table 1. Relative emphasis on traits in national selection indexes for Holstein populations.

Trait	Country (Index)												
	Australia (APR)	Canada (LPI)	Denmark (S-I)	France (ISU)	Germany (RZG)	Italy (PFT)	Japan (NTP)	Netherlands (DPS)	New Zealand (BW)	Spain (ICO)	Sweden (TMI)	United Kingdom (PLI)	United States (NM$)
Protein	36	31	21	35	36	42	55	32	34	32	21	41	33
Fat	12	20	10	10	9	12	20	7	13	12	4	18	22
Milk	−19		−3					−12	−17	12	−4	−18	
Protein (%)		2		2	4	3				3			
Fat (%)		1		2	1	2							
Longevity	9	7	8	13	25	8		8	8	3	6	17	11
Udder health (somatic cell score)	5	3	14	13	5	10		14		3	12	4	9
Fertility	8	5	9	13	1			10	10		10		7
Other diseases			2								3		
Udder conformation		16	9	8	6	13	21			16	12		7
Feet and legs (mobility)		11	5	1	4	6	4	5		10	9	3	4
Size	−4	4	2	2	2			−5	−18				−3
Dairy character					2								
Rump				1	1								
Final score						4				9			
Calving traits			6		4			7			12		4
Growth (meat)			5								6		
Temperament	4		2								3		
Milking speed	3	<1	6										

Completing the Package

All domestic dairy bulls and cows and all foreign dairy bulls evaluated by Interbull receive an evaluation for each trait in NM$. The same index is applied to young stock, males, females, and foreign males. If an animal has no data for a particular trait, its parent average is substituted. If parent evaluations are missing, unknown parent group solutions or breed averages are substituted. If a particular country has no data for a particular trait, its population average is assumed to equal the U.S. average. Indexes require an estimate for each trait, and even estimates with zero reliability are released so that breeders do not have to guess what estimate was used in the selection index.

NM$ is computed for 18 million U.S. cows and 110,000 bulls from 25 countries. Interbull and U.S. evaluations for dairy cattle are computed 4 times per year in February, May, August, and November. Most other countries have adopted the same schedule. Timing has been greatly improved so that only 3 weeks are required between data cutoff and delivery of worldwide results. Interbull provides evaluations for all traits in NM$ except cow fertility, and research on that trait is underway. Computer calculation of indexes is much better than hoping that cow and bull owners will take the time to combine all of the information correctly on their own.

Reliability (accuracy) of evaluations for dairy cattle is defined as the squared correlation of true and estimated breeding values. This statistic is less pessimistic than accuracy as defined in beef breeding: 1 minus the square root of the variation in prediction error divided by the additive genetic variation (Beef Improvement Federation, 2005). Both measures of accuracy are less optimistic than the original and better definition of accuracy: correlation of actual and estimated breeding values, which predicts future progress toward the goal. Reliability is provided for each trait and for NM$, along with the parent average, reliability of parent average, and daughter deviations for each trait so that breeders can see how the information from different relatives is combined in the animal model.

Traits with low heritability were once ignored but now are included in selection because some have coefficients of variation (standard deviation divided by trait average) larger than those for traditional traits. Breeders will select for traits that they are convinced have economic value and are evaluated accurately. Some traits have different values to different breeders, but an index based on average expected prices provides a reasonable goal and a useful ranking for the population. Professional researchers should be able to combine traits and to estimate economic values more accurately than individual breeders can in their spare time.

Computer mating programs that avoid inbreeding, protect against mating recessive defect carriers, match strong with weak traits, and assign the easiest calving bulls to heifers are used by about one third of dairy breeders. These programs also allow customized bull selection to meet each breeder's goals. Bourdon (1998) proposed similar flexible selection strategies for beef breeders. Flexibility is useful in free markets, but an official ranking helps breeders promote and locate superior stock, and a national goal gives breeders direction.

Conclusions

Breeders prefer complete and uniform information on a variety of traits along with an overall index of economic value. Dairy breeders can select on the USDA's NM$, breed association selection indexes, or custom indexes of their own creation. Goals have become more similar across breeds and across countries. Traits with lower heritability now receive much more emphasis but also require larger investment in progeny testing. Dairy cattle breeders depend on calculated genetic rankings because most traits of interest are sex limited and cannot be measured for bulls. Dairy cattle selection is a global industry with annual semen sales of nearly $1 billion from the best few thousand bulls worldwide. Breeders can quickly select the best bulls for overall economic return by using NM$.

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Multibreed Genetic Evaluations of Beef Cattle

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INTRODUCTION

Interest in crossbreeding in commercial cattle herds in the latter half of the 20th century sparked a flurry of experiments characterizing breeds and breed crosses for additive and nonadditive gene effects. Analytical models for estimation of these effects naturally followed. A logical extension was to apply the methodology to estimation of genetic merit from records in populations representing multiple breeds, and this area of research has received increased interest as composite and other crossbred animals are finding their way into commercial herds as seedstock. This presentation will be a discussion of the models for multiple breed genetic evaluations and on experiences gained in the application of these models to beef cattle evaluations in the U.S. It will conclude with a description of the plan for expanding multiple breed evaluations being proposed by the National Beef Cattle Evaluation Consortium (NBCEC).

MODELING

The genesis of models to analyze data from crossbreeding experiments in livestock species, not surprisingly, can be found in the analysis of line-cross data in plants. Gardner and Eberhart (1966) described analysis of diallel crosses assuming diploid inheritance, two alleles per locus, and no epistasis. Robison *et al.* (1981) extended the model for use in analysis of crossbred dairy data. Their model has the following features:

- Observations are linear combinations of breed additive (both direct and maternal) effects and breed combinations (heterosis for direct, paternal, and maternal effects).
- Breed effects are regressed by the fraction of genes represented in an individual for that breed, with genes originating from the sire or the dam delineated separately.
- Maternal breed effects are included and regressed by fraction of genes in the dam representing each breed.
- Heterosis effects for the direct (maternal) expression of a trait due to dominance are regressed by the percentage of loci in the individual (dam) with alleles from different breeds.

These authors noted that a model containing breed-composition groups could be used (that is, a separate group effect for each percent combination of breeds). These early models were devised with interest primarily in the estimation of genetic difference in strains (or breeds) and interactions between them (heterosis).

Paralleling investigations of multibreed analysis of data was research on grouping strategies in linear models for genetic evaluations. Models with group effects had been used in the earliest dairy sire evaluation procedures. In these early models, animals were assumed unrelated. There was renewed interest in research into grouping strategies when relationships were incorporated into the genetic evaluation models. Thompson (1979) described the concept of accumulated group effects in a sire model. His model incorporated ancestral group information by exploiting the structure of the numerator relationship matrix. Westell (1984, 1988) and Robinson (1986) independently extended this concept to an animal model. In addition, Westell (1984) used modified mixed model equations such that solutions of animal equations are genetic evaluations (combining the fixed group effects and random genetic components using the QP transformation [Quaas and Pollak 1981; Quaas 1988]). These studies were motivated by problems in evaluation of dairy cattle, but the results are general and provide an excellent mechanism to incorporate breed effects into a multibreed model.

Arnold *et al.* (1992) formulated the multibreed evaluation approach for a single-trait animal model. Using modified mixed model equations (QP transformed), they proposed the following model:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Zu} + \mathbf{Wh} + \mathbf{e},$$

where $\mathbf{y}$ is the vector of observation, $\boldsymbol{\beta}$ is a vector of fixed effects (typical of genetic evaluation problems, e.g. contemporary groups), $\mathbf{u}$ is a vector of breeding values, $\mathbf{h}$ is a vector of total nonadditive effects, and $\mathbf{e}$ is a vector of random residuals. $\mathbf{X}$, $\mathbf{Z}$, $\mathbf{W}$ are matrices relating effects to observations. The vector $\mathbf{u}$ represented in the modified equation is $\mathbf{Qg} + \mathbf{a}$, where $\mathbf{g}$ is the vector of breed additive effects (group effects), $\mathbf{a}$ is the vector of random additive genetic effects, and $\mathbf{Q}$ is the matrix relating fractions of breeds represented in individuals to the breed group effects. Further, $\mathbf{h}$ is modeled as $\mathbf{h} = \mathbf{Sd} + \mathbf{T}\boldsymbol{\delta}$, where $\mathbf{d}$ is a vector of fixed heterosis effects (sire breed × dam breed), and δ is a vector of random heterosis effects (e.g., sire × breed of dam). They considered predicting the random heterosis component, δ, to be "problematic" and suggested that "initial applications of this model to existing cattle populations will most likely operate under the assumption that a fixed component of heterosis is sufficient." This model is the foundation of the current multibreed evaluations systems in the U.S.

APPLICATIONS

Experimental results. An application of multibreed models is Rodriguez-Almeida *et al.* (1997). A simplified version of the Arnold model was fit for birth and weaning weights with direct and maternal effects for both traits. Of particular interest in this study was the ability of the procedure to separate effects in the model. Two data set were used:

1. Data set 1: Observations were from the base breeds and crosses used to create three composite breeds, MARC I, II, and III.
2. Data set 2: Data set 1 plus experimental data in which appropriate crosses and other matings provided better structure for estimation of effects in a multibreed analysis.

The results were sobering. Marked differences in estimates of direct and maternal breed effects were obtained from each data set. Results from MARC II for weaning weight are shown in the following adaptation of results in Rodriguez-Almeida *et al.* (1997):

	Data set 1 (MARC II)			Data set 2 (MARC II)		
Breed	Direct	Maternal	Sum	Direct	Maternal	Sum
Hereford	-4.7	-12.2	-16.9	0.9	-13.7	-12.8
Simmental	-42.2	94.6	52.4	29.8	26.0	55.8
Gelbvieh	-46.2	100.7	54.5	37.0	17.2	54.2

The authors pointed out that the sum of the direct and maternal estimates from both analyses were very similar while the components differed dramatically. This suggested that partitioning components in ill-designed data could be problematic. Data set 1 represents the nature and structure of data from the field. The authors concluded incorporation of experimental data into field data analysis, by some mechanism, is required to achieve satisfactory estimates of effects in multibreed models.

Multibreed model for national cattle evaluation: In the fall of 1997, the American (ASA) and Canadian Simmental Associations (CSA) published weight trait evaluations obtained from a joint analysis of three data sets that were previously analyzed separately. These populations were U.S. and Canadian Simmentals and U.S. Simbrahs. Because all three data sets included crossbred animals, a multibreed approach was used (Klei and Quaas 1995). This multitrait model for birth, weaning weight, and postweaning gain has the following features:

1. Contemporary groups contain animals of different breed compositions.
2. Additive breed differences are accounted for by regression on breed of founder × year groups.
3. Heterosis effects are accounted for assuming the expected heterosis is a result of the full heterosis between two breeds multiplied by the fraction of loci expected to contain one allele from each breed.
4. Heterogeneous variances by percent Simmental are used [Garrick *et al.* (1989)].
5. Age of dam effects are modeled with a 4^{th} order polynomial (Bertrand *et al.*, 1994). Weighted averages of breed age curves are used for crossbred dams.
6. A nonlinear 205-day age of calf adjustments is used.

Bayesian procedures were used for both breed additive genetic effects and heterosis effects. Information from literature were used as prior means. Prior variances were chosen so that neither priors nor data dominate solutions, except for heterosis where variances were chosen such that most weight was on the priors.

EXPERIENCES IN APPLICATION

Application of models like that implemented by Cornell for the national evaluation of data from ASA and CSA provides valuable experiences, and lessons learned from this application will be discussed.

Combining breeds for breed, age of dam, and heterosis effects. The Simmental data set has animals representing over 60 breeds but is dominated by four breeds: Simmental, Hereford (foundation cows in early years), Angus (sires used on Simmental heifers in later years) and Brahman (through contributions to Simbrah). For these breeds, plus other well represented breeds (Charolais, Gelbvieh and Limousin), breed effects were fit by year. Breeds with limited information were combined into one of four categories: American, British, continental, dairy, plus two "catchall" groups, U.S. and Canadian. Ages of dam effects were fit for categories. For heterosis, the effects were for combinations of any breed represented in the following categories: British, Continental, Zebu, and other. Thus, for a Hereford-Angus calf, heterosis would be for British×British; for a Simmental-Angus, the continental×British value would be used, etc.

Autoregressive prior for year within breed effects. Breed (or breed grouping) of founder×year effects were included. A Bayesian approach was used to overcome the problem of little information for some subclasses. The prior's means for a breed were constant over years but were not assumed independent. An autoregressive covariance structure with a large between-year correlation (.95) was assumed. This effectively eliminated large year-to-year fluctuations but allowed the founder effects to change over time without specifying a functional form for that change. It also allowed estimation of a founder-year effect that has not yet been expressed, e.g. maternal founder effects for the current calf crop.

Founder effects. In articles discussing breed effects obtained from multibreed analysis, the effects were interpreted as the mean of a population defined by a "breed." For the Simmental data sets, we questioned whether this was a fair interpretation. Producers providing data on individuals with nonSimmental genes were either "grading up," producing crossbred animals for sale as seedstock, or creating composites. The "founders" coming from these breeds were not a representative sample of animals from that breed. Breed-year effects were not viewed as estimates that could be used to make statements about true breed differences, and we referred to them as founder effects; e.g., the trends we saw for various breeds were not necessarily the trends observed in the respective purebred populations.

Gametic versus genetic trends. Genetic trends are usually estimated as average EPDs (or BVs) for calves born by year. In a multibreed evaluation, these can be computed for a particular breed or breed combination. We calculated for each breed (group) a "gametic" trend. Within each year of birth, animals' EPDs were regressed on their breed compositions to partition the yearly average EPD among breed groups. The regression coefficients estimated the genetic merit of genes transmitted from each breed (group) to a year's calves. This trend used information from every animal born in a given year to measure the genes from the different breed of founder groups. Every animal with some fraction of Simmental breeding contributed to the Simmental gametic trend. Likewise, every animal with some fraction of Angus breeding contributed to the Angus gametic trends.

"True" breed fractions versus association designations. Arnold *et al.* (1992) pointed out the importance of correctly identifying breeds represented in individuals as their evaluation will be a function of the breed effects. Breed associations for breeds derived from upgrading or as composites often have rules for the designation of individuals resulting from various matings. The danger exists that the rules lead to incorrect fractions of breeds represented. We recomputed breed fractions from all available pedigree information, which lead us to a problem of explaining evaluations of previously designated purebreds (100% Simmental) that now had fractions of other breed effects in their evaluations. We encountered an example of two bulls designated purebreds under ASA rules. They differed by the fraction of genes representing a second breed. With large numbers of progeny, the additive direct breed group effects had no significant impact on their evaluations. However, the heterosis effects differed when they were mated to purebred Simmental cows and as the number of progeny increased, the full expression of this difference was in the contrast between these bulls. This "change" in the contrast was difficult to explain given the bulls were designated by the association as purebreds.

Bases. In single-breed evaluation systems, the choice of a base usually revolves around which year establishes the base and then forcing solutions of animals born that year to be some constant, typically zero. In a multibreed analysis, base options are expanded, as now breed combinations can be included in the definition of the base. The base can be set by forcing solutions of a group of individuals to sum to zero or, as the ASA chose to do, the sum of the predominate four breeds' gametic values in 1991. A base is, of course, arbitrary and inconsequential to contrasts needed for ranking and selecting animals. However, EPDs are used in merchandising, and therefore, the choice of a base has economic ramifications.

Evaluations of animals from other breeds. The current Simmental multibreed system provided evaluations for animals of other breeds. These evaluations were based only on information in the Simmental data set. The evaluations and contrasts between them differed from official evaluations from their respective breeds. This was precisely the reason the ASA and CSA moved to a joint evaluation. As an example, we were challenged on the accuracy of the multibreed system based on contrasts reported between two prolific Angus bulls. Our initial contrasts between them (based on relatively few progeny) were quite different from the Angus analysis. As we have accumulated information, ours have moved to a reasonable reflection of the Angus evaluations. Providing results for these animals probably would not serve any real purpose. However, they will appear in pedigrees in our data set and so must be listed on official registration forms for those animals. To address this problem, the theoretical framework for incorporating "external EPDs" was developed **(Quaas and Zhang, 2001)** Incorporating external EPDs is a process that uses EPDs and accuracy values obtained in a different evaluation system to supplement the information in the target data set. The need, obviously, does not exist for using external EPDs if the data for those breeds are included in the evaluation. Since the inception of the multibreed analysis, two breeds have added their data sets, Maine Anjou and Chianina.

Current status and future plans of multibreed evaluations: Since the first application of the multibreed model for weight traits in 1997, several other systems have evolved. Cornell/ASA now has a multibreed model for carcass data that includes information from ultrasound measures of breeding animals. The University of Georgia has developed a multibreed system for weight traits.

The NBCEC has recently developed and has begun the implementation of a strategy for expansion of multibreed evaluations. We are currently running a prototype analysis for a greatly expanded number of breeds for weight traits. This involves the development of a national pedigree file, which is being done at Cornell. This file will help maintain the unique identity of animals registered across several breed data sets. We are also developing a national data file for evaluations with each university and breeds providing information on performance. We have begun investigation into expanding the number of traits included in the multibreed system as well to include carcass quality measures and threshold traits such as calving ease, heifer pregnancy, and stayability.

Is an EPD an EPD? ASA has published a single EPD for each animal for each trait under the assumption that an EPD is an EPD. We were hoisted by our own petard of terminology. The EXPECTED PROGENY DIFFERENCE has a very definite meaning, and educational programs have emphasized this meaning. However, the additive values predicted from the multibreed evaluation do not predict progeny differences between prospective parents of different breed composition. We are on safer ground when the comparison is between two individuals of the same breed bred to similar mates, assuming the absence of individual nonadditive differences. How will we deal with this in the future?

Colorado State University has taken the leadership in producing a decision-support web-based system to help producers assess the impact of selection decisions. This system uses existing EPDs to model the expected impact on total herd productivity. As such, phenotypic measures are generated based on herd information and the EPDs of prospective sires. This system will be expanded to incorporate information on cow breed composition and will incorporate heterosis into the predictions of phenotypic performance. It is unlikely that we will ever publish a "matrix" of EPDs showing the contribution of the genetic merit of the animal in question dependent on the breed composition of the mate. This decision-support system allows for the customizing the use of EPDs to each cattle operation.

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Making the Web equal profit – surfing for genetics

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Introduction

Genetic improvement is a straightforward result that follows the use of truly superior sires within the context of particular production, management and economic circumstances. But how does one identify truly superior sires? The rancher's answer to this question has varied over the last century, partly because of changes in production and economic circumstances but also because of changes in scientific knowledge, education and fashion. Nevertheless, the World Wide Web (www) has contributed very little to the rancher's ability to identify superior animals to increase their profit. This will all change with the next generation of ranchers for two reasons. One is about convenience; the other is about customized computation and decision support.

The convenience of the web

A hardcopy sire summary was a fantastic new resource when they were first released to the industry. However, a major problem with hardcopy is deciding the order in which the bulls will be presented to the reader. A telephone book is a useful resource to find a person's number, but not so useful to find the name of the person that corresponds to a particular phone number. So it is with the sire summary. It is a good resource to look up for details, by name, on one or a few bulls that you know to be of interest. For those interested in extreme animals for a particular trait, separate sections of trait leaders are useful.

However, most ranchers are interested in multiple trait improvement and the bulls that are trait leaders for one trait are seldom the bulls of most interest from a multi-trait perspective. Many breeders practice multiple trait selection through the use of independent culling levels. For example, they will not consider using a bull whose birthweight EPD exceeds a particular benchmark value. In high altitude conditions they may not consider using a bull with a PAP EPD that exceeds a particular threshold. Some breeders avoid animals that are at either high or low weight extremes. The web delivery of so-called database queries linked to an on-line sire summary provides a fantastic tool for filtering bulls according to any number of criteria and then sorting the subset of bulls that meet the filter. Commonly-used filters might be on the minimum or maximum EPD, the accuracy of the EPD, the breeder name or ranch location. Most Breed Associations already provide on-line access to the results of their evaluations.

The true genetic merit of a bull does not change from the moment of conception through the time the bull produces its own performance records and then produces offspring after use as a sire. However, our estimate of the merit of the bull (EPD), typically does change over time, starting with the parent average value for each trait with that estimate being modified upwards or downwards according to the superiority or inferiority of the individual relative to its contemporaries and then again based on the superiority or inferiority of its offspring. Bulls that are widely used in many regions will be continually accruing new information which can improve the EPD estimate. However, for historical reasons, most national beef cattle genetic evaluations are only undertaken once or twice a year. This requires that a deadline be used to determine the information that is included in any particular analysis. Any information collected after that deadline will not be used to improve the accuracy of sire EPDs until the next national analysis, six months or a year later. In the future, continuous genetic evaluation will become a reality. Continuous national evaluation is already used in livestock evaluations in other countries. Continuous evaluation provides some challenges for hardcopy sire summaries as these may become outdated before they can even be widely distributed. Web delivery can overcome these problems and readily provide the most up-to-date information. However, there are many more compelling reasons to surf the web in search of more profitable sires than simply the convenience of electronically sorting through lists of bulls.

Customized Computation using the web

Making profitable selection decisions on a repeatable basis requires one to simultaneously quantify the consequences of using particular animals as parents across a portfolio of economically relevant traits. Typically, sires that are more popular enjoy a premium price such that identifying the most profitable option involves weighing up the benefits of a particular sire in comparison to the cost. One of the early tools for quantifying the relative impact of alternative sires was the EPD. From a simplistic viewpoint, the EPD would appear to provide the required information. For example, suppose a cow-calf rancher sells animals at weaning. If a particular sire has a weaning weight EPD that is 20 lb above an alternative sire, it might be argued that this is all the information needed to determine the benefit of that sire. However, there are at least six reasons why such EPDs are not sufficient information to make good decisions without further analysis. These six reasons have their basis in statistics, genetics, systems biology, nutrition, economics and probability respectively. A consequence of these six issues is that arithmetic analysis of the entire portfolio of EPDs of a particular sire along with other genetic, production, management and economic circumstances are required to provide the utility that one might have traditionally (naively) expected from an EPD. This arithmetic analysis might be referred to as comprising sire selection by simulation (Bourdon, 1998). The web is ideally suited for providing such an analytical tool. These six reasons will now be explored in more detail.

1. Interpretation of threshold traits

Threshold analysis is commonly undertaken on categorical data, such as calving ease (Hoeschele et al., 1995). Philosophically it assumes that there is underlying continuous genetic and environmental variation with respect to the trait, but the phenotypic observation that is recorded by the rancher is limited to two or a few ordered categories. A threshold dictates which category is observed for given values of the underlying genetic and environmental factors and the fixed effects. Threshold analyses may concurrently account for correlated continuously observed variables. For example, the analysis of calving ease typically account for correlated information on birthweight as an indicator trait. Threshold analyses are also used for stayability (score 1 reflects a cow that was in the herd as a two-yr old and stayed in the herd up to or beyond six years of age or five calving opportunities or score 0 indicates the cow failed to stay that long) and for heifer pregnancy (score 1 reflects a heifer that was confirmed pregnant whereas score 0 reflects a heifer that failed to get pregnant).

The genetic merit computed from a threshold analysis is on an underlying scale that does not have conventional measurement units. Accordingly, estimates of merit from a threshold model are converted or transformed from the underlying scale back to the original observed scale of measurement in terms of a probability. A feature of this transformation is that it requires assuming some average circumstance or average incidence of the various observed categories. Put another way, this means that a sire that will provide a given shift in the underlying scale will be equivalent to different observed effects (or progeny differences) in different production circumstances. This is best demonstrated by graphic example as in Figures 1 & 2 for a bull with an underlying EPD that improves heifer pregnancy by 0.38 units. In the herd depicted in Figure 1, this bull will improve heifer pregnancy by 8% (8 calves per 100 heifers) by lifting pregnancy rate from 80 to 88%. The same bull used in herd 2 will only lift the pregnancy rate by 4.5%, from 90 to 94.5%.

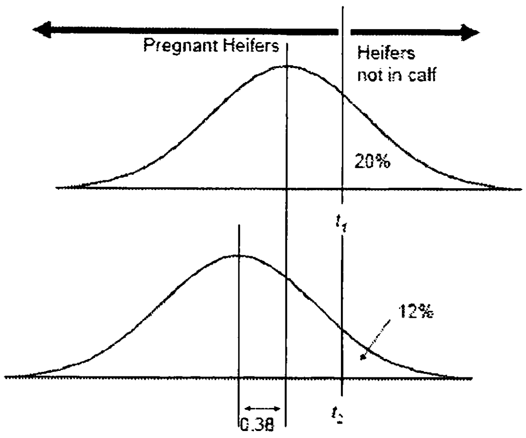

Figure 1[1]. The effect of a sire that improves heifer pregnancy (in his daughters) by 0.38 underlying units in a herd with an average 20% heifers not in calf is to increase the heifer pregnancy rate from 80% (100-20) to 88% (100-12).

A consequence of the underlying nature of these traits is that the published EPD and the progeny difference you expect to observe in your particular circumstances will not be the same unless your average levels of performance happen to be exactly the same as the value that was used in the published transformation. An incidence of 50% is typically used in the published transformation. This is close to the average incidence for stayability (where a typical herd has about half the number of six-year old cows compared to two-year old cows), but is not realistic for heifer pregnancy (which is typically 75-85%) or calving ease.

[1] Normal distribution tables are required to show that the threshold t_1 is at 0.84σ in order for 20% heifers to exceed the threshold. For a phenotypic sd =1.17 σ, then threshold t_2 is at 0.84+0.38/1.17=1.165 σ. Normal distribution tables can be used to show that the area to the right of that threshold will be 12%.

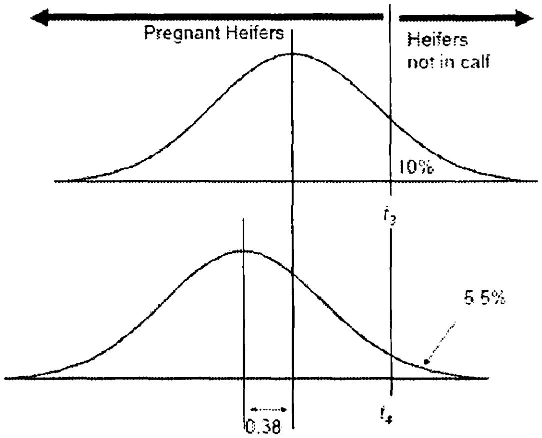

Figure 2[2]**.** The effect of the same sire as in Figure 1 that improves heifer pregnancy rate by 0.38 underlying units in a herd with an average 10% heifers not in calf is to increase the pregnancy rate from 90% to 94.5%.

The value of all threshold trait EPDs (heifer pregnancy, stayability and calving ease) thus varies with the current average level of performance. The effect on the observed scale of a given shift in the underlying scale is greatest if the average is 50% and declines as the average increases or decreases from that value. Furthermore the effect of a given increase (eg +0.38) or the equivalent decrease (-0.38) on the underlying scale is not typically the same on the observed scale.

It is not appropriate or practical for a hardcopy sire summary to produce these threshold EPDs for more than one observed scale. Altering the transformation will have no influence on the ranking of the sires, but it may have enormous influence on the productive consequences that would result from using a particular bull in your own circumstances. The web provides the ability to undertake the calculations required for a custom transformation so that the consequences of using a particular bull can be more appropriately quantified for your circumstances.

2. Multibreed evaluation and crossbreeding

Theoretically, the breeding value (or EPD) is determined by the sum (or half the sum) of all the average effects of the genes an individual carries. The effect of a gene is not generally expected to be the same in every population, due to dominance effects and to differences in gene frequencies between populations. In practice, various studies have indicated that EPDs perform reasonably well in terms of predicting differences in performance, in different populations, including in different breeds, with two exceptions. The first occurs when the environmental circumstances differ markedly in terms of nutritional, climatic or disease stress. The second exception occurs when the bulls comprise more than one breed or cross, or their mates represent more than one breed or cross. There are two possible explanations as to why EPDs may not perform in the context of such crossbreeding. The first is that the EPDs from each breed may be on a different base. This is currently the case with most evaluations where the EPD base is set independently of the base for other breeds. Using records from USDA's Clay Center, breed base adjustments for mainstream traits are published annually at BIF meetings (eg Van Vleck and Cundiff, 2004). The second explanation is due to the phenomenon of heterosis or hybrid vigor.

The National Beef Cattle Evaluation Consortium (NBCEC) is currently prototyping, at Cornell University, a multibreed analysis for many US beef breeds for growth traits. Similar analyses for carcass traits and for calving ease will soon be prototyped at the University of Georgia. These analyses will produce EPDs for all breeds that are comparable on the same base. It remains to be seen whether the resulting EPDs will be published on a common base or whether each Breed Association adjusts the results back to their usual base. It seems counterproductive to pool data across many breeds for joint analysis and then to report breeds on different bases. Multibreed dairy cattle analyses in New Zealand have been published on a common across-breed base for some years (for examples see www.aeu.org.nz).

In order to interpret the expected progeny performance in an across-breed setting, heterosis values must be taken into account. The heterosis values are expected to be different for each trait. Theoretically, the amount of heterosis is also a reflection of the genetic distance between breeds, as heterosis is simply recovering historical losses in performance that have resulted from inbreeding. Accordingly, the heterosis among breeds of similar type is expected to be more similar than among breeds of different backgrounds. Heterosis values can be predicted from multibreed evaluation systems. However, experience with the data structures that are represented within the context of US national beef cattle evaluations shows that Breed Association datasets are not particularly reliable for estimating

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[2] Threshold t_3 must be at 1.28 σ in order for 10% individuals to exceed the threshold. For a phenotypic sd =1.17 σ, then threshold t_4 is at 1.28+0.38/1.17=1.605 σ above the mean giving only 5.5% above that threshold.

of

Table 1. Yearling Weight EPDs used for theoretical and actual calculation of expected performance from two Angus and two Simmental (Simm) sires mated to different cow breeds[a].

YWT			Offspring Performance by cow breed			
			Angus	Simm	Hereford	Angus-Simm
	EPD	EPD				
Breed/Bull	Within-breed	Across-breed				
Angus 1	+65	+65	Base	$+h_{AS}$	$+h_{AH}$	$\frac{1}{2}h_{AS}$
Angus 2	+80	+80	+15	$+h_{AS}+15$	$+h_{AH}+15$	$\frac{1}{2}h_{AS}+15$
Simm 3	+58	+80	$+h_{AS}+15$	+15	$+h_{HS}+15$	$\frac{1}{2}h_{AS}+15$
Simm 4	+68	+90	$+h_{AS}+25$	+25	$+h_{HS}+25$	$\frac{1}{2}h_{AS}+25$
Angus 1			850 lb	863	873	857
Angus 2			865	878	888	872
Simm 3			878	865	878	872
Simm 4			888	875	888	882

[a] Angus 1 is breed average (Cundiff, 2004) for yearling weight. Angus 2 is 15 lb superior for yearling weight EPD. Simmental 3 is breed average for yearling weight. Simmental 4 is 10 lb above breed average. Across-breed EPDs are on an Angus base. The base adjustment for yearling weight in the Simmental breed is 22 lb (Van Vleck and Cundiff, 2004). Crossbred cows are ½Angus ½Simmental. Heterosis values for yearling weight F1's are taken to be different between each pair of breeds and are h_{AS} = 13 lb for Angus-Simmental, h_{AH} = 23 lb for Angus-Hereford, and h_{HS} = 13 lb for Hereford-Simmental.

heterosis. The approach originally adopted by Cornell University (Pollak and Quaas, 1998) and now used more widely involves a Bayesian procedure that introduces prior knowledge on likely heterosis values from previous well-designed published studies.

The use of within-breed and across-breed EPDs to predict crossbred performance is best demonstrated by example considering yearling weight in offspring resulting from Angus or Simmental sires over Angus, Simmental, Hereford or crossbred cows. The upper portion of Table 1 demonstrates the nature of the calculations for predicted performance using across-bred EPDs whereas the lower portion presents possible numerical values of EPDs given assumed base adjustments and heterosis values.

The example in Table 1 demonstrates that the ranking of the four sires is sensitive to the nature of the cow breed. Using straightbred Angus cows, the ranking of the sires for yearling weight is 4>>3>>2>>1. Using straightbred Simmental cows the ranking depends upon the value of h_{AS} and is 2>4>>3>1. Over Hereford cows the ranking depends upon the relative magnitude the heterosis values h_{AH} and h_{HS} and is 2=4>>3>1. Over these crossbred cows, the ranking is 4>>3=2>>1.

The consequences of these results are that any rancher intending to use bulls from more than one breed must currently deal with bulls listed in more than one sire summary. They must then know where to find and how to use the base EPD adjustments relevant to their circumstances. They must also know where to find and how to use the appropriate heterosis values. The situation is even more complex in multibreed circumstances for maternally-influenced traits where maternal and direct heterosis will have different coefficients when the dam and the offspring breed composition are not identical. All these problems can be overcome by web delivery of a single file of all EPDs from all breeds in a multibreed analysis. The arithmetic (shown in Table 1) to adjust for base (if required) and to account for heterosis can be readily achieved behind the scenes for the convenience of the user.

The shift to routine multibreed analysis will introduce challenges for Breed Associations in terms of data

Table 2. Influence of example EPDs on a number of economically relevant traits on sale weight at weaning from a 1,000 cow herd.

	EPD[1]				Performance		
Bull ID	WWD	STAY	HPG	CED	Weaning Wt	#Sold	Extra Wt sold per cow
Romeo	Average	Average	Average	Average	451 lb	744	Base[2]
Sierra	+30 lb	Average	Average	Average	481 lb	744	22 lb
Tango	+30 lb	+8%	Average	Average	482 lb	759	30 lb
Uniform	+30 lb	+8%	+12%	Average	482 lb	765	33 lb
Victor	+30 lb	+8%	+12%	+11%	482 lb	766	34 lb

[1] EPDs are for weaning weight direct (WWD), Stayability (STAY), Heifer Pregnancy (HPG) and calving ease direct (CED).

[2] Base herd of 1,000 cows weans 938 calves at an average 451 lb and sells 358 lb calf per cow wintered.

deadlines. An obvious approach to overcome this aspect is to provide continuous genetic evaluation. Each Association would upload their pedigree and performance information at their convenience, knowing that the next analysis (perhaps monthly, weekly or daily) will use all that information.

3. Interactions between economically relevant traits

Many of the economically relevant traits interact, to the extent that the observed differences in actual performance are not identical to those that would be predicted from EPDs. This occurs for even the simplest of traits, such as weaning weight. It is best demonstrated by example (Table 2), considering five alternative bulls used to generate all the replacements in the context of a straight-bred self-replacing cow-herd.

Relative to a base herd scenario (using Romeo), the use of a bull such as Sierra with an increased weaning weight direct of 30 lb will increase the average weaning weight by 30 lb provided all other EPDs are unchanged. Some cows fail to rear a live calf to weaning and a proportion of the weaned heifers need to be retained as replacements. Accordingly, the additional sale weight expressed per cow is 22 lb. Tango is a bull that has increased stayability as well as increased weaning weight direct. Increased stayability impacts sale weights at weaning in two ways. First, there are fewer heifer replacements required so more female calves can be sold at weaning. Second, the cow herd has a smaller fraction of first calvers and a larger fraction of mature cows. This increases average weaning weight as mature cows wean larger calves than first calvers. The combined effect of increased stayability and increased weaning weight direct leads to an increase of 30 lb saleable weaning weight per cow. Uniform is a bull with all the features of Tango in addition to an improved EPD for heifer pregnancy. For the same number of required pregnant rising two-year old replacement cows, Tango's daughters need fewer weanlings retained. This has the effect of increasing weaner sale numbers by a further 3 lb per cow compared to Tango, giving 33 lb more than Romeo. Victor is a bull with all the features of Uniform, in addition to improved calving ease direct. Calving ease and birthweight are traits that many producers emphasize. In this herd, with 22% first-calf heifers requiring assistance, the improved calving ease only results in an additional 1 lb sale weight per cow.

This example demonstrates that even a simple production system involving 1,000 cows with a straightforward goal based on weaning sale weight will be influenced by a portfolio of trait EPDs in addition to the obvious influence of weaning weight direct. Weaning weight direct EPDs alone are not a good indication of system performance, even for weaning weight.

4. Assessment of nutritional (input) implications

The nutritional or dry matter intake requirements of a cow herd and its replacements depend upon a number of factors. The major requirement for feed is in supporting the maintenance requirements of the mature cows. From the perspective of a typical mixed-age mature cow, this is influenced by its mature size, its condition score at maturity and its milk production potential. Added to these requirements, mature cows need feed to support gestation (varying with birth weight) and lactation (varying with milk production). The calves themselves require feed for maintenance and growth up to sale age (eg weaning) and to meet the requirements for replacement heifers. The replacement rate in terms of number of cows at first calving will vary with the stayability of the herd. The number of heifer calves that need to be retained to provide sufficient replacements will vary further with heifer pregnancy rate. In some circumstances, any change in the feed requirements of the cow herd can be met by purchasing in feed at some given feed cost. In other extensive grazing cases, the primary source of feed for the cow herd, their calves and replacements, is provided by the amount of pasture produced. This is principally determined by the land area and the amount of precipitation.

In order to identify the impact that sires will have on profit, it is therefore necessary to predict the feed requirements that will result from their use. Given this information, the cost of additional purchased feed can be determined, or the required modification to the stocking rate can be quantified. Computing the nutritional requirements of a cow-calf herd according to its age structure and other aspects of performance should be straightforward for any well-educated Animal Science graduate, but nevertheless requires access to the relevant tables (NRC, 1996) and a considerable amount of arithmetic. Both this knowledge and the arithmetic can be readily provided via a web-based decision support tool.

For example, consider a livestock system using the sires that were introduced in Table 2. Suppose the ranch environment was capable of supporting 1,000 cows of merit reflective of Romeo. Replacing the herd with daughters of Sierra with 30 lb increases in weaning weight (but no change in birth, yearling or mature weights) would increase nutritional requirements to support the faster pre-weaning growth. This would require a reduction in stocking rate equivalent to 2 cows to give a total herd of 998 cows in order to consume the same amount of feed on an annual basis. Increasing herd stayability through the use of Tango will reduce the number of replacements required to be kept postweaning, allowing 999 cows to be calved. Increasing heifer pregnancy with Uniform will further reduce heifer retention allowing herd size to increase to 1001 cows for the same annual feed consumption. The use of sires that modify maintenance energy requirements (through altered mature size or milk production potential) will have much more dramatic influence on the number of cows that can be managed in order to achieve the same annual feed consumption than do the examples above. The high genetic correlation between weights at various ages results in most bulls with higher growth rates being associated with higher mature size and maintenance energy. Failure to properly account for any such increases in nutritional requirements and resultant feeding costs will lead to overestimation of the value of improved growth and a tendency to overlook more profitable bulls with more moderate growth and improved stayability.

5. Assessment of financial implications – accounting for prices and costs

We have already demonstrated the need for considerable knowledge and arithmetic in order to properly quantify the levels of outputs and the number of inputs required for a particular production and management circumstance. In order to surf for profit, one must then combine the outputs according to their output values (which may vary with quality attributes that are modified by selection) and subtract the cost of inputs. Feed costs, costs that vary with the number of cows, veterinary and other labor costs may need to be taken into account. All this is easily achieved using the web. The example bulls used in Table 2 show that Sierra increases profit by about $22 per cow (relative to Romeo) and Tango, Uniform and Victor increase profit by $33, $34 and $35 respectively in the particular management, productive and economic circumstances modeled. These increases in net income are well worthwhile when one considers the number of cows a bull can breed over its lifetime.

6. Accounting for risk associated with the use of bulls with less than perfect accuracy

A few so-called proven bulls may have high accuracy EPDs for some traits, indicating that the current estimate of bull merit is unlikely to change much if additional, new information became available. Even proven bulls are likely to have some trait EPDs with reduced accuracy, such as traits that are measured late in life or after slaughter including stayability, heifer pregnancy, maintenance requirements or perhaps carcass merit. Most bulls will have only moderate accuracy EPDs as they will have been evaluated based on their parental and individual performance, without yet having the benefit of recorded offspring. Such bulls are equally likely to be better than their current estimate suggests, or worse than their current estimate. Limiting selection to proven bulls is therefore overlooking some of the young bulls that will turn out to be much better than can be currently assessed. The hardcopy sire summaries typically publish likely change tables, but it is no easy matter to simultaneously determine the impact of profit on inaccuracies in a whole portfolio of economically relevant trait EPDs. Sire selection by simulation can achieve this end, by simulating a number of possible realizations of each bull and determining the distribution of likely profit that will result from using each bull. This can be delivered by web-based decision support tools.

Web-based decision support is not just another index

It could be argued that the same kind of models that might underlie a decision support tool can be used to construct relative economic values for each economically relevant trait. Such weights could then be used to combine the individual trait EPDs into a single index figure, to reflect profitability (see for example MacNeil, these proceedings). Some of the six factors addressed above can be accounted for in a selection index. These include the interpretation of threshold traits, some of the interactions between economically-relevant traits, the assessment of nutritional requirements and the financial implications. However, the index must assume average values for many characteristics and to the extent that your circumstances may vary from that average, the index may be sub optimal. Index selection will not account for the multibreed context unless an index is created for every mating strategy. Nor will they typically account for risk.

Finally, there is a philosophical distinction between index selection and decision support. Index selection essentially makes decisions for you with little clarification as to why particular animals get the rankings and index values they receive, other than what might be able to be determined by inspection of the index weights. There is nothing wrong with this if you believe in the index and there are many examples of the positive improvements that can be achieved from the use of index selection.

Web-based decision support is more than simply on-line customized indexes. It can also provide justification as to why particular animals get the values they get. In this context it supports your decision by providing you with relevant information as to the ramifications of selection with respect to your production, management and economic circumstances.

Summary

Web-based sire selection allows you to select sires with quantified prediction and to scrutinize your resulting whole system performance, along the same lines that EPDs and indexes had attempted to provide. It can account for the peculiarities of threshold trait interpretation, the complexity of trait interactions, the knowledge of heterosis in crossbreeding contexts, and the arithmetic for predicting nutritional and economic ramifications.

The National Beef Cattle Evaluation Consortium (NBCEC) is developing such a decision support tool in concert with its other research activities regarding new EPDs for economically-relevant traits (such as maintenance energy) and multibreed evaluation. The prototype website is accessible at http://ert.agsci.colostate.edu.

Many current ranchers will never use web-based decision support. However, those early adopters of this technology have the opportunity to identify sires that they can be confident will increase their profit, rather than using sires that may simply lead to genetic change, without providing genetic improvement.

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Live Animal, Carcass and End Product Committee

Thursday, July 7, 2005
2:00 – 5:00 pm

Chair: Robert Williams, American-International Charolais Association

Update on Ultrasound Guidelines Council (UGC)

Robert E. Williams
American-International Charolais Association
Kansas City, Missouri

UGC Certification of Field and Lab Technicians

Lisa Kriese-Anderson
Auburn University
Auburn, Alabama

UGC Systems Review of Ultrasound Technology

Scott Greiner
Virginia Tech.
Blacksburg, Virginia

Have Phenotypic Trends for Carcass Traits Followed Genetic Trends?

Dan Moser
Kansas State University
Manhattan, Kansas

Producer Applications Session

Thursday, July 7, 2005
2:00 – 5:00 pm

Chair: Sally Northcutt, American Angus Association

Documenting Your Product: Genetics and Management

Moderator: Cody Wright, South Dakota State University

Process Verified Programs: Application and Value

Cara Gerken
IMI Global, Inc.
Platte City, Missouri

Program Development and Opportunities

Jack Ward
American Hereford Association
Kansas City, Missouri

Blake Angell
Red Angus Association of America
Denton, Texas

Jim Shirley
American Angus Association
Saint Joseph, Missouri

Selection Decisions Committee Agenda
Thursday, July 7, 2005
2:00 – 5:00 pm

Chair: Darrh Bullock, University of Kentucky

Selection Decision Support Panel

Sally Northcutt
American Angus Association
Saint Joseph, Missouri

Dorian Garrick
Colorado State University
Fort Collins, Colorado

Robert E. Williams
American-International Charolais Association
Kansas City, Missouri

Dairy Experiences in Adaptability – What are the consequences of extreme selection for productivity?

Toni Oltenacu
Cornell University
Ithaca, New York

Beef Cattle Adaptability – What is it and what can we do about it?

Bill Hohenboken
Virginia Tech. and Oregon State University

Beef Cattle Adaptability Panel – Potential and problems for developing a genetic evaluation on adaptability.

Members to be determined

Genetic Improvement of Beef Cattle Adaptation in America

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U.S. Meat Animal Research Center, Clay Center, NE
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University of Kentucky, Lexington
Radakovich Cattle Company, Earlham, IA

Introduction

Management systems and environments differ widely for beef cattle populations across America. A typical animal may occupy several environments during its lifetime, each presenting a unique set of challenges. No animal or breed is maximally efficient in all environments, nor is any animal or breed maximally adapted to all of the challenges encountered in any one environment. To a certain degree, therefore, all beef cattle in America are less than optimally adapted. Profitability and maintenance of the integrity of production environments can be improved through programs to balance genetic potential for production, product quality and environmental adaptation.

With financial support from the USDA Agricultural Research Service and BIF and under the auspices of the National Beef Cattle Evaluation Consortium, concerned geneticists and cattle producers met in March, 2004[f] to define adaptation in beef cattle, characterize important stressors in major production environments and identify opportunities to improve adaptation through genetic means. Results were presented in a symposium in October, 2004. This document will describe those conclusions and identify strategies for improvement.

Why are American beef cattle less than optimally adapted?

Response mechanisms to environmental challenges have been evolving in cattle populations for millions of years. Adaptation has been successful, and populations capable of sustained production now exist throughout most inhabited regions of the world. Why, then, are American beef cattle less than optimally adapted? There are several reasons.

Prior to domestication, cattle had a demanding but uncomplicated job description; they had first to survive and then to reproduce. To facilitate accomplishment of these goals, anatomical, physiological, immunological and behavioral mechanisms evolved that were appropriate to conditions in Eurasia, their center of origin. Thousands of bovine generations hence, their domestic descendents in contemporary America face vastly different parasites, diseases, stresses and nutritional challenges. It is not surprising that **a gene pool conferring adaptation to past and distant environments confers less than optimum adaptation to current, and indeed, to future conditions.**

Cattle were domesticated in western Asia some 10,000 years ago. Cattle and cattle production technologies subsequently migrated outward from centers of domestication, eventually to colonize much of Europe, Africa and Asia. With an estimated initial migration rate of six miles per decade[g1], natural selection could easily accommodate adaptation to newly encountered environments. During recent times, however, the speed of migration has accelerated (air freight can transport animals, gametes and embryos throughout the world in a matter of hours). Management systems are changing more rapidly as well, typically in the direction of greater intensification. Compared to only a few decades ago, for example, cows now produce their first calf at two rather than three years of age, animals are maintained at higher density per unit of land area

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[e] Radakovich Cattle Company, Earlham, IA.
[a] Facilities provided by the Noble Foundation, Ardmore, OK.
[g] Numerical footnotes correspond to citations listed at the end of the report.

and cattle are fed to market on higher energy diets. In many instances, **management systems and environments are changing more rapidly than animal populations can adapt to such changes through natural selection[2].**

Domestication and subsequent migration created opportunities for the formation of and differentiation among many locally adapted cattle populations. Our ancestors lived in a society of small tribes at that time, with limited material and cultural exchange between groups[3]. The role of cattle was determined by the needs of each tribe- milk and meat production, power generation, the accumulation of wealth and religious or cultural iconography, for example. Tribal definition of value thus imposed a new 'environmental' challenge on cattle populations, that of fulfilling an economic role. Phenotypic selection was applied, as animals more successful in meeting the community standard of value were allowed to reproduce while less successful individuals were not[4]. Planned mating and natural selection exerted by local environmental challenges also promoted the creation of populations well adapted to local requirements. As human social organization gradually evolved from tribes to communities, communities to villages, villages to cities, cities to states and states to nations, interactions among societies increased[5], and the isolation of local cattle populations diminished. When allele frequencies and gene combinations favorable to production in a local environment were disrupted through exchange of breeding animals, adaptation to specific environments declined. National and international trade in breeding animals, gametes and embryos now allows an animal to produce offspring in environments very different from the one to which that individual is adapted. While providing many benefits to efficient livestock production, **movement of genes into new environments can reduce adaptation of a resident herd to its own unique conditions and challenges.**

An idea whose time has come back

Beef cattle geneticists in the American south and west concluded in the 1970's that "genetic adaptation to local environments is important in commercial beef cattle production"[6]. Furthermore, "indiscriminate distribution of breeding stock (or their semen) to different environments" should be avoided until something is known of the adaptive merit of that stock. They advised that animals be performance tested under environmental conditions similar to those that their progeny are likely to encounter. Evidence supporting these recommendations was provided by their classical experiment to investigate genotype by environment interaction. They started with two genotypes, a line of Hereford cattle selected in and adapted to Montana and another Hereford line selected in and adapted to Florida. These states also constituted the production environments; half of each herd was transferred to the other location, where production of the cows and their descendents was monitored over an 11-year span. Genotype by environment interaction would occur if the production difference between cows of Montana versus Florida origin differed depending upon the location in which they were compared. Such was the case. At Miles City, Montana, the Montana cows and their descendents exceeded Florida cows and their descendants by an average of 14 pounds calf production per year. In Brooksville, Florida, average annual calf production of Florida cows and their descendants was 84 pounds greater than that of Montana cows and their descendants! As might have been expected, cows from each origin were most productive in the environment to which they were adapted.

Gradual response to mild selection to increase performance for production traits, as occurred during most of the history of the co-dependence between cattle and man, generally does not detract from an animal's ability to survive and reproduce. In fact, selection to increase sustained annual production selects automatically for traits important to adaptation. In recent decades, however, refined knowledge of inheritance, improved information technology and advanced reproductive techniques has allowed dramatic increases in selection intensity and selection response. Rapid response to intense selection for increased product (as opposed to increased sustained annual production) can sequester resources formerly utilized to support reproduction and survival. **Rapidly increased genetic potential for production may be achieved, therefore, at the expense of decreased genetic merit for adaptation.**

Hidden costs of selection

Among domestic food animals, broiler chickens are the poster species for rapid rate of response to selection. They are highly prolific and turn generations rapidly, allowing for a high intensity of selection. Furthermore, commercial poultry breeding companies have clear, consistent objectives, most prominently to increase growth rate, feed conversion efficiency and breast meat yield. Selection responses in these traits have not been without cost[7]. Undesirable correlated selection responses include reduced fertility of broiler breeders and increased severity and incidence of *ascites, sudden death syndrome, distortion of long bones and tibial dyschrondroplasia throughout the life cycle. In a similar manner, progeny testing and artificial insemination have fostered rapid response to selection for increased milk yield in dairy cattle, for which undesirable correlated responses include poor rebreeding performance of young cows and increased incidence of metabolic imbalances in lactating cows[8]. In swine, intense selection to increase growth rate and feed conversion efficiency has been accompanied by increased skeletal abnormalities and impaired reproduction[9]. Such undesirable side effects should come as no surprise. Within an environment, an animal can accumulate no more than some fixed level of nutritional resources. When a higher proportion of that total is required to support performance for intensively selected production traits, a smaller proportion is available to meet all other physiological demands.*

Who benefits from improved beef cattle adaptation?

Potential benefits from genetic improvement in beef cattle adaptation include enhanced animal well being, increased profitability for beef cattle producers, more desirable products for beef consumers, enhanced resource conservation and more effective utilization of forage resources.

Improved adaptation enhances animal well being. Stress is a fact of life. Fortunately, response mechanisms have evolved to stressors commonly encountered in a population's evolutionary past. These physiological, immunological, metabolic and behavioral responses generally are sufficient to maintain biological integrity and physical well being. However, when responses are inappropriate or inadequate, stress can lead to distress, defined here as ill health or compromised well being[10]. In a maladapted population, inherent response mechanisms to prevailing environmental challenges do not maintain satisfactory well being of many individuals. An adapted population is one in which most individuals do cope successfully with those stresses most commonly encountered in their environment.

When cows are vertically challenged.

Although native to and domesticated in western Asia, cattle are now raised in most semi-arid through humid, tropical through temperate and coastal through alpine regions of the world. Individuals are most likely to be poorly adapted at one or the other extreme of an environmental continuum. One such case is high altitude disease of cattle, of economic and welfare concern in mountainous regions of the American west. A synonym is 'brisket disease', named for edema which results when low oxygen pressure at high altitude induces labored respiration, increased heart rate, elevated blood pressure and fluid accumulation in the thoracic cavity of affected individuals. A tool to select breeding stock resistant to high altitude disease was developed through research at Colorado State University and elsewhere[11]. Pulmonary arterial blood pressure (PAP) measured at high elevations is heritable and is indicative of genetic susceptibility to brisket disease. Individuals with PAP below a specific benchmark produce offspring likely to be resistant to brisket disease; those whose PAP score exceeds that threshold typically produce a higher proportion of susceptible calves.

Improved adaptation enhances financial well being of beef cattle producers. Beef cattle production cannot be profitable unless cattle are productive, efficient and produce a desirable end product. Selection to improve traits contributing to those ends is desirable if not required. In addition, cattle that are genetically adapted to their environment incur lower costs than un-adapted but otherwise comparable cattle. Overall profitability of beef cattle production would be enhanced by including locally-rational measures of adaptability in industry selection schemes and breeding objectives.

When enough is just enough

Selenium (Se) is an essential trace mineral for animal nutrition. Its concentration in the soil varies widely across cattle producing regions of America, and in plants grown upon those soils as well. Although many cattle receive an appropriate amount of Se in their diet, some are marginally to severely deficient[12] while others experience selenosis[13] (toxicity from excess Se). Cattle at the Quinn Cow Company near Pine Ridge, South Dakota, fall into the latter category. Each year, some exhibit lameness, ill thrift and reduced calf production (the symptoms of selenosis), leading to premature culling. The Quinns believe that average resistance to Se toxicity is increasing in their herd, although slowly, as natural selection eliminates genes causing increased susceptibility. These detrimental genes could be re-introduced, however, through purchased bulls whose genetic resistance to selenosis is unknown. If a readily measurable trait indicative of ability to absorb Se from the diet could be identified, breeding animals could be selected whose genetic merit for Se *absorption was appropriate for forages that the progeny were likely to consume. High absorber bulls could be selected for regions low in Se and low absorbers for regions in which selenosis had been a problem.*

Improved adaptation reduces cost and enhances quality of beef. Typically, a portion of the economic benefit of improved agricultural efficiency is passed on to the consumer as lower prices and/or better quality of product.

Improved adaptation enhances food security. Well-adapted populations are more resilient than poorly adapted populations to temporal variation in their environment, differences among years in weather, feed quantity and feed quality, for example. Accordingly, annual product yield from well-adapted herds will vary less than that of poorly-adapted herds. When cow herds and market animals are well adapted to their production environments, it is easier to maintain a safe, reliable and uniform supply of beef.

When less is more

Just as high incidence of infectious disease may signal a poor fit between a population of cattle and its environment, low disease incidence suggests that a population is well adapted. Because adapted cattle, in general, will be healthier, they should require fewer therapeutic injections of antibiotics. Public health officials are concerned that antibiotic residues in food products may promote antibiotic resistance in organisms that are pathogenic to humans. Reducing the use of antibiotics within the production chain for beef could, therefore, benefit public health and food security as well. Economic benefits would accompany these social benefits. Each time that an animal is injected, there is a possibility that the injection site may become infected. According to the National Cattlemen's Beef Association 1995 National Beef Quality Audit, resultant blemishes reduce carcass value an average of $7.05 per steer and heifer slaughtered in America[14]. Producers of better adapted and healthier cattle would escape some proportion of this financial burden.

Improved adaptation lessens the need to modify production environments. Beef cows have been called a scavenger species. Their traditional agro-ecological role has been to convert foodstuffs not directly usable by man to wholesome, nutritious meat and other valuable products. They do this best when they are well adapted to the environment in which they find themselves. When they are not well adapted to a prevalent challenge, a management option is to modify the environment to more closely satisfy their needs. Such modifications are never without monetary cost, and they may incur social costs as well. For example, recreational users of public forest and range lands prefer 'natural' to altered environments, and adapted cows are more likely than un-adapted cows to prosper on unmodified lands.

One cow's fodder is another cow's poison

Hank Maxey raises cattle in the Piedmont region of Virginia. Forage grows well on his farm in spring and autumn but not during the hot and often droughty summer. In fact, tall fescue (Festuca arundinacea) is the only grass species that tolerates the climatic, nematode and insect stresses characteristic of much of the southeastern United States at that time. It does so because of its symbiotic association with the endophytic fungus, Neotyphodium coenophialum[15]. Together, fungus and grass produce toxins that are harmful not only to invertebrate consumers of the grass but to livestock as well[16]. Affected cattle experience severe discomfort from heat stress, leading to reduced forage intake, lower milk yield, slower growth and impaired reproduction. Lost production exceeds $800 million per year[17]. Farmers in the 'fescue belt' report that some cattle within each herd are particularly susceptible to fescue toxicosis while others are largely unaffected. Research suggests that inheritance is partly responsible for observed differences and that tolerance to endophyte-infected fescue could be improved by among-breed[18] and within-breed[19] genetic selection, as several southern cattle breeders are attempting to achieve.

Improved adaptation enhances resource conservation and utilization. Cattle production has sometimes been criticized for contributing to environmental deterioration. It also, however, can serve to maintain or improve pastoral environments. For example, cattle are grazed in the Grayson Highlands State Park in southwestern Virginia to prevent reforestation of meadows that contribute to habitat diversity. Several European countries subsidize traditional cattle production enterprises to maintain rural economies and environments. To contribute effectively to environmental conservation, cattle must be satisfactorily adapted to the particular environment that they are assisting to conserve.

Designing cows for resource conservation
When the right number of cattle consume the right amounts of the right forages at the right times, according to the physical and ecological characteristics of a specific site, range beef cattle production is a remarkably sustainable enterprise. This requires skillful and judicious management. Cattle, and the wild ungulates with which they share the range, prefer grazing near streams. Therefore, one of the most intractable problems on mountainous, semi-arid ranges has been to prevent over-utilization of riparian zones before there has been adequate utilization of upland terrain. Can beef cattle be selected for more uniform utilization of a forage resource? Researchers from Montana State University reported that Tarentaise cattle (an alpine breed) spent a higher proportion of time grazing on slopes distant from water sources than Hereford cattle (native to a farming region)[20]. They reported heritable variation within Herefords in propensity to graze steeper, drier areas of the range as well. New Mexico State University researchers reported among-breed[21] and within-breed[22] genetic variation in diet selection, an important component of utilization of native range. Perhaps cattle can be selected for improved utilization of a heterogeneous forage resource, reduced degradation of riparian habitat and reduced grazing pressure on especially palatable plant species.

Strategies and Tools for Genetic Improvement

Breeding objectives are critically needed that would rationally combine selection for product quality, production and adaptation. Decision support tools are needed to evaluate alternative breed choices and mating systems for adaptability and production efficiency within specific environments and their specific challenges.

A first step in designing breeding strategies is to access existing knowledge of heritability, breed differences, inbreeding depression and heterosis for adaptation to important nutritional, physical, climatic, management and economic stressors within major beef production environments in America. Less is known of genetic correlations among adaptive traits and of genetic correlations between traits contributing to adaptation and those affecting production and product. Designed experiments will be needed to estimate genetic parameters required for specific breeding goals.

Breeding value estimation procedures should be developed for specific adaptive traits and for overall adaptation to particular environments. Predictions should utilize indicator traits and marker assisted selection, as appropriate; and research to identify new information sources should be conducted.

In order to fund the research and development necessary to design programs for genetic improvement of beef cattle adaptation, it would be beneficial to quantify the expected impact of improved genetic adaptation on the cost and revenue of beef cattle production and on animal well being, sustainability of beef cattle production systems, the integrity of production environments and the health and economic well being of beef consumers.

Achieving site-specific adaptation
The number of traits contributing to adaptation in any environment typically is too large to allow all of them to be optimized by selection. Rex Ranches of Ashby, Nebraska take a different approach. They define what a cow must accomplishment by her fourth birthday in order to be successfully ADAPTED to their ranch and its challenges. Such elite cows are given the opportunity to leave as many descendents as possible in future generation; while cows that fail to meet the benchmark criteria are prevented from leaving many replacement offspring. This program should improve adaptation but, because of the inherent limitations of bovine reproduction, only slowly. In 2004, National Beef Cattle Evaluation Consortium scientists used records from the Rex Ranch to test a program to increase genetic merit for site-specific adaptation. Using procedures that are routine for genetic evaluation of production and product quality traits, data from the entire herd were analyzed simultaneously to estimate genetic merit for adaptation not only of four-year-old cows but of their male and female relatives as well. Although requiring further development, the method shows promise as a tool for within-herd genetic evaluation of adaptation, as defined for specific needs and conditions.

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Cowherd Efficiency Committee

Friday, July 8, 2005
2:00 – 5:00 pm

Chair: Mark Enns, Colorado State University, Fort Collins

High Altitude Disease – An example of genetic variation for adaptability

Dorian Garrick
Colorado State University
Fort Collins, Colorado

How do we evaluate adaptability?

John Pollak
Cornell University
Ithaca, New York

The role of cow efficiency in beef production--A New Zealand Perspective

Barrie Ridler
Grazing Systems
New Zealand

High Altitude Disease – An example of genetic variation for adaptability

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

High altitude disease, also known as brisket disease, dropsy or big brisket affects some cattle living 5,000 ft or more above sea level. The disease was observed by Spanish conquistadors in South America more than 500 years ago, although its relationship to pulmonary hypertension caused by high altitude was not proven until the 1950s. The disease results from thickening and increased restriction to blood flow in small arteries in the lungs as a result of the reduction in blood O_2 saturation at high elevations. The pulmonary system compensates by increasing blood pressure that in turn increases leakage of fluids into the chest cavity and brisket. The heart may also increase in size, enlarging so much that the valves no longer meet, leading to back-flow of blood at each contraction.

The disease affects both sexes and all breeds of cattle (but not sheep or elk) to varying extents. Cattle subjected to previous selection at high altitude may suffer losses of no more than a few percent attributable to this disease. In contrast, cattle bred at low altitude with no history of natural or artificial selection for high altitude performance may sometimes suffer losses up to 40-50%. Moving cattle to low altitude usually leads to prompt recovery.

The pulmonary artery delivers O_2-depleted blood from the right ventricle to the lungs so the first symptom of the developing disease is an increase in pulmonary arterial pressure (PAP). A saline-filled plastic tube attached to a heart monitor can display the PAP when the tube is passed through a needle into the jugular vein and from there into the upper right side of the heart, through a valve, into the lower right side, through another valve and into the pulmonary artery. This procedure has been used for more than 30 years to generate PAP scores as an indicator trait to assist selection to reduce high altitude disease. Testing is more reliable at higher altitude and only after an acclimatization period of at least three weeks. Elevated PAP can reflect any respiratory or pulmonary disease. Low apparent PAP scores can result from an incorrectly inserted catheter. In order for selection to be effective it must be undertaken by a veterinarian that is competent at this technique. Cattle that are well-suited to high altitude have pressure scores below 35 mmHg whereas ill-adapted cattle exceed 45 mmHg.

The PAP scores are heritable and repeatable when undertaken by a reliable operator. Heritability estimates range from 0.32 to 0.7 (Enns et al., 1992) with no evidence of maternal genetic or maternal permanent environmental effects. Tybar Angus ranch in Carbondale Colorado have, since 1984, tested almost every animal in their Angus stud. Proven, fashionable Angus sires with moderate growth and high marbling EPDs have been progeny tested for PAP at Tybar. Sire EPDs for PAP have ranged from -5 to +5 mmHg. Sires with favorable (low) PAP EPDs based on their progeny test have been used more widely to produce performance-tested sale bulls with "genes that fit" the high altitude environment.

Cattle can vary in their adaptability to various environments in terms of their ability to withstand stress. Important factors that can cause genotype-environment interactions include nutritional, climatic and disease stress. An indicator of the most serious form of genotype-environment interaction is a re-ranking of sires when progeny tested in different environments. Accordingly, an interesting issue in relation to adaptability to high altitude environments is the comparison of sire productivity based on offspring performance at Tybar ranch and the productivity of the same sires assessed using the American Angus Association performance data obtained across a range of environments over the nation, principally at low altitude.

Growth trait EPDs (birthweight, BWT; weaning weight direct WWD and maternal WWM; and yearling weight, YWT) were computed using a multi-trait animal model applied to Tybar data alone. The correlations were computed between the 132 sire EPDs from Tybar records and the corresponding EPDs from the American Angus Association. The correlations were 0.61, 0.42, 0.39 and 0.33 for BWT, WWD, WWM, YWT, respectively.

The correlations between sire EPDs in independent datasets provide an estimate of the genetic correlation between the two sets of circumstances, provided the evaluations are highly accurate in both datasets. In practice, the accuracy of the EPDs are less than perfect and the estimated correlation between EPDs will be biased downwards relative to the genetic correlation. Monte Carlo procedures can be used to construct the distribution of the expected correlation. This procedure can be adapted for independent or for datasets that demonstrate a part-whole relationship as is the situation in this case where the Tybar records contribute to the American Angus evaluation. Under the null hypothesis that the genetic correlation is unity between growth performance in Tybar productive circumstances and national average circumstances, the 5% critical values were 0.63, 0.65, 0.37 and 0.60 for the four traits respectively.

These results suggest that there is little evidence that BWT and WWM are different traits at Tybar compared to national circumstances. In contrast, the observed correlation in EPDs for WWD and YWT are much too low to have resulted from a unit genetic correlation. Treating the two datasets as independent, the genetic correlation between Tybar and national environments would have to be less than 0.74 for WWD and less than 0.66 for YWT for the observed correlations to be non significant at the 5% level.

There was no evidence that the re-ranking of sires for WWD and YWT was associated with their PAP EPDs. It might have been expected that the bulls with elevated PAP EPDs would have produced ill-adapted offspring for high altitude whose growth was inferior to the offspring of the same sires used as low altitude. Other aspects of the environment must have been responsible for ranking changes.

Enns, R.M. J.S. Brinks, R.M. Bourdon and T.G. Field. 1992. Heritability of pulmonary arterial pressures in Angus cattle. Proc. West. Sect. Amer. Soc. Animal Sci. 43:111-112.

Emerging Technology Committee
Friday, July 8, 2005
2:00 – 5:00 pm

Chair: Craig Hufflhines, American Hereford Association

Impact of Bovine Gene Sequencing Project on Seedstock Industry

Ronnie Green
USDA-ARS
National Program Leader

Consortium Update on Gene Marker Validation

Dick Quass
Cornell University
Ithaca, New York

Dr. Mark Allan- Feed Efficiency and Genomics at USDA-MARC

Mark Allan
USDA-Meat Animal Research Center
Clay Center, Nebraska

Breed Association Discussion Regarding Technology Integrity

Members to Be Determined

Genetic Predictions Committee

Friday, July 8, 2005
2:00 – 5:00 pm

Chair: Larry Cundiff, US Meat Animal Research Center

Across Breed EPD Update

L. Dale Van Vleck
USMARC, ARS, USDA
Lincoln, Nebraska

EPDs for Feed Efficiency

Dorian Garrick
Colorado State University
Fort Collins, Colorado

Including ET Animals in Genetic Evaluations

Keith Bertrand
University of Georgia
Athens, Georgia

Using DNA Parentage Testing in Genetic Evaluation

Robert Weaber
University of Missouri
Columbia, Missouri

Across-Breed EPD Tables for the Year 2005 Adjusted to Breed Differences for Birth Year of 2003

L. D. Van Vleck and L. V. Cundiff
Roman L. Hruska U.S. Meat Animal Research Center, ARS, USDA, Lincoln and Clay Center, NE 68933

Introduction

This report is the year 2005 update of estimates of sire breed means from data of the Germplasm Evaluation (GPE) project at the U.S. Meat Animal Research Center (MARC) adjusted to a year 2003 base using EPD from the most recent national cattle evaluations. Factors to adjust EPD of 16 breeds to a common birth year of 2003 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 MILK component of maternal weaning weight (MWWT).

Some changes from the 2004 update (Van Vleck and Cundiff, 2004) are as follows:

Records from USMARC for birth, weaning, and yearling weight were the same as last year. The EPDs from the Maine-Anjou national cattle evaluations were computed with a new base which causes major changes in the across-breed adjustment factors for Maine-Anjou weights and maternal milk.

A considerable number of maternal records (weaning weights of grandprogeny) were added again this year, ranging from about 190 for Hereford and Angus to about 75 for Simmental, Limousin, Charolais, Gelbvieh, and Red Angus. For the first time, maternal records for Brangus (62) and Beefmaster (71) were included.

1) For BWT, the MARC records were the same as last year so any changes from the analysis done last year will be due to EPDs reported by the breed associations. The new Maine-Anjou base resulted in a change in the across-breed adjustment factor from 6.7 to 6.3 lb. The base year for Angus was changed from 1979 to 1982. Their model also was changed to include maternal genetic effects.

2) For WWT, the MARC records were also the same as last year. The new Maine-Anjou base changed that adjustment factor from 17.6 to -5.3 lb.

3) For YWT, the same animals had records at MARC as last year. The new Maine-Anjou base changed the across-breed adjustment factor from 5.5 to -41.7 lb.

4) a) About 190 maternal weaning weights for both Hereford and Angus grandsires and about 75 for Simmental, Limousin, Charolais, Gelbvieh and Red Angus grandsires were added to the maternal analysis. Changes in the across-breed adjustments were not large except for that due to the Maine-Anjou base change (from 7.6 to -9.4 lb).
   b) The second crop of Brangus and Beefmaster sired heifers had calves with weaning weights available this year and so for the first time are included in the maternal milk analyses (62 and 71 grandprogeny, respectively).

The across-breed table adjustments apply **only** to EPDs for most recent (in most cases: spring, 2005) 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 adjusts 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 MARC.
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 3,404 weaning weight records of 795 daughters representing 174 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 23.20 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 (1/4) (3.01) added to its birth weight. A Red Poll sired calf of an Angus by MARC III dam would have (1/8) (14.70) plus (1/4) (23.20) 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 (1997–2004). 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 MARC 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 (21) of dam (1970-76, 86-90, 92-94, 97-99, and 2000-02) by damline combination (101) 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 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 (4,630 dams for BWT, 4,395 for WWT, 4,243 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 later to adjust for genetic trend and bulls used at MARC.

The fixed effects for the analysis of maternal effects included breed of maternal grandsire (17 including Pinzgauer), maternal grandam line (Hereford, Angus, MARC III), breed of natural service mating sire (17), sex of calf (2), birth year-GPE cycle-age of dam subclass (84), and mating sire breed by GPE cycle by age of dam subclass (45) with a covariate for day of year of birth. The subclasses are used to account for confounding of years, mating sire breeds, and age 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 (618) and dam (3,196 daughters of the maternal grandsires). Mating sires were unknown within breed. For estimation of regression coefficients of grandprogeny 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 MARC Solutions

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

MARC breed of sire solution for breed i (MARC (i)) adjusted for genetic trend (as if bulls born in the base year had been used rather than the bulls actually used):

$$M_i = MARC(i) + b[EPD(i)_{YY} - EPD(i)_{MARC}].$$

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

$$A_i = (M_i - M_x) - (EPD(i)_{YY} - EPD(x)_{YY})$$

where,

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

$EPD(i)_{YY}$ 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 = 2003 for the 2005 update),

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

b is the pooled coefficient of regression of progeny performance at MARC on EPD of sire (for 2005: 1.03, 0.85, and 1.13 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.

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

$$MWWT(i) = MARC(i)_{MGS} + b_{wwt}[EPD(i)_{YYWWT} - EPD(i)_{MARCWWT}] + b_{MILK}[EPD(i)_{YYMLK} - EPD(i)_{MARCMLK}]$$

MARC breed of maternal grandsire solution (MWWT(i)) adjusted for genetic trend and direct genetic effect:

$$MILK(i) = [MWWT(i) - 0.5\,M(i)] - [\overline{MWWT} - 0.5\,\overline{M}]$$

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

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

where,

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

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

$EPD(i)_{MARCWWT}$ is the weighted (by number of grandprogeny at MARC) average of EPD for WWT of MGS of breed i having grandprogeny with records at MARC,

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

$EPD(i)_{MARCMLK}$ is the weighted (by number of grandprogeny at MARC) average of EPD for MILK of MGS of breed i having grandprogeny with records at MARC.

b_{WWT}, b_{MLK} are the coefficients of regression of performance of MARC grandprogeny on MGS EPD for WWT and MILK (for 2005: 0.58 and 1.14).

$M(i) = M_i$ is the MARC breed of sire solution from the first analysis of direct breed of sire effects for WWT adjusted for genetic trend.

$\overline{MWWT}$ and $\overline{M}$ are unneeded constants corresponding to unweighted averages of MWWT(i) and M(i) for i = 1..... 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, MARC analyses to estimate breed of sire differences and the adjustments to the breed of sire effects to a year 2003 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 many breeds are continuing to become more similar to the arbitrary base breed, Angus. Most of the other breeds have not changed much relative to each other. Column 7 of Tables 1-3 and column 10 of Table 4 represent the best estimates of breed differences for calves born in 2003. These pairs of differences minus the corresponding differences in average EPD for animals born in 2003 result in the last column of the tables to be used as adjustment factors for pairs of sires with within-breed EPD.

Birth Weight

The range in estimated breed of sire differences for BWT relative to Angus is large: from 1.1 lb for Red Angus to 9.0 lb for Charolais and 11.9 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. Differences from Angus were only slightly changed from the 2004 update (Van Vleck and Cundiff, 2004) but most of the changes continue generally a trend to slightly smaller differences from Angus.

Suppose the EPD for birth weight for a Charolais bull is +2.0 (which is above the year 2003 average of 1.4 for Charolais) and for a Hereford bull is also +2.0 (which is below the year 2003 average of 3.7 for Herefords). The across-breed adjustment factors in the last column of Table 1 are 2.9 for Hereford and 10.0 for Charolais. Then the adjusted EPD for the Charolais bull is 10.0 + 2.0 = 12.0 and for the Hereford bull is 2.9 + 2.0 = 4.9. The expected birth weight difference when both are mated to another breed of cow, e.g., Angus, would be 12.0 - 4.9 = 7.1 lb.

Weaning Weight

Weaning weights also seem to be becoming more similar for the breeds when used as sire breeds. Most of the changes between the year 2004 and 2005 updates were less than 2 lb. All except three sire breed means for WWT adjusted to year of birth of 2003 are within about 10 lb of the Angus mean.

Yearling Weight

Changes in adjusted differences from Angus from the 2004 update were generally to become more similar to Angus. Adjusted to a base year of 2003, Angus have heavier yearling weights than 10 breeds (10.4 to 50.0 lb), lighter yearling weights than 2 breeds (11.1 and 18.2 lb), and slightly heavier than 3 breeds (1.1 to 3.1 lb).

MILK

The changes from last year for MILK compared to Angus for the current base year were generally small. Comparison of Hereford and Angus changed somewhat. The greatest changes in the across-breed adjustment factors were for Maine-Anjou which changed its base.

Table 5 summarizes the average Beef Improvement Federation (BIF) accuracy for bulls with progeny at MARC weighted appropriately by number of progeny or grandprogeny. South Devon bulls had relatively small accuracy for all traits as did Hereford, Brahman, and Maine-Anjou bulls. Braunvieh bulls had low accuracy for milk. The accuracy values for Brangus are relatively high. 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 MARC 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 1.03 for BWT, 0.85 for WWT, and 1.13 for YWT were used to adjust breed of sire solutions to the base year of 2003. 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 MARC herd and of progeny in herds contributing to the national genetic evaluations of the 16 breeds. The regression coefficient for Angus birth weight EPDs changed from 1.02 last year to 0.86 this year. The reason is that the American Angus Association has now added maternal effects to the model they use for calculating EPD for birth weight.

The regression coefficient for female progeny on sire EPDs for YWT was 0.98 compared to 1.26 for steers. These differences are probably expected because postweaning average daily gains for heifers 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. For reasons that have never been clear, the regressions for sex used to fluctuate widely from year to year, but for the past few years the pattern has been fairly consistent (female estimates have ranged from 0.93 to 1.02; while male estimates have ranged from 1.26 to 1.32).

The coefficients of regression of records of grandprogeny 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. The standard errors for the regression coefficients by breed are large except for Angus and Hereford. The standard errors for regression coefficients over all breeds of grandsires associated with heifers and steers overlap for MILK EPDs. Again, the pooled regression coefficients of 0.58 for MWWT and 1.14 for MILK are reasonably close to the expected regression coefficients of 0.50 and 1.00, respectively.

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 MARC 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):

$$(29.0 + 15.0) - (-1.8 + 30.0) = 44.0 - 28.2 = 15.8.$$

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 2003 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:

$\text{SEP(difference)} = \sqrt{0 + 75 + 50} = 11.2$ 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.

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Table 1. Breed of sire solutions from MARC, mean breed and MARC EPD used to adjust for genetic trend to the year 2003 base and factors to adjust within breed EPD to an Angus equivalent – BIRTH WEIGHT (lb)

	Number		Raw MARC Mean	Ave. Base EPD		Breed Soln at MARC		Adjust to 2003 Base		Factor to adjust EPD To Angus
Breed	Sires	Progeny	(1)	Breed 2003 (2)	MARC Bulls (3)	+ Ang (4)	vs Ang (5)	+ Ang (6)	vs Ang (7)	(8)
Hereford	113	1817	87	3.7	2.5	88	3.6	89	4.2	2.9
Angus	105	1421	84	2.4	1.7	84	0.0	85	0.0	0.0
Shorthorn	25	181	87	1.8	0.8	90	6.4	91	6.7	7.3
South Devon	15	153	80	0.1	-0.2	88	4.3	89	3.9	6.2
Brahman	40	589	98	1.8	0.7	96	11.6	97	11.9	12.5
Simmental	48	623	87	1.8	2.7	91	7.0	90	5.3	5.9
Limousin	40	589	83	2.2	0.7	87	3.0	89	3.8	4.0
Charolais	75	675	89	1.4	0.4	93	8.8	94	9.0	10.0
Maine-Anjou	18	218	94	2.6	5.8	95	10.6	91	6.5	6.3
Gelbvieh	48	595	89	1.8	1.1	88	4.1	89	4.1	4.7
Tarentaise	7	199	80	2.2	1.8	87	3.2	88	2.9	3.1
Salers	27	189	85	1.2	1.8	88	4.4	88	3.0	4.2
Red Angus	21	206	85	0.4	-0.8	85	0.6	86	1.1	3.1
Braunvieh	7	188	88	1.1	0.8	89	5.1	89	4.7	6.0
Brangus	21	215	91	2.1	2.5	90	5.9	90	4.8	5.1
Beefmaster	21	214	96	0.4	0.8	92	8.3	92	7.2	9.2

Calculations:

(4) = (5) + (1, Angus)

(6) = (4) + b[(2) – (3)] with b = 1.03

(7) = (6) – (6, Angus)

(8) = (7) – (7, Angus) – [(2) – (2, Angus)]

Table 2. Breed of sire solutions from MARC, mean breed and MARC EPD used to adjust for genetic trend to the year 2003 base and factors to adjust within breed EPD to an Angus equivalent – WEANING WEIGHT (lb)

	Number		Raw MARC Mean	Ave. Base EPD		Breed Soln at MARC		Adjust to 2003 Base		Factor to adjust EPD To Angus
				Breed 2003	MARC Bulls	+ Ang vs Ang		+ Ang vs Ang		
Breed	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hereford	112	1712	503	36.0	22.6	501	-2.7	513	-2.8	-1.8
Angus	106	1315	504	37.0	23.5	504	0.0	516	0.0	0.0
Shorthorn	25	170	521	13.2	6.6	518	14.1	524	8.2	32.0
South Devon	15	134	443	19.2	0.1	503	-0.6	520	4.1	21.9
Brahman	40	509	532	14.2	4.5	520	16.1	528	12.8	35.6
Simmental	47	564	505	33.4	23.6	526	22.4	535	19.2	22.8
Limousin	40	533	477	35.5	20.7	503	-0.8	516	0.3	1.8
Charolais	74	600	514	19.2	8.4	527	23.3	537	21.0	38.8
Maine-Anjou	18	197	459	38.8	47.0	519	15.1	512	-3.5	-5.3
Gelbvieh	48	559	507	40.0	32.3	518	14.3	525	9.3	6.3
Tarentaise	7	191	476	12.0	-4.8	507	2.7	521	5.6	30.6
Salers	27	176	525	15.2	7.0	516	11.7	523	7.2	29.0
Red Angus	21	199	535	29.0	27.2	505	1.0	507	-9.0	-1.0
Braunvieh	7	183	451	7.0	7.3	516	12.0	516	0.2	30.2
Brangus	21	208	550	23.1	26.7	524	20.3	521	5.7	19.6
Beefmaster	22	215	563	6.0	13.3	530	26.3	524	8.5	39.5

Calculations:

(4) = (5) + (1, Angus)

(6) = (4) + b[(2) – (3)] with b = 0.85

(7) = (6) – (6, Angus)

(8) = (7) – (7, Angus) – [(2) – (2, Angus)]

Table 3. Breed of sire solutions from MARC, mean breed and MARC EPD used to adjust for genetic trend to the year 2003 base and factors to adjust within breed EPD to an Angus equivalent – YEARLING WEIGHT (lb)

Breed	Number Sires	Number Progeny	Raw MARC Mean (1)	Ave. Base EPD Breed 2003 (2)	Ave. Base EPD MARC Bulls (3)	Breed Soln at MARC + Ang vs Ang (4)	Breed Soln at MARC + Ang vs Ang (5)	Adjust to 2003 Base + Ang vs Ang (6)	Adjust to 2003 Base + Ang vs Ang (7)	Factor to adjust EPD To Angus (8)
Hereford	112	1627	852	61.0	38.6	852	-20.0	877	-21.7	-14.2
Angus	106	1257	872	68.5	44.6	872	0.0	899	0.0	0.0
Shorthorn	25	168	918	20.7	12.9	887	15.0	896	-3.1	44.7
South Devon	15	134	744	26.1	0.1	868	-3.7	898	-1.4	41.0
Brahman	40	438	838	23.4	8.2	832	-40.1	849	-50.0	-4.9
Simmental	47	528	852	57.8	38.9	889	16.7	910	11.1	21.8
Limousin	40	527	797	66.7	42.1	849	-23.3	876	-22.6	-20.8
Charolais	74	566	882	33.5	15.7	897	25.1	917	18.2	53.2
Maine-Anjou	18	196	787	77.4	93.4	884	12.3	866	-32.8	-41.7
Gelbvieh	48	555	849	73.0	58.0	864	-7.8	881	-17.8	-22.3
Tarentaise	7	189	807	23.0	-3.4	837	-35.2	867	-32.4	13.1
Salers	27	173	899	25.1	9.1	880	7.8	898	-1.1	42.3
Red Angus	21	194	916	52.0	46.9	877	5.4	883	-15.8	0.7
Braunvieh	7	182	737	8.0	11.8	856	-16.4	851	-47.7	12.8
Brangus	21	152	977	38.2	44.9	896	24.1	889	-10.4	19.9
Beefmaster	22	157	991	10.5	23.3	893	20.9	878	-20.5	37.5

Calculations:

(4) = (5) + (1, Angus)

(6) = (4) + b[(2) – (3)] with b = 1.13

(7) = (6) – (6, Angus)

(8) = (7) – (7, Angus) – [(2) – (2, Angus)]

Table 4. Breed of maternal grandsire solutions from MARC, mean breed and MARC EPD used to adjust for genetic trend to the year 2003 base and factors to adjust within-breed EPD to an Angus equivalent – MILK (lb)

Breed	Number MGS	Number Gpr	Number Daughters	Raw MARC Mean (1)	Mean EPD Breed WWT (2)	Mean EPD Breed MILK (3)	Mean EPD MARC WWT (4)	Mean EPD MARC MILK (5)	Breed Soln at MARC MWWT Ang (6)	Breed Soln at MARC MWWT vs Ang (7)	Adjust to 2003 Base MWWT Ang (8)	Adjust to 2003 Base MWWT vs Ang (9)	MILK (10)	Factor to Adjust MILK EPD to Angus (11)
Hereford	108	2758	709	479	36.0	14.0	20.8	6.8	478	-20.5	495	-25.2	-17.1	-18.8
Angus	104	2013	530	498	37.0	19.0	19.3	8.9	498	0.0	520	0.0	6.8	0.0
Shorthorn	22	251	69	527	13.2	2.4	6.5	6.8	521	23.3	520	0.4	3.1	12.9
South Devon	14	347	69	488	19.2	7.1	0.0	5.5	501	3.5	514	-5.4	-0.7	4.5
Brahman	40	880	216	522	14.2	6.3	4.7	2.9	529	31.0	538	18.7	19.0	24.9
Simmental	47	1058	239	515	33.4	5.5	21.4	8.1	522	24.0	526	6.3	3.4	10.1
Limousin	40	1033	240	482	35.5	18.8	18.5	16.0	490	-7.6	504	-16.3	-9.6	-16.2
Charolais	68	966	235	504	19.2	6.1	6.5	3.2	509	10.5	519	-0.6	-4.3	1.8
Maine-Anjou	17	485	86	533	38.8	19.2	46.3	22.0	516	18.4	509	-10.9	-2.4	-9.4
Gelbvieh	46	916	232	530	40.0	18.0	32.1	17.3	520	22.4	526	6.1	8.2	2.4
Tarentaise	6	341	78	513	12.0	1.5	-6.0	4.7	517	18.6	523	3.6	7.6	18.3
Salers	25	351	87	534	15.2	8.4	5.5	11.9	521	23.0	523	2.9	6.1	9.9
Red Angus	21	261	89	489	29.0	16.0	27.2	13.9	502	4.0	505	-14.3	-3.0	-6.8
Braunvieh	7	502	92	542	7.0	0.0	7.9	-0.4	523	25.4	523	3.5	10.2	22.4
Brangus	18	62	42	502	23.1	9.7	25.9	4.3	505	7.2	510	-10.0	-6.1	-3.6
Beefmaster	20	71	50	509	6.0	2.0	14.8	-1.2	504	5.9	502	-17.3	-14.8	-4.6

Calculations:

(6) = (7) + (1, Angus); (8) = (6) + b_{WWT}[(2) – (4)] + b_{MLK} [(3) – (5)] with b_{WWT} = 0.58 and b_{MLK} = 1.14; (9) = (8) – (8, Angus);

(10) = [(9) – Average (9)] – 0.5[(7, Table 2) – Average (7, Table 2)]; (11) = [(10) – (10, Angus)] – [(3) – (3, Angus)].

Table 5. Mean weighted[a] accuracies for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), maternal weaning weight (MWWT) and milk (MILK) for bulls used at MARC

Breed	BWT	WWT	YWT	MWWT	MILK
Hereford	0.57	0.54	0.49	0.51	0.49
Angus	0.72	0.75	0.69	0.71	0.62
Shorthorn	0.82	0.80	0.74	0.82	0.79
South Devon	0.37	0.39	0.38	0.41	0.41
Brahman	0.50	0.55	0.37	0.55	0.42
Simmental	0.94	0.93	0.93	0.94	0.93
Limousin	0.92	0.89	0.82	0.90	0.84
Charolais	0.71	0.65	0.56	0.64	0.55
Maine-Anjou	0.72	0.71	0.71	0.71	0.71
Gelbvieh	0.72	0.66	0.50	0.70	0.57
Tarentaise	0.95	0.95	0.94	0.95	0.95
Salers	0.83	0.83	0.77	0.82	0.83
Red Angus	0.87	0.85	0.84	0.84	0.81
Braunvieh	0.84	0.85	0.83	0.85	0.77
Brangus	0.80	0.78	0.64	0.81	0.63
Beefmaster	0.63	0.72	0.57	0.75	0.58

[a]Weighted by number of progeny at MARC for BWT, WWT, and YWT and by number of grandprogeny for MWWT and MILK.

Table 6. REML estimates of variance components (lb^2) for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), and maternal weaning weight (MWWT) from mixed model analyses

	Direct			Maternal
Analysis[a]	BWT	WWT	YWT	MWWT
Direct				
Sires (650) within breed (17)	11.4	152	631	
Dams (4395) within breed (3)	26.6	876	1233	
Residual	68.2	1535	4037	
Maternal				
MGS (618) within MGS breed (17)				197
Daughters within MGS (3196)				937
Residual				1342

[a]Numbers for weaning weight.

Table 7. Pooled regression coefficients (lb/lb) for weights at birth (BWT), 205 days (WWT), and 365 days (YWT) of F_1 progeny on sire expected progeny difference and by sire breed, dam breed, and sex of calf

	BWT	WWT	YWT
Pooled	1.03 ± 0.05	0.85 ± 0.05	1.13 ± 0.05
Sire breed			
Hereford	1.18 ± 0.08	0.79 ± 0.07	1.12 ± 0.07
Angus	0.86 ± 0.10	0.79 ± 0.10	1.16 ± 0.08
Shorthorn	0.68 ± 0.48	0.77 ± 0.43	1.18 ± 0.34
South Devon	0.91 ± 0.57	-0.15 ± 0.36	-0.05 ± 0.40
Brahman	1.82 ± 0.26	1.11 ± 0.26	0.69 ± 0.24
Simmental	1.05 ± 0.22	1.24 ± 0.17	1.29 ± 0.15
Limousin	0.68 ± 0.17	0.55 ± 0.16	1.17 ± 0.15
Charolais	1.03 ± 0.14	0.95 ± 0.13	0.91 ± 0.12
Maine-Anjou	1.07 ± 0.37	0.51 ± 0.48	0.17 ± 0.49
Gelbvieh	1.01 ± 0.16	1.24 ± 0.27	1.34 ± 0.22
Tarentaise	0.67 ± 0.89	0.76 ± 0.55	1.38 ± 0.61
Salers	1.19 ± 0.38	0.98 ± 0.45	0.77 ± 0.45
Red Angus	0.54 ± 0.19	0.56 ± 0.34	0.75 ± 0.30
Braunvieh	0.47 ± 0.37	0.86 ± 0.82	2.05 ± 0.54
Brangus	1.44 ± 0.34	0.80 ± 0.44	0.47 ± 0.40
Beefmaster	1.61 ± 0.57	1.47 ± 0.38	1.60 ± 0.43
Dam breed			
Hereford	0.92 ± 0.08	0.79 ± 0.08	0.99 ± 0.07
Angus	1.12 ± 0.06	0.89 ± 0.06	1.17 ± 0.06
MARC III	0.98 ± 0.08	0.86 ± 0.09	1.20 ± 0.09
Sex of calf			
Heifers	1.01 ± 0.06	0.95 ± 0.06	0.98 ± 0.06
Steers	1.05 ± 0.06	0.76 ± 0.06	1.26 ±.0 06

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 grandam, and sex of calf

Type of regression	MWWT	MILK
Pooled	0.58 ± 0.04	1.14 ± 0.06
Breed of maternal grandsire		
Hereford	0.55 ± 0.06	1.12 ± 0.11
Angus	0.57 ± 0.09	1.06 ± 0.12
Shorthorn	0.33 ± 0.37	0.93 ± 0.49
South Devon	0.30 ± 0.24	-1.22 ± 0.85
Brahman	0.46 ± 0.20	0.53 ± 0.33
Simmental	0.78 ± 0.17	1.15 ± 0.41
Limousin	1.20 ± 0.13	1.97 ± 0.24
Charolais	0.44 ± 0.11	1.38 ± 0.20
Maine-Anjou	0.13 ± 0.34	0.48 ± 0.38
Gelbvieh	0.87 ± 0.23	1.50 ± 0.33
Tarentaise	0.20 ± 0.68	0.76 ± 0.82
Salers	0.90 ± 0.32	2.26 ± 0.36
Red Angus	0.95 ± 0.30	1.68 ± 0.34
Braunvieh	– ± –	3.13 ± 0.71
Brangus	0.59 ± 0.91	0.88 ± 0.82
Beefmaster	0.95 ± 0.76	3.50 ± 0.76
Breed of maternal grandma		
Hereford	0.55 ± 0.06	1.58 ± 0.10
Angus	0.61 ± 0.05	1.03 ± 0.09
MARC III	0.56 ± 0.08	0.88 ± 0.10
Sex of calf		
Heifers	0.58 ± 0.05	1.13 ± 0.08
Steers	0.58 ± 0.05	1.14 ± 0.08

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

Breed	HE	AN	SH	SD	BR	SI	LI	CH	MA	GE	TA	SA	RA	BV	BS	BM
HE	0.0	0.2	0.8	1.4	0.5	0.5	0.5	0.4	1.0	0.4	2.6	0.8	0.8	1.2	0.9	1.0
AN	14	0.0	0.9	1.4	0.5	0.5	0.5	0.4	1.1	0.5	2.6	0.8	0.8	1.2	0.9	1.0
SH	53	55	0.0	2.0	1.2	1.1	1.2	1.0	1.6	1.0	3.1	1.1	1.4	1.7	1.7	1.7
SD	82	83	122	0.0	1.7	1.3	1.4	1.3	2.1	1.6	3.7	1.9	1.8	2.3	2.2	2.3
BR	36	37	78	110	0.0	0.9	0.9	0.8	1.3	0.8	2.6	1.1	1.2	1.5	1.3	1.4
SI	28	29	69	79	56	0.0	0.5	0.5	1.3	0.6	2.8	1.1	0.8	1.4	1.3	1.3
LI	31	32	72	82	58	30	0.0	0.5	1.3	0.7	2.9	1.1	0.8	1.5	1.3	1.4
CJ	24	25	61	81	52	29	31	0.0	1.2	0.5	2.7	0.9	0.8	1.3	1.2	1.3
MA	62	64	97	127	86	75	78	71	0.0	1.0	3.2	1.5	1.6	1.1	1.9	1.9
GE	28	30	63	95	54	37	39	34	62	0.0	2.8	0.9	0.8	1.2	1.2	1.3
TA	151	154	188	219	158	167	170	163	191	164	0.0	3.1	3.2	3.4	3.4	3.5
SA	49	51	70	118	74	66	68	57	93	60	184	0.0	1.4	1.7	1.6	1.7
RA	46	46	88	110	75	49	51	48	95	52	188	84	0.0	1.7	1.5	1.6
BV	69	72	105	135	93	83	85	79	67	69	198	101	102	0.0	2.0	2.1
BS	65	65	113	141	96	85	87	82	122	85	212	109	99	129	0.0	1.0
BM	66	66	115	142	97	86	89	83	123	87	213	111	102	131	77	0.0

[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 53 + 300 + 200 = 553 with SEP = $\sqrt{553}$ = 23.5.

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

Breed	HE	AN	SH	SD	BR	SI	LI	CH	MA	GE	TA	SA	RA	BV	BS	BM
HE	0	4	19	28	11	9	10	8	22	9	42	18	17	24	20	20
AN	13	0	20	28	11	10	10	8	23	9	43	18	17	25	20	20
SH	50	52	0	43	27	25	26	22	36	23	56	26	33	38	38	38
SD	58	59	98	0	36	27	28	27	45	32	66	42	39	47	46	46
BR	25	26	66	75	0	18	18	16	29	16	43	25	26	31	29	29
SI	25	26	65	60	42	0	10	9	27	12	48	24	18	29	27	27
LI	27	28	67	62	44	31	0	10	28	13	48	25	18	29	28	28
CJ	21	22	58	59	38	27	29	0	26	11	46	21	18	27	26	26
MA	55	57	93	101	70	69	70	64	0	22	58	35	35	24	41	41
GE	23	24	59	68	39	34	35	29	58	0	46	21	19	23	27	27
TA	123	126	161	171	127	139	140	134	164	135	0	55	56	59	60	60
SA	41	44	70	89	58	57	58	50	84	50	153	0	31	37	36	37
RA	45	46	85	88	62	51	52	48	89	51	159	77	0	37	34	34
BV	81	83	119	127	97	95	96	90	95	84	190	110	115	0	42	42
BS	85	85	129	135	103	102	104	98	133	100	202	120	121	160	0	21
BM	75	75	119	125	93	92	94	88	123	90	192	110	111	150	115	0

Formulating and Using EPDs to Improve Feed Efficiency

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Many producers have been communicating their apparent need for an EPD to reflect feed efficiency. Over the last few decades, the nature and scope of traits for which EPDs have been generated or sought has grown from output-based characteristics (eg weaning and yearling weights), to include carcass and meat quality attributes (eg marbling and fat depth) and most recently, reproductive characteristics (eg heifer pregnancy and stayability). Producers have recognized that feed requirements are a major determinant of the likely stocking rate in extensive cow-calf circumstances and a significant component of the finishing costs of cattle. Some breeders have attempted to collect intake records with a view to gaining information on efficiency of conversion of feed into beef.

Common measures of feed efficiency used in intensive industries such as poultry and pork production include gain per unit of feed and its reciprocal feed per unit of gain. A natural use for individual feed intake information for an interested breeder is therefore to calculate such a ratio based on phenotypic performance for phenotypic selection, or to calculate an EPD using the phenotypic ratios.

Animal breeders have long recognized the theoretically undesirable properties of ratio traits (Gunsett, 1987) and known that index selection based on inputs and outputs is a more effective method of improving efficiency. Recent research (MacNeil, 2005) has demonstrated the theoretical result in the context of improving beef cattle efficiency.

The logical development of an index approach begins with the definition of a breeding goal. We will limit our consideration to breeding goals that emphasize profit. The next step is to list the traits that influence the breeding goal (Harris et al., 1984). Recalling the definition of profit as income minus costs, the list of traits should include measures of output (eg sale weight) and measures of input (eg feed requirements). It does not make sense to include feed efficiency in the list, as that would represent double counting since the outputs and the inputs that comprise the definition of feed efficiency are already in our list of traits.

The next step in the logical development of a breeding program is to determine the relative emphasis of each trait in the list. This involves quantifying the answer to the following question "how much does profit change for a unit change in this trait, all other traits in the list held constant". At this point, any double counting of traits in the previous step should become apparent. Suppose our list of traits had included weaning weight, feed costs and feed efficiency. We would need to answer the question, "how much does income and therefore profit increase if weaning weight increased by 1 lb with no change to feed requirements or feed efficiency". The answer would be the expected sale price per lb. We would then need to answer the question "how much does expenses and therefore profit change with a unit increase in feed requirements with no change in sale weight or feed efficiency". The answer would be the feed cost. Finally, we would need to answer the question, "how much does profit change if there was a unit change in feed efficiency with no change in sale weight or feed requirements". The answer is there would be no change in profit since the determinants of income and expenses would be unchanged.

Indexes are constructed by summing up the values obtained by multiplying each EPD by its influence on profit, known as the relative economic value. Given the relative economic value for feed efficiency is zero, a feed efficiency EPD would get no emphasis in an index with profit as a goal. Productivity would get rewarded based on the value of extra production, and feed requirements would get penalized based on the cost of any additional feed required. The animals with the highest index values would be those with the greatest net income, or sale value less costs. These are the most economically efficient animals. Hence this index would improve economic efficiency. It would also be expected to increase biological efficiency. The reverse is not necessarily true. That is, selection for an efficiency ratio will not necessarily improve profit. This can be demonstrated by the trivial example with three animals shown in Table 1.

The rancher with a goal based on individual animal profit would clearly prefer the sire Romeo over Oscar and Papa. However, the rancher with an efficiency ratio mindset would prefer Papa. Papa has a higher ratio than Oscar, even though it achieves the same profit. Romeo has a lower (less favorable) ratio but higher profit. The conclusion is that if your goal is profit, it is better to select on an index of profit than on a ratio of input and output components.

Selection objectives developed for various Breed Associations and other organizations by Dr Mike MacNeil (Charolais, Circle-A Angus Sire Alliance, Hereford, Limousin and Simmental) reward productive animals but recognize increases in feed requirements associated with faster growth or larger mature size bring associated costs. Such indexes will increase feed efficiency, principally by diluting maintenance. The decision support software developed by the National Beef Cattle Evaluation Consortium (ert.agsci.colostate.edu) uses EPDs to predict the productive and economic consequences of using particular animals as sires, within the context of a particular production, management and economic circumstance. That software identifies the changes in productivity and the changes in feed requirements. It provides the user with two options regarding the valuation of feed. The number of animals that can be managed to consume the same amount of feed that the existing herd requires can be calculated by the system, a method of valuing feed based on its opportunity cost (Garrick, 2002). Alternatively, the number of breeding cows can be kept constant and any increase (decrease) in feed requirements can be met by feed purchases (sales) at a user-input price.

Some ranchers/feedlotters are motivated to consider the concept of individual efficiency ratios primarily when they have means to record individual feed intake. However, nutritionists have been researching and publishing models (NRC 1996) to predict feed requirements on the basis of maintenance, growth rate, composition of gain, pregnancy and lactation for at least a century. Accordingly, feed requirements of individual animals can be estimated from many of the routinely recorded performance attributes. It is therefore not necessary to observe and record individual feed intake in order to account for the expected feed requirements of animals from the same cohort or contemporary group that differ in productivity. Observed feed intake measures are typically more costly to obtain than feed requirements predicted from performance and have the disadvantage of including measurement errors. However, they do provide the means of identifying sires whose offspring consistently consume more or less than is expected. Such difference between observed and expected feed intake are known as residual feed intakes or RFI.

The US beef cattle industry, along with those in most other countries, does not currently have any national system to collect or manage feed intake measurements. From the perspective of national evaluations, even if the US did have such a system, there is no agreed approach to utilize that information. It has already been argued in this document that it makes little sense to produce EPDs for some ratio trait such as feed efficiency. It does make sense to rank animals for profit including the costs associated with feed intake. One alternative would be to produce an EPD for feed intake. This could be calculated from production records of growth and performance for some animals and from phenotypic observations on feed intake on others. Such an evaluation would nee to be done in a multitrait setting, so that bulls with many performance recorded offspring would have an upper limit on the accuracy of their feed requirement EPD. Alternatively, decision support models and selection indexes could account for expected intake, in the same manner as they do today, and EPDs could be produced for RFI. Such EPDs could be readily taken into account in the selection index or decision support approach. In any event, standardized approaches need to be developed for the collection of feed intake data. Furthermore, there are many alternative approaches to predict RFI from feed intake data. An approved method needs to be agreed upon and communicated. Where collected, raw feed intake measures rather than computed RFI should be stored on databases, in order that different methods of computing RFI could be implemented in the future. The National Beef Cattle Evaluation Consortium is currently debating many of these issues. There is a role for BIF in this regard, to standardize and communicate the outcome of such deliberations.

Table 1. Output, input, profit and efficiency ratios of three candidate sires for selection.

Bull ID	Output ($/dtr[1])	Input ($/dtr)	Net Income[2]	Efficiency[3]
Oscar	$500	$200	$300	2.5
Papa	$400	$100	$300	4.0
Romeo	$750	$300	$450	2.5

[1] Output and input are expressed in financial terms, per daughter (dtr).

[2] Net income is the value of the outputs column less the cost of inputs column and may not be the same as profit which typically includes other fixed costs.

[3] Efficiency is defined here as the ratio of outputs to inputs ($/$). In this case, higher ratios are desirable. It could equally be defined in other units such as lb/lb or as its reciprocal, inputs/outputs, in which case lower values would be desirable.

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FRANK H. BAKER

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

Frank H. Baker
photograph of portrait in Saddle and Sirloin Club Gallery – Everett Raymond Kinstler, Artist

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.

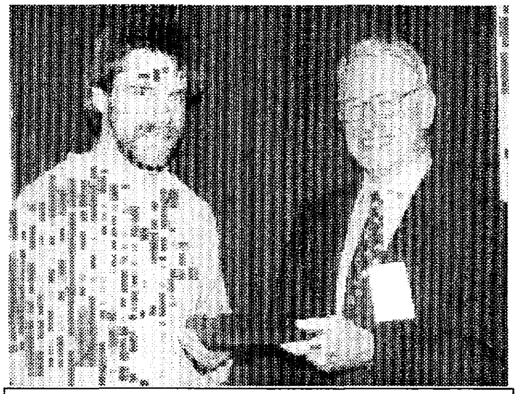
Frank Baker received many awards in his career, crowned by having his portrait hung in the Saddle and Sirloin Club Gallery at the International Livestock Exposition, Louisville, Kentucky, on November 16, 1986. His ability as a statesman and diplomat for the livestock industry was to use his vision to 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 Ríos-Utrera	University of Nebraska	2004
Matthew A. Cleveland	Colorado State University	2005
David P. Kirschten	Cornell University	2005

2004 Frank Baker Award Recipients

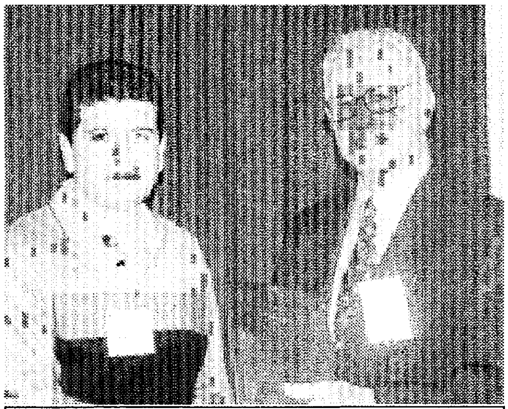
Reynold Bergen – University of Guelph



Reynold Bergen (left) receives the 2004 Frank Baker Award from S.R. Evans, 2004 BIF President.

Essay Title: *The Genetic Improvement of Carcass Composition in Beef Cattle*

Angel Ríos-Utrera – University of Nebraska-Lincoln



Angel Rios-Utrera (left) receives the 2004 Frank Baker Award from S.R. Evans, 2004 BIF President.

Essay Title: *Genetic Evaluation of Carcass Traits: Looking at the Effects of Slaughter End Points*

Using Days to Finish EPD to Identify Optimum Finish Endpoints for Profit Optimization in Post-Weaning Beef Production

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INTRODUCTION

There are 38 branded beef programs currently certified by the USDA (Agricultural Marketing Service, 2005) and countless other marketing options available from packers and alliances. As many as 50% of fed cattle are sold nationwide using a formula or grid, a figure that may go as high as 75% by the end of the decade (CattleFax, 2002). An increasing number of beef producers are moving to systems that reward quality cattle and they are faced with the challenge of efficient production that meets the needs of the packer (and ultimately the consumer) while maintaining their own profitability. An important contribution to that efficiency, in part, will be a focus on developing new selection and management tools for improving profitability in the post-weaning phase of production.

Adoption of new marketing strategies has increased the focus on genetic improvement of carcass traits and subsequent research has shown the benefits of grids and alliance programs to producers of quality cattle, when pertinent performance data is available. Schroeder and Graff (1999) and Koontz, et al. (2000) showed that cattle managed appropriately to a target finish endpoint and marketed on a grid were much more profitable than if they had been sold on a live basis. Other research has also supported the economic benefits from properly managed cattle in value-based marketing systems (Cooper, et al., 1999; Gresham et al., 2001; Trenkle, 2001). Cattle fed to an optimum compositional endpoint will be more profitable to the producer.

Traditionally many fed cattle have been marketed at a time-constant or a perceived finish-constant endpoint based on expected pen averages. This suggests that some are under-valued and others over-valued when sold on a live basis (Rathwell, 2000). Under grid marketing systems, revenue is dependent on the value of each individual carcass at the time of harvest. To improve revenue in retained ownership or alliance situations, some selection has focused on genetic improvement of traits that influence carcass merit, such as carcass weight, ribeye area, backfat, marbling score, etc. Selection decisions of this type, however, are inefficient without accounting for the optimum finish endpoint (versus the adjusted endpoint used for calculating the EPD) or the costs of production associated with reaching that endpoint, and may have little actual impact on profitability.

An economically relevant trait (ERT) is one that can describe some cost of production or income stream and thus, is directly related to profitability (Golden et al., 2000). The length of time on feed needed for an animal to reach a desired carcass composition is economically relevant in the finishing phase. A reduced days to finish requirement (e.g., days to weight, days to backfat, days to marbling score, etc.) reduces costs of production, while marketing cattle at an optimum endpoint improves revenue. Genetic predictions of days to finish traits and the identification of optimum finish endpoints are necessary components for maximizing profitability in post-weaning production. The following reviews research on the challenges of identifying optimum finish endpoints and the prediction of, and selection for, growth, carcass and days to finish traits in livestock production. Also presented are the implications of days to finish predictions, in conjunction with optimum finish endpoints, on sire selection for profit maximization.

REVIEW OF LITERATURE

Defining optimum finish endpoints

Management of feedlot cattle to a desired compositional endpoint is critical to maintaining profitability. The ideal compositional endpoint should be wholly dependent on the demand for cattle with specific carcass characteristics, as indicated by buyer price signals (Feuz et al., 1993). Amer et al. (1994) defined this optimal endpoint as "...the point at which the present value of profits from the farm enterprise are maximized". They developed a bioeconomic model to compare beef cattle breeds under varying management and marketing situations at the feedlot level. Cattle were fed to three constant endpoints: fat depth, weight, and days on feed and it was determined that profitability among breeds was highly dependent on the slaughter endpoint used. Further, they concluded that cattle maintaining a high level of profitability over large ranges of time on feed may be more beneficial to feedyard managers, as some cattle are marketed at less than optimum points due to market considerations.

Williams and Bennett (1995) specifically defined the optimum finish endpoint in terms of the maximum present value of profit per rotation (one cycle of cattle in and cattle out) or profit per day. Results of their economic model, integrated with a previously described biological model (Keele et al., 1992), showed that breed differences in profitability may be affected by choice of marketing system (e.g., a marbling- versus a muscling-focused grid). These results are supported by earlier work using the same biological model (Williams et al., 1995) that showed considerable variation in biological efficiency between different genotypes and different production systems. It seems that the definition of an optimum endpoint may be constant (i.e., the point at which profit is maximized), but selection of the actual endpoint under differential management systems is a more difficult task.

Factors affecting choice of finish endpoint

Clearly there are many factors: genetic, biological, environmental, and market-linked that determine an optimum finish endpoint. Bennett and Williams (1994) suggested that endpoints would depend on the biological type of animals used and market prices. During times of low feed costs Continental-type cattle tended to be most efficient when slaughtered at a constant weight, and British-type cattle tended to have higher feed efficiencies when marketed at constant carcass fatness or marbling score (quality grade). They indicated that slaughter of animals at different endpoints can cause re-ranking in the economic efficiencies of different biological types, affecting time on feed requirements and profitability. Supporting these findings, Gregory et al. (1994) found large breed differences (using British and Continental breeds, as well as composites) in backfat thickness and marbling score for cattle fed to four time endpoints.

Mandell et al. (1997a) also found that choice of slaughter endpoint had an effect on important live and carcass traits. Evaluating four backfat thickness endpoints they reported an increase in average daily gain, carcass weight, and marbling score as backfat thickness was increased. These results were attributed to a simple function of increased fat deposition as days on feed increased to reach a constant backfat thickness. In a separate study, Mandell et al. (1997b) showed that Charolais cattle fed to a constant backfat thickness endpoint were less efficient at converting feed-to-gain than those fed to a constant weight endpoint. They also found differences in percent intramuscular fat between the two endpoints.

Environment (feeding and/or management) also affects selection of optimum finish endpoints. Gregory et al. (1994) reported differences in marbling score and fat thickness between animals fed a low- or high-energy diet. Mandell et al. (1997a, b) found a diet (corn versus barley) effect on carcass weight, backfat thickness, and marbling score, but reported no effect when comparing forage versus grain diets. The net returns for cattle fed corn (compared to barley) were significantly higher. Other research (Bidner et al., 1981; Schaake et al., 1993) has shown increased marbling scores when feeding a grain diet. The impact of factors affecting choice of endpoint supports the alignment of management systems with desired marketing endpoints, but identification of endpoints for individual animals is difficult.

Factors affecting growth and carcass composition to finish

To successfully manage cattle to an optimum finish endpoint, once an endpoint has been identified, knowledge of fat deposition rate effects on days to finish and subsequent effects on carcass characteristics is important, especially when considering multiple cattle genotypes. Carcass value is dependent on fat content - both the total amount of carcass fat and the fat deposited in specific areas (Tatum et al., 1986b) - and so the length of time an animal is on feed to deposit sufficient fat is economically significant. Through differences in fat deposition, the number of days on feed impacts carcass composition as well as costs associated with feeding to a specific endpoint.

Tatum et al. (1986b) found that cattle entering the feedlot were depositing carcass fat at a much faster rate than either bone or muscle, with the percentage of carcass fat increasing as carcass weight increased. The control of fat deposition and distribution in feedlot animals is important to producers, and the topic has been heavily studied over the past twenty years. Much of the work has shown that genetic and environmental factors affect the deposition and partitioning of fat (internal versus intramuscular or subcutaneous) in cattle.

Callow (1961) suggested that the partitioning of fat is closely linked to selection history, that is, animals selected for beef characteristics (conformation and fleshing ability) as opposed to those selected heavily for milk production, partition fat differently. Comparing fat deposition in Hereford, Dairy Shorthorn, and Friesian steers, Callow found that Herefords tended to deposit a high amount of fat subcutaneously, while Friesians deposited more fat internally (i.e. kidney, pelvic and heart fat), with Dairy Shorthorns (a dual purpose breed) somewhere in between. A later study (Fisher and Bayntun, 1984) reported similar results, postulating that selection differences between British beef and dairy breeds did affect distribution of subcutaneous and intermuscular fat. Furthermore, Griffin et al. (1992) reported significant differences in yield grade, a carcass measurement affected by fat deposits present, between beef and dairy carcasses.

Subsequent studies (Charles and Johnson, 1976; Kempster et al., 1976) have suggested that fat partitioning in continental breeds is intermediate to that of British beef and dairy breeds. Other work (Berg and Butterfield, 1976; Wood, 1982; Berg and Walters, 1983) supports these findings showing that differences in fat deposition are attributable to the maturity characteristics of the breed. Early maturing cattle (British beef breeds) deposit fat at a younger age than do later maturing cattle (Continental and some dairy breeds). The proportion of fat deposited subcutaneously tends to be larger in early maturing cattle than those that mature later. Block et al. (2001) found similar results when comparing fat distribution in Charolais, Hereford, and Angus crossbred steers. They reported lower initial and final backfat thickness measurements for the Charolais-cross steers, compared to each group of British-cross steers.

Differences in fat deposition can also be seen as a function of frame size (Block et al., 2001). Cianzio et al. (1982) reported a tendency for small-framed steers to deposit fat at younger ages and at lighter weights than those with larger frame sizes. Looking at the effect of frame size on carcass composition, Tatum et al. (1986a) evaluated percentage of carcass fat for three frame size groups (small, medium, and large – representing USDA classifications of frame size), and showed that each group had a different amount of fat at a constant carcass weight. They also found that the small-, medium-, and large-framed steers attained an average amount of carcass fat at very different weights, with the large-framed steers having the largest mean weight. Most commercial fed cattle are marketed at a constant level of fatness (McMorris and Wilton, 1986), and these results indicate that variation in carcass weights may be related to differences in frame size of slaughter cattle and the effect of differing fat deposition rates.

Tatum et al. (1986b) also looked at the effects of frame size on the partitioning of carcass fat and found that feeder-cattle frame size was not associated with differences in the relative deposition of separable fat. They did find, however, that frame size had an effect on the percentage of fat in each of the deposits as compared to total fat, indicating that frame size had an effect on fat partitioning but not overall fat deposition. The smaller-framed steers had a higher proportion of subcutaneous fat when compared to those of a larger frame size. Larger-framed cattle tended to reach a constant USDA marbling score at lower levels of total separable fat, but smaller framed-cattle often have better marbling scores when compared at similar ages or weights (DeRouen et al., 1992). Frame size can provide insight into the influence of an animal's mature size on growth and carcass development, and variation in genotype (early-, intermediate-, or late-fattening) seems to contribute to differences in fat partitioning (Tatum et al. 1986a,b; Belk et al., 1991).

Block et al. (2001) reported that marbling scores for Hereford- and Angus-cross cattle were dependent on breed rather than frame size, indicating differences in fat distribution attributable to breed genetic differences (Berg and Walters, 1983; Dubeski et al., 1997). Lunt et al. (1985) found differences in fat deposition between Angus, Brahman, and Angus X Brahman steers. The Brahman cattle deposited more subcutaneous fat early in the feeding period while the Angus steers had more internal fat. No differences were reported in percentage of intramuscular fat, however. These studies suggest a breed effect on fat distribution.

There are also a number of non-genetic factors that can affect fat deposition in cattle. Corah et al. (1995) showed that administration of exogenous glucocorticoids (Dexamethasone) was effective in increasing the amount of subcutaneous fat deposition in Brangus steers. Simms et al. (1988) found a decreased mean quality grade, indicating a decrease in intramuscular fat deposition, in Continental-cross steers implanted with Zerenol (estrogenic) in the finishing phase. Similarly, Gerken et al. (1995) reported a decrease in intramuscular fat deposition in Brangus steers when using some estrogenic implants (though other androgenic implants increased mean marbling score).

Studying genetic and non-genetic factors, Beaver et al. (1989) looked at the effect of breed and diet on the rate of fat deposition in Angus and Brangus steers. Their results indicated a breed effect on rate of fat deposition, with the Angus steers depositing at much higher rates than the Brangus steers ($P < 0.10$). However, they found that when steers were fed a low- to moderate-energy diet, diet had a greater effect on fat deposition than did breed. These results agree with Bennett and Williams (1994) who suggested that body composition is dependent on energy intake (among other factors) and animals can be managed in such a way as to reach any fat deposition target.

Rates of fat deposition and the amount of fat in a given deposit can have a large impact on carcass characteristics, especially USDA yield and quality grades, in slaughter cattle. Cattle must be managed in such a way as to lay down a sufficient amount of intramuscular fat (marbling) to meet quality grade standards, without depositing too much fat in subcutaneous, intermuscular, or internal deposits that may affect yield grade (Tatum et al., 1986b). Knowledge of deposition rates will also decrease overfeeding, which can produce carcasses outside of acceptable weight ranges. Identification of appropriate feeding strategies and finish endpoints, given cattle of a particular biological type, is essential.

Predicting finish endpoints

The factors affecting carcass characteristics at different slaughter endpoints indicate that standardized days on feed requirements are not practical for predicting optimum finish endpoints. Ultrasound technology has used live measurements to objectively determine when an animal reaches an optimum compositional endpoint and to predict carcass merit at that endpoint, essential components of profitability when marketing cattle on a grid (Brethour, 1992). Backfat thickness is one of the most important parts of carcass yield and the best indicator of body composition (Powell and Huffman, 1973), and Brethour (1992) found this trait to be effectively and easily measured using ultrasound. Brethour concluded that ultrasound measures may actually be more precise and accurate than carcass measures for backfat thickness, and calculated the repeatability of these measures to be 0.975 and the correlation between ultrasound and carcass measures to be 0.90.

Evaluating the effectiveness of ultrasound as a management tool, Reverter et al. (2000) reported moderate to high positive correlations between ultrasound scans and carcass measurements for backfat thickness and percent intramuscular fat of 0.79 and 0.47, respectively. They concluded that scanning for intramuscular fat (marbling) is feasible. May et al. (2000) found strong positive correlations (0.81 and 0.73) between ultrasound (live and carcass) and actual carcass measures for backfat thickness and showed that live ultrasound is a viable option for determining carcass composition prior to slaughter. This work supports a 1992 review (Houghton and Turlington) that reported the correlations of carcass traits, as predicted by ultrasound, to their respective carcass measurements as ranging from 0.45 to 0.96 for backfat thickness and 0.20 to 0.91 for marbling score. The large range in values was explained as possible differences in technicians and instrumentation, as well as hide thickness or the presence of dirt or hair. These studies, and others (Perkins et al. 1992; Herring et al. 1994), indicate that live measurements can be an effective tool for predicting carcass performance and are essential for the management of cattle to the optimum finish endpoint.

Predicting days to finish

The number of days required for an animal to reach an optimum finish endpoint is economically relevant to beef producers. Any reduction in the number of days on feed would be of great benefit to producers by reducing costs, and as long as the cattle are still able to hit grid targets, positively affecting revenue (Golden et al., 2001). The National Beef Quality Audit – 2000 (McKenna et al., 2002) found that almost 30% of marketed carcasses had a backfat thickness measurement in excess of 1.5 cm, indicating that they may have been on feed too long, incurring unnecessary feed costs. Conversely, the same audit reported that over 45% of beef carcasses did not achieve at least a low choice quality grade or were lightweight; such carcasses would receive discounts on some grids. Cattle that remain on feed too long are a waste of feed resources, while those that are not fed long enough likely do not achieve desired carcass specifications (Brethour, 2000), and both can adversely affect profitability.

Little work has been done to evaluate days to finish in beef cattle, but there is some research available showing the effects of days on feed on carcass performance. Van Koevering et al. (1993) found that increasing the number of days on feed increased marbling scores, but only to a point; they reported no benefits of feeding steers longer than 133 days. Similarly, Hermesmeyer et al. (2000) showed that increased feeding time improved quality grade and carcass weight, but reduced feed efficiency. Prediction of days to finish is important to producers in the feeding phase in order to balance predicted income and costs of production.

Ultrasound measurements have been suggested as a way to make an accurate prediction of days to a constant weight or compositional endpoint (Brethour, 2000; Hassen et al., 1999). Brethour (2000) presented an equation to predict the number of days required to increase marbling score by one level in Continental- and British-cross steers:

$$T = \left[\frac{(A_2 - I)}{b}\right]^{(1/m)} - \left[\frac{(A_1 - I)}{b}\right]^{(1/m)}$$

where **T** was the number of days to reach the target marbling score; $\mathbf{A_1}$ was the beginning marbling score; $\mathbf{A_2}$ was the target marbling score; **I** was the intercept; and **m** and **b** were constants unique to each breed. The results of this research indicate that ultrasound measurements may have the potential to assist in the prediction days to finish and allow the identification of animals that will efficiently achieve quality grade targets.

Selection for post-weaning growth and carcass traits

Some form of selection has long been used (implicitly or explicitly) to improve production efficiency for increased profitability given particular marketing alternatives. Often selection is focused on traits that are perceived to be most related to profit, while other important traits are ignored, as are important trait relationships. In the past, selection focused mainly on traits important in the cow-calf phase of production, but recently there is an increasing interest in selection for post-weaning growth and carcass performance. In order to make intelligent selection decisions, especially concerning profitability, it is essential to consider all traits and trait relationships that impact growth and carcass development in the post-weaning phase.

Table 1 lists published heritability estimates (and associated standard errors) for several traits related to post-weaning growth. In general, the cited studies indicate that sufficient additive genetic variation exists for growth to make genetic progress, through selection, possible. Heritability estimates for weaning weight (0.09 to 0.39), feed conversion ratio (0.06 to 0.46) and relative growth rate (0.18 to 0.35) were generally in the low-moderate to moderate range. Estimates for post-weaning gain (0.36 to 0.49), yearling weight (0.16 to 0.48) and feedlot daily gain (0.19 to 0.64) were mostly high-moderate to high in value. In terms of phenotypic selection, the two traits representing the amount of gain following weaning (post-weaning and feedlot daily gain) have the greatest potential for genetic improvement.

Selection for the improvement of one growth trait is likely to have an effect on other growth traits when a correlation between traits exists. Table 2 contains phenotypic and genetic correlations between each of the post-weaning growth traits from a number of studies. The correlations between weight and gain traits were generally positive and moderate to high indicating that selection for the increase of one weight trait, for example, would yield genetic progress in other weight and gain traits. Especially high, positive genetic correlations were observed between weaning weight and yearling weight (0.47 to 0.78), post-weaning gain and yearling weight (0.44 to 0.93), yearling weight and feedlot daily gain (0.83) and feedlot daily gain and relative growth rate (0.71 to 0.81).

The estimates in Table 2 also indicate a strong negative relationship between gain and feed conversion. Negative correlations between feed conversion ratio and all other growth traits (-0.21 to -0.90) were observed. A strong genetic antagonism appears to exist between the amount of gain during post-weaning growth and the efficiency of that gain.

Table 3 lists published heritability estimates (and associated standard errors) for beef cattle carcass traits that may be important to profitability when cattle are valued on a carcass basis. There appears to be sufficient additive genetic variation for genetic improvement in carcass performance. Heritability estimates for all traits were in the moderate to high range. The traits with the largest estimates were longissimus muscle area (0.22 to 0.97), marbling score (0.12 to 0.88) and quality grade (0.47 to 0.62). These are not surprising as the distribution of muscle and fat, in the intramuscular depot, occur in early growth (Berg and Butterfield, 1966; Johnson et al., 1973) and would not be expected to be affected to a great extent by management when comparing cattle at similar maturity levels.

The feeding endpoint (actual or adjusted) is listed with the heritability estimates in Table 3 where known. Koots et al. (1994a) found no consistent differences between unadjusted heritability estimates (unknown endpoints) and those adjusted for age, weight or backfat thickness. Shanks et al. (2001) also reported little effect of adjusting heritability estimates to different endpoints.

Genetic and phenotypic correlations between carcass traits are listed in Table 4. From published estimates there were high, positive correlations between carcass weight and dressing percent (0.47 to 0.61), backfat thickness (0.13 to 0.95) and longissimus muscle area (0.02 to 0.66). Generally, there was also a high positive genetic relationship between backfat thickness and marbling score (-0.13 to 0.62), between marbling score and quality grade (0.73 to 1.00) and between longissimus muscle area and percent retail product (0.18 to 0.53). The genetic correlation between marbling score and yield grade was positive and moderate (0.26 to 0.45), but this relationship is usually unfavorable.

There were few consistent negative correlations (Table 4) except the weight or fat traits with percent retail product. The genetic correlation between backfat thickness and percent retail product was negative and ranged from low to high (-0.07 to -0.74). There were also some low to moderate negative genetic correlations between longissimus muscle area and marbling score (-0.12 to 0.44) and yield grade (-0.26 to -0.61). The latter being a favorable relationship. These correlation estimates highlight the well-known antagonism between traits relating to animal fatness and those important to muscle yield.

To truly gauge the selection effects for growth or carcass traits on animal growth and composition it is necessary to understand trait correlations that may exist. Table 5 contains phenotypic and genetic correlations between all post-weaning and carcass traits previously discussed. The genetic correlations between carcass weight and the post-weaning weight and gain traits were positive and moderately-high to high. The correlations between backfat thickness and the same post-weaning traits were not consistent and ranged from large negative to large positive values. In general, though, increases in phenotypic performance and genetic potential for post-weaning gain, feedlot daily gain and relative growth rate would yield increased performance (higher levels of fat) and genetic progress in backfat thickness.

Correlations involving marbling score were also not consistent, but there was a general negative relationship with weaning weight, yearling weight and feedlot daily gain and a positive relationship with post-weaning gain and relative growth rate. It is interesting to note that the lone correlation estimate between quality grade and feedlot daily gain is positive, contradicting the marbling score relationship with feedlot daily gain. Few other relationships were large enough or consistent enough to be of interest.

Selection for days to finish

Days to finish traits are beginning to receive some attention in the beef industry, but have been most widely used and reported in commercial swine production. Selection strategies to effectively estimate days on feed requirements are essential for pork producers. According to Stewart et al. (1990), it cost an average of \$0.17 per day to maintain a pig in a growing/finishing facility, excluding feed. Feed costs averaged another \$0.154 per kilogram. Because costs of production can be accurately estimated in swine production, the national swine genetic evaluation includes selection indices based on underlying profit functions (Stewart et al., 1990; 1991). Of particular interest in the finishing phase has been the number of days it takes a market hog to reach a weight endpoint (Li and Kennedy, 1994), an indicator of market readiness. Selection for reduced days to finish has been implemented to improve the economic efficiency of swine production (Faust et al., 1992).

Several studies have estimated the heritability of days to finish in swine populations with values ranging from 0.11 to 0.30, depending on breed and weight endpoint analyzed, suggesting that sufficient variation exists for successful selection. A 1992 simulation study (Faust et al.) reported a phenotypic decrease in days to 242 lb of 3.5 days over a ten-year period, using a finishing phase selection index. The National Swine Improvement Federation (NSIF) has determined that a decrease in the requirement for days to 250 lb is worth approximately \$0.12 per day (NSIF, 1997). Because of this potential economic impact, the Swine Testing and Genetic Evaluation System (STAGES, 1998) indices include ERT expected progeny differences, such as days to finish, and allow producers to evaluate the potential profitability of using alternative sires.

Johnston et al. (1992) estimated heritability and correlations with carcass traits for days to a constant backfat endpoint in Charolais cattle. They found days to finish in beef cattle to be moderately heritable at 0.24 (with a standard error less than 0.10). They reported a negative correlation between days to finish and post-weaning weight and growth traits. Conversely, days to finish was positively correlated with carcass weight, longissimus muscle area and marbling score. The phenotypic correlation estimates followed the same trend.

Recent work has focused on using random regression models for genetic predictions of days to finish. Kuehn (2000) studied the viability of using random regression models that include intercept and linear terms only to produce a genetic evaluation for days to finish weight and days to finish backfat in beef cattle. He found that an average of at least 2.5 observations per animal would be needed to obtain accurate variance components for each trait, but determined that it is possible to predict breeding values for the amount of time required for an animal to reach a specific compositional endpoint. These breeding values can be estimated using few observations per animal. Following Kuehn, Jubileu (2003) compared genetic evaluation for days to finish using random regression to traditional univariate and multivariate models. Jubileu found that he could successfully calculate breeding values for days to finish weight using the random regression model. The advantage of this approach is that a weight EPD may be calculated at any age (or number of days on feed) or an age EPD derived for any custom weight simply using the following (Kuehn, 2000):

$$\text{EPD (age or weight)} = b_0 + b_1 * \text{(desired endpoint)}$$

where b_0 is the intercept breeding value (or EPD) and b_1 is the linear coefficient breeding value (or EPD) for each individual sire.

Research completed in 2002 (Cleveland) looked at simulated economic outcomes using predictions of days to finish from random regression models in beef cattle. Similar to results reported by Williams and Bennett (1995) and Williams et al. (1995), Cleveland found an interaction affecting sire ranking for net return between sire genotype and finish endpoint when progeny were fed to a constant weight, backfat, and marbling score. The results indicated that length of time on feed had a greater effect on net return than did carcass performance, when cattle were managed to predetermined constant endpoints. Cleveland concluded that models incorporating predictions of days to finish and precise costs of production have the potential to become important selection and management tools to assist producers in maximizing profitability in the finishing and harvest phase of production.

CONCLUSIONS AND IMPLICATIONS TO GENETIC IMPROVEMENT OF BEEF CATTLE

The evolution of breeding and genetics over the past 50 years, especially in beef cattle, has included a transition from selection based on animal appearance to selection based on performance. However, the evolution from selection based on performance to economic selection is not complete (Harris and Newman, 1994). Producers have access to a large variety of EPD, but are not provided with the necessary tools to evaluate how multi-trait selection affects their profitability, much less the effect on potential profits farther along in the production chain. Breeders have little context for using genetic predictions intelligently (Bourdon, 1998), and complicating the issue further is the lack of available EPD for traits that directly affect revenue and/or costs of production.

The shift towards value-based marketing systems has increased the incentive for collection of feedlot and carcass performance data. The use of individual animal identification, in conjunction with performance information that can be easily measured, will make it feasible to calculate genetic predictions of days to finish traits using random regression models. The nature of random regression, however, negates the possibility of providing a useful EPD to producers in the traditional format due to the number of possible production-specific feeding endpoints. Additionally, supplying yet another EPD to an already information-overloaded industry is not likely to improve profitability or realized genetic improvement. More importantly, selection for a reduced days to finish requirement, without identification of the optimum finish endpoint, would likely reduce the costs of production but could have an unintended impact on carcass composition and may or may not maximize profit. While economically relevant, days to finish traits alone do not indicate expected economic outcomes in post-weaning production.

Current genetic predictions of post-weaning growth and carcass traits, alone, provide no decision-making framework for the producer whose goal is to maximize profitability. There exists a need for a straightforward method of selection, particularly when considering feedlot and carcass performance. Predictions of days to finish should be incorporated into current genetic evaluation as they provide an important genetic component for selection and management tools that rank sires based on expected profitability in a given production system. The ultimate goal should be to use these predictions (including current growth and carcass EPD) for identifying progeny optimum finish endpoints and developing web-accessible decision support tools that contain operation-specific production parameters to identify sires of progeny that maximize profitability in the finishing and harvest phase. The output from these types of tools should be likely phenotypic outcomes based on underlying genetic and environmental factors that are understandable and allow producers to make informed, economically-based selection decisions.

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Table 1. Published heritability estimates for post-weaning growth traits in beef cattle[a].

Source	Growth traits[b]					
	WWT	**PWG**	**YWT**	**FDG**	**RGR**	**FCR**
Smith and Cundiff, 1976					0.25±0.12	
Buchanan et al., 1982	0.18±0.01	0.49±0.04	0.37±0.03			
Koch et al., 1982				0.57[c]		
Lamb et al., 1990	0.12±0.12	0.44±0.17				
Winder et al., 1990	0.39±0.02	0.36±0.02	0.40±0.02			
Kriese et al., 1991	0.21	0.56				
MacNeil et al., 1991				0.38±0.16		
Johnston et al., 1992	0.09[c]		0.16[c]	0.19[c]	0.18[c]	
Woodward et al., 1992	0.18					
Gilbert et al., 1993				0.22±0.10	0.35±0.12	
Koots et al., 1994a	0.17±0.09	0.40±0.12	0.35±0.11		0.15±0.09	0.36±0.15
Gregory et al., 1995	0.34±0.09	0.36±0.09				
Meyer, 1995	0.20±0.009		0.28±0.02			
Meyer, 1995	0.23±0.008		0.31±0.01			
Shepard et al., 1996	0.20±0.07			0.47±0.14		
Tosh et al., 1999	0.33		0.48			
Kaps et al., 2000						
Arthur et al., 2001a						0.32±0.06
Arthur et al., 2001b				0.34±0.04	0.33±0.05	0.46±0.04
Riley et al., 2002				0.64		
Splan et al., 2002	0.14±0.02					
Koch et al., 2004	0.19	0.39	0.48			
Robinson and Oddy, 2004				0.23±0.06		0.06±0.04

[a]h^2 ± SE
[b]**WWT** = weaning weight; **PWG** = post-weaning gain; **YWT** = yearling weight; **FDG** = feedlot daily gain; **RGR** = relative growth rate (percent change in weight postweaning); **FCR** = feed conversion ratio (kg feed/kg gain)
[c]standard errors < 0.10

Table 2. Published estimates of phenotypic (P) and genetic (G) correlations (± SE) between post-weaning growth traits in beef cattle.

Source		Growth traits[a]				
		PWG	YWT	FDG	RGR	FCR
	WWT					
Smith and Cundiff, 1976	P				-0.48	
	G				0.08±0.45	
Buchanan et al., 1982	P					
	G	0.46±0.18	0.74±0.11			
Winder et al., 1990	P	0.10	0.78		-0.45	
	G	0.18	0.63		-0.38	
Johnston et al., 1992	P		0.69	0.18	-0.36	
	G		0.47	-0.10	-0.62	
Koots et al., 1994b	P	0.12	0.68		-0.31	
	G	0.39	0.78		-0.10	
Arthur et al., 2001a	P					
	G					-0.21±0.20
	PWG					
Buchanan et al., 1982	P					
	G		0.93±0.04			
Winder et al., 1990	P		0.74			
	G		0.75			
Koots et al., 1994b	P		0.74			-0.64
	G		0.44			-0.76
Robinson and Oddy, 2004	P					-0.08±0.03
	G					-0.86±0.10
	YWT					
Winder et al., 1990	P				0.24	
	G				0.25	
Johnston et al., 1992	P			0.75	0.21	
	G			0.83	0.39	
Koots et al., 1994b	P				0.36	-0.46
	G				0.35	-0.60
	FDG					
Smith and Cundiff, 1976	P				0.77	
	G				0.78±0.15	
MacNeil et al., 1991	P					-0.48
	G					-0.43±0.28
Johnston et al., 1992	P				0.79	
	G				0.81	
Gilbert et al., 1993	P				0.67	
	G				0.71±0.15	
Arthur et al., 2001a	P					-0.74
	G					-0.62±0.06
Arthur et al., 2001b	P				0.68	-0.54
	G				0.71±0.09	-0.46±0.08
	RGR					
Koots et al., 194b	P					-0.72
	G					-0.79
Arthur et al., 2001b	P					-0.64
	G					-0.90±0.04

[a] **WWT** = weaning weight; **PWG** = post-weaning gain; **YWT** = yearling weight; **FDG** = feedlot daily gain; **RGR** = relative growth rate (percent change in weight post-weaning); **FCR** = feed conversion ratio (kg feed/kg gain)

Table 3. Published heritability estimates for carcass traits in beef cattle[a].

Source	End-point	Carcass traits[b]							
		CWT	**DP**	**FT**	**LMA**	**MS**	**QG**	**YG**	**%RP**
Cundiff et al., 1964		**0.39** ±0.24[c]		**0.43** ±0.33	**0.73** ±0.29		**0.62** ±0.27	**0.36** ±0.31	**0.40** ±0.24
Brackelsberg et al., 1971				**0.43**	**0.40**	**0.73**	**0.74**		
Koch, 1978	Days	**0.68** ±0.25		**0.68** ±0.25	**0.28** ±0.24	**0.34** ±0.25			
Koch et al., 1982[d]				**0.41**	**0.56**	**0.40**			**0.63**
Lamb et al., 1990		**0.31** ±0.15		**0.24** ±0.14	**0.28** ±0.15	**0.33** ±0.15		**0.24** ±0.14	
Arnold et al., 1991	Weight	**0.24**		**0.49**	**0.46**	**0.35**			
Jonhston et al., 1992[d]	QG	**0.09**			**0.38**	**0.26**			
Gilbert et al., 1993	FT	**0.26** ±0.16		**0.14** ±0.14	**0.48** ±0.20	**0.28** ±0.17			
Wilson et al., 1993	Age	**0.31** ±0.04		**0.26** ±0.04	**0.32** ±0.04	**0.26** ±0.04			
Koots et al., 1994a	Age	**0.45** ±0.12	**0.35** ±0.13	**0.43** ±0.13	**0.43** ±0.14	**0.37** ±0.12			
Koots et al., 1994a	FT	**0.35** ±0.22		**0.43** ±0.22	**0.40** ±0.22	**0.66** ±0.22			
Koots et al., 1994a	Weight	**0.30** ±0.13	**0.51** ±0.11	**0.44** ±0.13	**0.48** ±0.23	**0.37** ±0.09			
Gregory et al., 1995		**0.23** ±0.08	**0.19** ±0.08	**0.25** ±0.08	**0.22** ±0.08	**0.48** ±0.09			
Moser et al., 1998	Age	**0.59** ±0.06		**0.27** ±0.05	**0.39** ±0.06				
Pariacote et al., 1998		**0.60** ±0.19	**0.49** ±0.19	**0.46** ±0.19	**0.97** ±0.21	**0.88** ±0.21		**0.54** ±0.19	
Splan et al., 1998		**0.50** ±0.06		**0.66** ±0.07	**0.61** ±0.06	**0.71** ±0.07			**0.66** ±0.07
Crews and Kemp, 2001	Weight /FT	**0.38** ±0.16		**0.46** ±0.18	**0.54** ±0.19	**0.55** ±0.19			
Shanks et al., 2001	Age	**0.32**		**0.10**	**0.26**	**0.12**			**0.09**
Shanks et al., 2001	Weight			**0.14**	**0.22**	**0.12**			**0.12**
Shanks et al., 2001	MS	**0.30**		**0.10**	**0.28**				**0.09**
Shanks et al., 2001	FT	**0.33**			**0.29**	**0.13**			**0.17**
Kemp et al., 2002	Age	**0.48**		**0.35**	**0.45**	**0.42**			
Riley et al., 2002	FT	**0.55**	**0.77**	**0.63**	**0.44**	**0.44**	**0.47**		

[a] h^2±SE
[b] **CWT** = carcass weight; **DP** = dressing percent; **FT** = 12[th] rib backfat thickness; **LMA** = longissimus muscle area; **MS** = marbling score; **QG** = USDA quality grade; **YG** = USDA yield grade; **%RP** = percent retail product
[c] CWT per day of age
[d] SE < 0.10

Table 4. Published estimates of phenotypic (P) and genetic (G) correlations (± SE) between carcass traits in beef cattle.

Source		Carcass traits[a]						
		DP	FT	LMA	MS	QG	YG	%RP
	CWT							
Cundiff et al.,	P		0.31	0.46		0.16		-0.26
1964	G		0.15	0.66		0.47		0.02
Koch, 1978	P		0.42	0.37	0.18			
	G		0.95±0.21	0.02±0.46	-0.33±0.39			
Lamb et al.,	P		0.38	0.58	0.28			
1990	G		0.14±0.37	0.68±0.19	0.64±0.20			
Arnold et al.,	P							
1991	G		0.36	0.09	0.33			
Johnston et	P			0.51	-0.03			
al., 1992	G			0.45	-0.31			
Wilson et al.,	P		0.24	0.43	0.08			
1993	G		0.38	0.47	-0.06			
Koots et al.,	P	0.42	0.39	0.45	0.15			
1994b	G	0.61	0.38	0.47	0.10			
Gregory et	P		0.28	0.40	0.13			-0.24
al., 1995	G		0.13±0.25	0.66±0.20	0.31±0.20			-0.12±0.22
Pariacote et	P	0.41±0.03	0.19±0.04	0.47±0.03	0.09±0.04		0.20±0.04	
al., 1998	G							
Riley et al.,	P	0.24		0.44	0.17	0.16	0.48	
2002	G	0.47		0.52	0.39	0.37	0.56	
	DP							
Koots et al.,	P		0.17	0.08	0.06			
1994b	G		0.31	0.34	0.16			
Pariacote et	P		0.19±0.04	0.31±0.04	0.04±0.04		0.07±0.04	
al., 1998	G		-0.16±0.31	0.79±0.16	0.08±0.24		-0.56±0.29	
Riley et al.,	P		0.23	0.16	0.16	0.13	0.24	
2002	G		0.42	0.02	0.35	0.26	0.48	
	FT							
Cundiff et al.,	P			-0.01		0.05		-0.14
1964	G			0		0.07		-0.07
Brackelsberg	P				0.42	0.34		
et al., 1971	G				0.62	0.48		
Koch, 1978	P			-0.08	0.25			
	G			0.03±0.44	0.73±0.38			
Koch et al.,	P			-0.15	0.24			-0.74
1982	G			-0.44	0.16			-0.74
Wilson et al.,	P			-0.08	0.12			
1993	G			-0.06	-0.13			
Koots et al.,	P			-0.09	0.22			
1994b	G			-0.08	0.36			
Pariacote et	P			-0.16±0.04	0.20±0.04		0.78±0.02	
al., 1998	G			-0.31±0.23	0.26±0.24		0.67±0.15	
Riley et al.,	P			0.10	0.30	0.31	0.81	
2002	G			0.02	0.56	0.58	0.93	

(Continued)

Table 4. ***Continued.*** Published estimates of phenotypic (P) and genetic (G) correlations (± SE) between carcass traits in beef cattle.

Source		Carcass traits[a] DP	FT	LMA	MS	QG	YG	%RP
	LMA							
Cundiff et al.,	P					0.05		0.62
1964	G					0.32		0.18
Brackelsberg	P				-0.07	-0.06		
et al., 1971	G				-0.12	-0.09		
Koch et al.,	P				0.03			0.60
1982	G				-0.14			0.53
Pariacote et	P				-0.08±0.05		-0.61±0.03	
al., 1998	G				-0.17±0.19		-0.85±0.10	
Riley et al.,	P				0.12	0.10	-0.30	
2002	G				0.44	0.32	-0.26	
	MS							
Brackelsberg	P					0.96		
et al., 1971	G					0.73		
Koch et al.,	P							-0.07
1982	G							-0.37
Gregory et	P							-0.43
al., 1995	G							-0.60±0.20
Pariacote et	P						0.22±0.04	
al., 1998	G						0.26±0.22	
Riley et al.,	P					0.96	0.26	
2002	G					1.00	0.45	
	QG							
Riley et al.,	P						0.27	
2002	G						0.48	

[a]**CWT** = carcass weight; **DP** = dressing percent; **FT** = 12th rib backfat thickness; **LMA** = longissimus muscle area; **MS** = marbling score; **QG** = USDA quality grade; **YG** = USDA yield grade; **%RP** = percent retail product

Table 5. Published estimates of phenotypic (P) and genetic (G) correlations (± SE) between post-weaning growth and carcass traits in beef cattle.

Source	Carcass traits[a]	Growth traits[b]					
		WWT	**PWG**	**YWT**	**FDG**	**RGR**	**FCR**
	CWT						
Smith and	P					0.29	
Cundiff, 1976	G					0.72±0.27	
Koch, 1978	P	0.59		0.94	0.74		
	G	0.48±0.25		0.96±0.03	0.78±0.11		
Lamb et al.,	P		0.64				
1990	G		0.94±0.04				
Arnold et al.,	P						
1991	G	0.13		-0.03	0.00	0.10	
Johnston et	P	0.55		0.66	0.44		
al., 1992	G	0.03		0.32	0.32		
Koots et al.,	P	0.57	0.60	0.81		0.29	
1994b	G	0.84	0.77	0.91		0.72	
Gregory et	P	0.58					
al., 1995	G	0.42±0.18					
Riley et al.,	P				0.87		
2002	G				0.84		
	DP						
Koots et al.,	P	0.20	0.03	0.18			0.06
1994b	G	0.08	0.07	0.19			0.21
Riley et al.,	P				-0.03		
2002	G				-0.01		
	FT						
Smith and	P					0.08	
Cundiff, 1976	G					0.85±0.34	
Koch, 1978	P	0.12		0.33	0.32		
	G	0.59±0.34		0.86±0.24	0.62±0.21		
Koch et al.,	P				0.17		
1982	G				0.05		
Lamb et al.,	P	0.20	0.30				
1990	G	0.49±0.41	0.05±0.34				
Arnold et al.,	P						
1991	G	-0.28		-0.13	0.17	0.19	
Koots et al.,	P	0.16	0.31			0.06	0.15
1994b	G	0.04	0.32			0.85	-0.24
Gregory et	P	0.16					
al., 1995	G	0.15±0.22					
Tosh et al.,	P			0.19			
1999	G			-0.13			
Riley et al.,	P				0.39		
2002	G				0.49		
	LMA						
Smith and	P					0.17	
Cundiff, 1976	G					0.46±0.34	
Koch, 1978	P	0.23		0.35	0.27		
	G	0.16±0.50		0.01±0.46	-0.07±0.38		
Koch et al.,	P				0.32		
1982	G				0.34		

(Continued)

Table 5. ***Continued.*** Published estimates of phenotypic (P) and genetic (G) correlations (± SE) between post-weaning growth and carcass traits in beef cattle.

Source	Carcass traits[a]	Growth traits[b]					
		WWT	PWG	YWT	FDG	RGR	FCR
	LMA						
Lamb et al.,	P	0.39	0.34				
1990	G	0.43±0.42	0.48±0.25				
Arnold et al.,	P						
1991	G	0.33		-0.06	-0.18	-0.13	
Johnston et	P	0.33		0.31	0.13		
al., 1992	G	-0.27		-0.11	-0.07		
Koots et al.,	P	0.22	0.25	0.35			0.17
1994b	G	0.40	0.24	0.29			0.46
Gregory et	P	0.24					
al., 1995	G	0.49±0.21					
Riley et al.,	P				0.39		
2002	G				0.58		
	MS						
Koch, 1978	P	-0.05		0.13	0.20		
	G	-0.02±0.47		-0.57±0.41	-0.62±0.35		
Koch et al.,	P				0.07		
1982	G				0.15		
Lamb et al.,	P	0.15	0.24				
1990	G	0.71±0.24	0.48±0.23				
Arnold et al.,	P						
1991	G	-0.01		0.20	0.54	0.62	
Johnston et	P	-0.05		-0.09	-0.08	-0.04	
al., 1992	G	-0.55		-0.51	-0.16	0.09	
Woodward et	P	0.02					
al., 1992	G	0.16					
Koots et al.,	P	-0.04	0.15	0.14		0.09	
1994b	G	-0.17	0.08	-0.37		1.04	
Gregory et	P	0.01					
al., 1995	G	0.12±0.17					
Riley et al.,	P				0.15		
2002	G				0.28		
	QG						
Riley et al.,	P				0.14		
2002	G				0.32		
	YG						
Riley et al.,	P				0.42		
2002	G				0.41		
	%RP						
Smith and	P					-0.10	
Cundiff, 1976	G					-0.54±0.47	
Koch et al.,	P				-0.15		
1982	G				-0.13		
Gregory et	P	-0.12					
al., 1995	G	-0.09±0.18					

[a]**CWT** = carcass weight; **DP** = dressing percent; **FT** = 12^{th} rib backfat thickness; **LMA** = longissimus muscle area; **MS** = marbling score; **QG** = USDA quality grade; **YG** = USDA yield grade; **%RP** = percent retail product
[b]**WWT** = weaning weight; **PWG** = post-weaning gain; **YWT** = yearling weight; **FDG** = feedlot daily gain; **RGR** = relative growth rate (percent change in weight post-weaning); **FCR** = feed conversion ratio (kg feed/kg gain)

Pathways to Change: Efficiency of Feed Utilization

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INTRODUCTION

For the last several decades, selection for beef cattle in the U. S. has been for improving outputs such as weaning weight, yearling weight, and carcass traits, while trying to maintain or decrease birth weight. In the last decade, advances have been made in genetic predictions for fertility and lifetime production. Net profitability is a function of both outputs and inputs, therefore approaches need to be considered that optimize the relationships between outputs and inputs. Genetic predictions have been recently developed to assist producers with selection for decreasing or optimizing the maintenance energy of the cow relative to her output (calf weaning weight), and to balance possible trade-offs between growth and carcass traits.

Efficiency of feed utilization is one trait that has received considerable attention. Early work with efficiency of feed utilization was concerned with feed conversion (intake/gain), or its' inverse feed efficiency (gain/intake). Residual feed intake has been studied recently as a possible way to reduce intake while maintaining constant output (gain). Variation in feed intake may be partitioned into two parts: a production-related and a non-production-related component. Luiting (1998) defined residual feed intake as the non-production related part.

The purpose of this paper is threefold: 1) to review the current understanding of efficiency of feed utilization as it relates to production and maintenance traits, 2) to review the statistical procedures of the measures of feed conversion and feed efficiency, and 3) to synthesize current knowledge of efficiency of feed utilization into a package that seedstock and commercial breeders can understand and utilize.

REVIEW OF LITERATURE

Feed Conversion and Feed Efficiency

Early work with efficiency of feed utilization (EFU) in beef cattle focused on estimating heritabilities of post-weaning gain (PWG) and feed intake (FI). Knapp and Nordskog (1946), Knapp and Clark (1950), Kincaid *et al.*, (1952), Warwick and Cartwright (1955), and Dawson *et al.*, (1955) all investigated these genetic parameters. Many of the heritabilities for PWG and FI were probably over-estimates, due in part to limitations in statistical estimation procedures of the time, and also partly due to the small numbers in most of those studies. These researchers also investigated correlations among EFU, PWG, FI, and other body measurements such as size and fatness, and found that increasing EFU was correlated with changes in size and body composition. This research established correlations among traits related to EFU that might be components in variation of EFU, but the estimates of those correlations will be omitted here since they are now considered over-estimates of the actual parameters.

Koch *et al.*, (1963) suggested that if it were not possible to measure intake, then selection for gain would lead to over 80% as much genetic improvement as selecting directly for feed efficiency. The authors also noted that studies involving carcass composition were needed to determine feed efficiency measures for energy conversion or for edible portion instead of increase in body weight without regard to composition of gain, as was studied in that experiment. It is apparent that those researchers understood that there were correlations between FI, PWG, feed efficiency (FE) and body composition traits.

Koots *et al.*, (1994a) summarized 184 published papers regarding heritability of PWG, 23 papers regarding FI, 28 papers regarding feed conversion (FC), and 9 regarding FE. The weighted averages of the heritabilities for PWG, FI, FC, and FE were 0.31, 0.34, 0.32, and 0.37, respectively. A lower FC ratio indicates a more efficient animal; since FE is the inverse of FC, a lower FE ratio indicates a less efficient animal.

Brelin and Brannang (1982) reviewed 4 studies, which demonstrated high genetic correlations (-0.61 to -0.95) between FC and PWG, indicating that animals with higher gains were more efficient. Koots *et al.*, (1994b) reviewed similar papers with regards to genetic and phenotypic correlations among the four traits mentioned above (PWG, FI, FC, and FE) and other traits. They found that FC was genetically correlated with FI and PWG at levels of 0.71 and –0.67, respectively. The phenotypic correlations between FC and FI and PWG were 0.75 and –0.64, respectively. These results indicate that more efficient animals have less intake relative to PWG than inefficient animals. FC was highly correlated with yearling weight (YW), with genetic and phenotypic correlations of –0.60 and –0.46, respectively. There were no estimates of the correlations between FC and mature weight (MW), however YW had genetic and phenotypic correlations of 0.72 and 0.54 with MW. These results suggest that more efficient animals will be larger at yearling age and probably larger at maturity. FC was moderately associated with backfat (BF), dressing percentage (DP), and lean percent (LP), with genetic correlations of –0.24, 0.21, and –0.32, respectively. The phenotypic correlations were 0.14, 0.06 and –0.14 for BF, DP, and LP, respectively. These correlations show that more efficient animals will tend to be leaner than less efficient animals, and that selection for efficiency may result in decreased fat, and increased lean and dressing percentage. FI was strongly related to PWG, both genetically and phenotypically, with correlations of 0.68 and 0.51, respectively. FI had a high genetic correlation with marbling (MA) at 0.90, while the phenotypic correlation was 0.24. Average daily gain (ADG) was correlated with carcass weight (CW), LP and rib-eye area (REA). The genetic correlations were 0.87, 0.31, and 0.32, respectively. The phenotypic correlations between ADG and CW, LP, and REA were 0.68, -0.03, and 0.28, respectively. This suggests that animals with higher ADG have larger carcasses, with more lean and a higher dressing percentage, and that selection for those traits will result in changes in the same direction.

Fan *et al.*, (1995) found similar results in Hereford and Angus bulls. Weighted average genetic and phenotypic correlations will be presented here. It should be noted that there were large differences in some of the genetic parameters between the breeds in this study, indicating that measures of EFU may differ among breeds. The weighted average genetic correlations between ADG and metabolizable energy intake (MEI), FE, and YW were 0.82, 0.57, and 0.69, respectively. The phenotypic correlations between the same traits were 0.64, 0.64, and 0.84, respectively. These results are in agreement with those summarized by Koots *et al.*, (1994b). In this study, FE was more independent of FI than in the studies summarized by Koots *et al.*, (1994b). The genetic and phenotypic correlations between FE and FI in this study were 0.11 and –0.14, respectively.

Arthur *et al.*, (2001) investigated residual feed intake (RFI) and also looked at more conventional methods of measuring EFU. In that study, FC was genetically (-0.62) and phenotypically (-0.74) correlated with ADG. FC was not as strongly correlated with FI, with genetic and phenotypic correlations of 0.31 and 0.23, respectively. FI was correlated with rib-fat (RF) and REA at moderate levels both genetically and phenotypically. The correlations were 0.27 and 0.23 for the genetic and phenotypic correlations between FI and RF, and 0.43 and 0.33 for the same correlations between FI and REA. The genetic and phenotypic correlations between FC and carcass traits were near zero for all traits.

When taken together, these results support the hypothesis that selection for increased EFU results in larger, leaner cattle at yearling age and slaughter weight, and will probably result in similar results at maturity. However, the results indicate that selection for FE or FC may be less predictable in the effects on intake.

Residual Feed Intake

Koch *et al.*, (1963) first described residual feed intake in beef cattle. At the time of that publication, the authors clearly understood the need to adjust feed intake to account for differences in weight. It should be noted that the authors studied three measures of efficiency:

- intake adjusted for gain and mid-weight (RFI)
- gain adjusted for differences in feed consumption after first adjusting feed consumption for differences in mid-weight to account for average differences in maintenance-residual or net daily gain (RDG, NDG)-a larger positive value is favorable
- ratio of gain to feed consumed, using feed consumption adjusted for differences in mid-weight.

The authors concluded that the second measure (RDG, NDG) was the most accurate description of the cause and effect relationships of efficiency, and that it resulted in the highest heritability.

In general, RFI is defined as FI minus FI predicted from a regression equation developed from data of the group being evaluated. The prediction equation may vary depending on the study, and new equations are being developed that include adjustments for associated traits (Basarab *et al.*, 2002, Carstens *et al.*, 2002, Crews *et al.*, 2005). Typically, the prediction equation has been based on mid-weight and ADG. This is the form of RFI that is reported on in this review. Mid-weight is included in the regression equation to account for differences in energy consumption attributable to maintaining the weight of the animal (maintenance requirements), and ADG is included in the equation to account for differences in energy consumption attributable to the weight gain of the animal (requirements for growth); therefore, the theory behind the concept of RFI is that RFI is related to the extra variation in animal intake that is not explained by differences in maintenance and growth requirements. RFI is phenotypically independent of the traits used to estimate feed intake due to the statistical properties of the regression equation, so it allows comparison between animals with differing levels of production (ADG) during the test period. A lower, negative value of RFI is desirable. The inverse value of RFI is usually referred to as net feed intake (NFI), or net feed efficiency (NFE), Pitchford, (2000). A higher, positive value for NFI and NFE is desirable. Kennedy *et al.*, (1993) demonstrated that while RFI was phenotypically independent of production, there may be underlying genetic correlations that result in change in the component traits or other correlated traits that may become apparent with selection. Kennedy *et al.*, (1993) suggested that genetic covariances, rather than phenotypic covariances may be used to calculate *genetic* residual feed intake.

There has been recent work investigating RFI in beef cattle. Arthur *et al.*, (1998) reported on studies completed in beef cattle with regards to RFI. The heritability of RFI in the four publications summarized range from 0.14 to 0.41. In a study with Angus cattle, Arthur *et al.*, (2001) found heritabilities of 0.39, 0.28, 0.29, and 0.39 for FI, ADG, FC, and RFI, respectively. Genetic and phenotypic correlations between FC and RFI were 0.66 and 0.53, respectively. RFI was independent of ADG, with genetic and phenotypic correlations of –0.04 and –0.06, respectively. RFI was correlated with FI genetically and phenotypically with correlations of 0.69 and 0.72, respectively. RFI relationships were near zero for all traits, except for the genetic and phenotypic correlations between RFI and RF, which were 0.17 and 0.14, respectively, which were of low magnitude, but different from zero. These results suggest that RFI will be successful in decreasing intake for the observed amount of gain, thus improving EFU. The authors concluded that both phenotypic and genetic variation exists in EFU, and that RFI may be a reasonable tool to make progress in efficiency.

Herd and Bishop (2000) studied RFI and its' association with other performance and carcass traits in Hereford cattle. Heritabilities for FI, ADG, FC, and RFI were 0.31, 0.38, 0.17 and 0.16, respectively. They showed that RFI was phenotypically independent of weight and actual ADG (correlations were not different from zero). RFI was genetically independent of ADG (0.09), and genetic correlations with WW and YW were of slightly higher magnitude (0.34 and 0.15, respectively), but with large standard errors still encompassing zero. There were high genetic and phenotypic correlations (0.61 and 0.70, respectively) with FC. The genetic and phenotypic correlations between RFI and carcass lean were –0.43 and –0.22, respectively, indicating that part of the increased efficiency was due to increasing lean percent of the carcass.

Liu et al., (2000) investigated RFI and found that it was phenotypically independent of test weight and ADG. The phenotypic correlation between RFI and FC was 0.43. The phenotypic correlation between RFI and FI was 0.49.

Carstens *et al.*, (2002) found that RFI was phenotypically correlated with FI and FC in Braunvieh-sired crossbred steers, with correlations of 0.59, and 0.49, respectively. RFI was not correlated with final weight, ADG, REA, or MA. They also concluded that increased leanness may have contributed to better EFU, but the contribution was of low magnitude. Genetic correlations were not estimated in that study.

Basarab *et al.*, (2003) concluded that RFI was related to composition of gain, with 6.9% of the differences in RFI being explained by differences in composition of liveweight gain. Those animals with favorable RFI had less FI than unfavorable RFI animals, and slightly less MA, intermuscular fat (IM) and internal carcass fat. The two groups were similar in weight gain. The authors concluded that to avoid undesirable changes in carcass composition that may result with selection for RFI, the prediction equation could be adjusted to account for compositional changes by the use of real-time ultrasound.

Richardson and Herd (2004) have recently summarized the results of a single generation divergent selection experiment to test the effectiveness of selection for RFI, and to investigate its' component parts. They concluded that differences in energy retained in protein and fat accounted for 5% of the differences in RFI (Appendix I, Figure I). Differences in digestion contributed about 10% and feeding patterns 2%. The heat increment of digestion contributed 9% to the overall variation, and activity contributed 10%. Protein turnover, tissue metabolism, and stress were estimated to have contributed to at least 37% of the variation in RFI. About 27% of the variation in RFI was contributed by other processes such as ion transport, which have not yet been specifically measured. The results from this study indicate that there is variation in EFU that may be captured that is independent of changes in composition and size.

Recommendations to producers that want to test bulls for RFI suggest that they should first select the top 10-20% of the bull calves at weaning for inclusion in a feed test (Archer *et al.*, 2004). Liu *et al.*, (2000) also concluded that producers should first select bulls based on performance at weaning for inclusion in tests to determine RFI. Crews *et al.*, (2005) have published a multiple trait index designed to improve net feedlot income that includes daily DMI, ADG, and slaughter weight. In that study, RFI was defined as the difference between actual intake and that predicted by phenotypic regression of daily DMI on ADG, metabolic mid-test weight, and on-test gain in ultrasound subcutaneous fat depth and longissimus muscle area.

It appears that the major impact that RFI has on changing EFU is to decrease intake for the observed gain; the cattle gain the same weight with less FI. The results of studying RFI to date have indicated that the concept of RFI may be useful to describe differences in EFU that are not completely described by FE, however the biological causes of differences in RFI independent of changes in FI need to be further investigated.

Differences in Biological Type

Studies at MARC (Gregory *et al.*, 1997) suggested that differences in FE among biological types of cattle depended on the test parameters (Appendix I, Figure II). In general, breeds that excelled at efficiency to a marbling endpoint such as the British breeds like Hereford, Angus, and Red Angus were less efficient than Continental breeds like Simmental, Charolais, Limousin and Gelbvieh when evaluated at retail product endpoint (Cundiff, et al., 2004). The breeds that had higher ADG were generally more efficient in gain constant periods. This is in agreement with earlier studies by Klosterman and Parker, (1976). In general, on a gain constant basis, those animals with the ability to make larger and leaner gains will be more efficient. On a carcass fat basis, those same animals will be less efficient since they will have to be on feed longer, accumulating more total maintenance requirement, and thus more total intake to reach the same endpoint. To a retail product endpoint, the larger or leaner animals will have an advantage in EFU. Several authors (Gregory, et al, 1997, Cundiff et al., 2004, Kress and MacNeil, 1999) have stated that a 50% British – 50% Continental animal can optimize the trade-offs between marbling and yield, and are more efficient at more total endpoints, resulting in greater flexibility in the marketing plan.

Blood Pathways – IGF-I

Stick *et al.*, (1998) investigated IGF-I concentrations of individually fed steers on differing planes of nutrition. The results from that study suggested that increases in serum IGF-I concentrations were associated with increases in ADG and FE.

Insulin-like Growth Factor-I (IGF-I) has also been suggested as a possible low-cost approach to predicting feed efficiency (Johnston *et al.*, 2002). Weighted averages from two herds indicated that the heritability of IGF-I concentration was 0.37. Genetic correlations with RFI, FC, FI, ADG, and YW were 0.28, 0.34, 0.25, 0.27, and 0.22, respectively. These results indicate that selection for increased IGF-I concentrations should result in favorable changes in RFI and FC.

The heritability of serum IGF-I levels was also estimated by Davis *et al.*, (2003) from Angus cattle, and a heritability of 0.32 was reported. The authors also studied the relationships between IGF-I and weight- and age adjusted Ultrasound BF and REA. Genetic correlations between IGF-I concentration and those traits were low.

Animal Temperament

Burrow and Dillon (1997) and Voisinet *et al.*, (1997) demonstrated that temperament had negative effects on ADG. The authors concluded that feedlot operators should select cattle for feeding that have calm dispositions. In a trial with bulls and steers, Brown, *et al.*, (2004) demonstrated that while exit velocity from a chute did not affect FC or RFI, exit velocity was associated with lower gains (r = -0.34 and – 0.17), and decreased intake (r=-0.25 and –0.25) for bulls and steers, respectively. Petherick *et al.*, (2002) reported that flight speed was negatively correlated with FC. The correlation from that study was –0.60. The authors also reported that flight speed was not associated with intake, but was associated with ADG. The correlation between flight speed and ADG was –0.18.

Complete Production System Efficiency

A large portion of the input for production of beef is the total feed required by the breeding herd and feedlot cattle. It has been estimated that the cow herd uses between 65% and 85% of the energy required for beef production (Gregory, 1972; Klosterman and Parker, 1976; Dickerson, 1978; Ferrell and Jenkins, 1985; Montano-Bermudez *et al.*, 1990). When the energy costs of raising replacement females are included, the energy costs of breeding females may be as much as 89% of the total herd requirements (Thompson and Barlow, 1986). Only 13% of the metabolizable energy fed to the cow and calf is recovered as net energy in the calf at slaughter (Klosterman and Parker, 1976).

Cow size is important as it relates to maintenance requirements. Montano-Bermudez *et al.*, (1990) concluded that large and medium mature size cows required 11% more energy than small mature size cows, and that milk production differences accounted for 23% of the variation in maintenance requirements. Ferrell and Jenkins, (1985) concluded that a relatively large proportion of maintenance energy requirements can be attributed to visceral organs, especially the liver and gastrointestinal tract.

Several authors have concluded that cow size has little effect on overall biological efficiency (Klosterman and Parker, 1976; Morris and Wilton, 1976). However, these conclusions are based upon the assumption of feeding levels appropriate to meet the nutrient requirements of the cows. When cattle are maintained under suboptimum or more extensive range environments there may be important genotype x production interactions, suggesting that cow biological type fitness for a specific environment may be different in extensive vs. intensive production systems. (Klosterman, 1972; Fitzhugh, 1978; Ferrell and Jenkins, 1985). These statements verify that maximizing biological efficiency may not always result in optimum economic efficiency.

Notter *et al.*, (1979) showed that costs for cow maintenance, lactation, and growth account for 65 – 70% of the total energy required for beef production, but only about 35% of the total cost of production. This is due in part to the dichotomy between the costs of feed in the cow-calf sector when compared to the feedlot sector. Cattle-Fax (2004) summarized data over the years 1998 – 2002 and showed an average pasture and feed cost for the cow herd of $165.17 on a per cow exposed for breeding basis. The average weight of a weaned calf of 522 pounds resulted in a feed cost per cwt of $31.61. This value does not reflect the costs of developing replacement heifers, or the value of cull cows. For the same time period, the feedlot cost of feed was $33.29 per cwt. Assuming a 1250 pound slaughter weight, the total feed cost during the feeding period was $245.82. A ten percent increase in EFU would result in a savings of $24.50 for the feedlot sector. However, a ten percent increase in EFU by the cowherd would only result in a saving of $16.52. If the feedlot sector prices were adjusted to an annualized basis to be compared to the cowherd costs, which are already annualized, the savings in the feedlot sector compared to the cowherd sector would be even greater. Assuming the time in the feedlot to be 7 months, the annual savings to the feedlot sector would be $42.00 per animal unit vs. $16.52 for the cost savings in the cow sector.

Archer *et al.*, (1999) acknowledged that total system efficiency is dependent on feed use by all classes of animals in the system. They suggested that measuring feed intake on young animals and using correlations among traits on young and mature animals might improve efficiency in the whole system. Heifers selected for RFI as weaned calves were measured again as mature cows by Archer *et al.*, (2002). The phenotypic correlations between growth (ADG and metabolic weight) and feed efficiency (FI and RFI) traits measured post-weaning and at maturity were moderate (0.28-0.70), but genetic correlations were high (0.72 – 0.98), indicating that efficiency of mature cows may be improved through selection on criteria measured in the post-weaning phase.

Effects of Heterosis

Kress and MacNeil (1999) summarized the effects of individual and maternal heterosis on numerous traits of beef cattle. Individual heterosis for FC is low, with only a 2% improvement. However, the effect of maternal heterosis on total production system EFU is larger. Maternal heterosis is not free; there is an increase in cow forage intake, and cow-calf TDN consumed of 2% and 3%, respectively. However, the ratio of calf weaning weight/cow weight is increased by 8%, and calf weaning weight per cow exposed for breeding is increased by 18%. Additionally, crossbred cows have 38% more longevity than straightbred cows, resulting in lower heifer development costs. As long as the cost of pasture and supplemental feed is lower than the value of the additional output, the increased forage intake of the crossbred cow and calf is offset, resulting in an annual average net return of $70 per cow for the average F_1 crossbred cow. The authors emphasized that heterosis tends to be larger in limited feed environments.

Barriers to Improving EFU in Beef Cattle

Parnell, (2001) described several reasons why improvement in EFU is slow. The expense of obtaining individual animal intake, both in labor and in facilities expense is large. The primary limitation to research and resulting genetic progress in these traits is the expense of gathering intake data on *suitable numbers* of animals to make genetic progress. Automated feeding and weighing devices are being developed and implemented. Calan Broadbent Feeding Gates are used in the Angus Sire Alliance Research Center (Herring and Bertrand, 2001). Pinpointer feeding devices are used to measure individual intake at Warden Farms Angus in Iowa. (Warden, 2004, personal communication) However, the limitation to these approaches is the ability to measure enough animals to accurately estimate genetic parameters of EFU, and also to find enough animals to rapidly disseminate genetic progress from the seedstock herds to the commercial level. GrowSafe Systems, Ltd, markets an individual animal monitoring system. Although the purpose of the system was originally to monitor health and behavioral activities of animals, the system has found new use by researchers to estimate individual animal intake to group fed animals. The GrowSafe system can be used more than one time per year, depending on the availability of candidate animals from seedstock herd. The one-time capacity of the GrowSafe systems in the United States is over

9,000 head (Sundstrom, 2005, personal communication).

Pollak and Kirschten, (2002), suggested the use of a growth model developed originally to predict individual intake of group fed animals in the feedlot sector (Fox *et al.*, 2002a; Fox *et al.*, 2002b; Tedeschi *et al.*, 2004) to predict individual feed requirements for group feed purebred bulls in the seedstock sector. This model, called the Cornell Value Discovery System (CVDS), has been used to predict individual intake of group-fed bulls from the New York State Bull Test. Records from that test for the previous four years indicate that the CVDS predicted feed required accounted for 97-99% of the feed delivered to the pens (Baker, 2005, personal communication).

Researchers have developed a model with a similar component at Roman L. Hruska U. S. Meat Animal Research Center (MARC). The Decision Evaluator for the Beef Industry (DECI) has the capability to predict individual animal intake based upon actual performance measures of the animal. Williams *et al.*, (2005) published phenotypic and genetic parameters for a dataset containing 504 animals. Using both the CVDS model and the DECI model, they found phenotypic correlations between actual FI and CVDS predicted intake and DECI predicted intake of 0.69 and 0.77, respectively. The genetic correlations between actual FI and CVDS predicted intake and DECI predicted intake were 0.95 and 0.96, respectively. They concluded that due to the strong genetic relationships between actual FI and the predicted intake data, that predicted DMI might be used in genetic evaluations in place of actual FI. Van der Werf, (2004) demonstrated that selection for an index including RFI was equivalent to selection indexes using the component traits of RFI: FI, ADG, and mid-weight, and that selection on RFI did not obtain better response than for selection on the component traits in an index. Predictions from DECI and CVDS might be useful in selection indexes using predicted FI, ADG, and mid-weight.

Limitations of Ratios in a Selection Program

Much work has been completed concerning the use of ratios to describe differences in biological settings (Tanner, 1949; Sutherland, 1965). Koch *et al.*, (1963) addressed the difficulties of dealing with ratios by proposing a linear index selection in the form of RFI. That same approach has been supported by other researchers investigating RFI (Arthur *et al.*, 1998; Liu *et al.*, 2000; Herd and Bishop, 2000). Herring and Bertrand, (2001) illustrated that more than one set of *input:output* variables can optimize a ratio (Appendix II, Table I). This may result in selection for low ADG animals if only the ratio is considered in selection. Gunsett, (1984) summarized the problems of utilizing selection based on ratios as: 1) the statistical properties of a ratio are poor resulting in erratic response to selection, 2) the response to selection in component traits cannot be predicted accurately, and 3) ratios may produce fallacious indications of economic well-being.[1]

The livestock industry seems to favor describing differences in terms of FC, rather than FE. This is because it is much easier to understand differences in performance of animals or pens expressed as a ratio of 6:1 vs. 5.5:1 when compared to their inverses, 0.1667 and .1818, respectively. The expression of EFU as FC or FE does not likely affect the ability to describe phenotypic differences among animals (see Appendix II, Equation 0.2). When the gain is expressed as total gain over the trial period, and the feed is expressed as the total feed over the trial period, rather than daily gain, and daily feed, there should be no statistical problem with describing animals phenotypically using FC. However, in selection programs, these conclusions will probably not hold: if selection for FC or FE is practiced, FE should be the trait selected for.

Conclusions and Implications for Genetic Improvement of Beef Cattle EFU

In the last 50 years, scientists have made much progress in understanding the component traits in EFU, and the association of EFU with related traits. Early studies showed that part of the variation in EFU was due to mature size differences of animals and differences in composition of gain. Considering the type of cattle predominant in America at that time, the recommendation to select for more size and gain to capture differences in EFU was sound advice. However, within an extensively managed biological system, only so much size can be selected for before undesirable consequences may occur such as a decrease in conception rate due to the larger cows

[1] Recommendations that ratios be expressed as output/input (e.g., gain/feed, not feed/gain) were suggested in Journal of Animal Science Style and Form 1992. 70:319. See Appendix II, Equation 0.1 for an example of ratios that may result in spurious estimates. FE will be more stable than FC when selection is applied. This is because as animal scientists are better able to partition variance in gain and intake into component parts to control undesirable changes in related traits, the variance in adjusted intake or adjusted gain will become closer to zero (0), which will result in spurious results in the FC ratio.

inability to meet nutrient requirements on limited feed resources.

FE and FC can be selected for, but the resulting changes in the component traits might be somewhat unpredictable. In all studies, selection for FE or FC resulted in increases in ADG, but the amount of change varies among studies. Resulting changes in FI are less predictable. If a ratio describing EFU must be used, FE should be the choice.

RFI recently has been "rediscovered" with regards to beef cattle and has been able to show more clearly how to effect desired selection changes in intake. Single generation selection responses to RFI have been considerable. RFI has the advantage of being robust enough that control can be exerted over component traits to hold those traits constant over generations, if change in those traits results in unfavorable fitness for a particular production environment. However, RFI can only be utilized to decrease intake to the point that either daily gains become economically insufficient in the feedlot sector, or female reproduction or calf growth is affected in the cow-calf sector, resulting in an unsustainable income level. Additionally, since the component traits are available from recent studies, research should investigate the second measure of EFU originally proposed by Koch et al., (1963) which suggested that ADG adjusted for intake (net daily gain) was a better measure of EFU than RFI. This approach will probably result in the same change in composition that selection for RFI has caused, but it can be done without the resulting decrease in intake, and may thus be more sustainable in a selection strategy over time. Currently, we do not know the long-term effects of genetically reducing FI.

It should be noted, that in the selection trials for RFI, WW was not considered as part of the selection criteria in conjunction with RFI. In those trials, RFI was unrelated to weight or growth, which implies that there is variation in RFI independent of size, and that selection for RFI should not change size. However, if WW (or another weight trait) is tandemly selected for along with RFI, we might expect a change in size as it relates to the other trait selected for. RFI is independent of size, growth, and weight. RFI and a weight trait in a tandem selection scheme may result in a change in size due to the other traits' association with size. Adding a component for mature size into RFI equations may be necessary to offset the resulting increase in mature size that may occur with more recent recommendations to select for RFI and ADG in a tandem index. Net daily gain may favor many of the same animals as a tandem index of residual feed intake and average daily gain without being as computationally intensive.

Scientists have been able to estimate the variation in RFI due to its' component parts. Work should continue along these lines to investigate the possibility of isolating those parts of RFI that may be independent of other important traits, for use in selection programs. Scientists should also relate the variation in the component parts of RFI back to FC/FE, so producers can more easily understand how the component parts relate to what they actually measure, and can more easily understand the causal components in FC/FE.

Computer models have been proposed to serve as a replacement for measuring actual FI. Results from field trials and research settings indicate that this approach is promising, especially since a much larger number of animals, male and female, can be measured each year. The trade-off between precision of measurement on a limited numbers of animals when compared to less precise measurements on a large number of animals is being investigated. More work needs to be completed to quantify the use of these predictive models in a selection index, as compared to selection indexes using actual FI.

IGF-I concentrations may be measured as a possible indicator of EFU. More work needs to be completed in this area to fully substantiate the use of blood IGF-I concentration in a selection scheme. Additionally, work is needed to determine the causal components of variation in IGF-I concentration in the event that IGF-I concentration is controlled in a qualitative nature. If that is the case, then a genetic test could possibly be developed to test for the presence of the gene regulating IGF-I concentration.

Producers will need to identify their target output trait so they can optimize genetic progress in EFU, since the chosen selection strategy will vary depending on target output. If a producer sells calves at weaning, the selection strategy will be different than if they retain ownership of the calves though the feedlot, or until slaughter. Producers that sell calves at weaning should concentrate on increasing the efficiency of use of feed resources by crossbreeding, with some emphasis also for weaning weight. If a producer retains ownership through the feedlot, but sells before slaughter, they can put less emphasis on marbling traits, and more on growth traits. If a producer is selecting for a high yield, lean carcass target output, they will not need to hold marbling constant, and some of the improvement in EFU can come from changes in composition. However, if a producer is selecting for a high marbling market target, they must hold composition changes constant over time, or the marbling score will tend to decrease with selection for EFU. Producers should realize that matching the biological type to the production environment would probably improve net income more than maximizing EFU without regards to biological type. Producers should also realize that a planned crossbreeding system will play a more important role in improving overall ranch efficiency than concentrating on improving feedlot efficiency. The work of the producer may be simplified greatly by the correct blend of English and. Continental genetics. The cattle produced from the English/Continental cross have the ability to excel at more target endpoints than straightbred cattle, resulting in more marketing flexibility.

The challenge for scientists and livestock producers is to capture that part of EFU that improves net profit in both the feedlot sector and the cow-calf sector, without affecting the other sector in an unfavorable way. Whatever the market target is, the producer will be challenged to improve EFU while maintaining appropriate mature size for the production environment, while the feedlot sector will continue to demand more efficient cattle. Progress has been made in describing differences in EFU that is independent of mature size. Selection tools are being developed that producers can use to capture improved EFU on the ranch while still delivering feed efficient cattle to the feedlot. From the feedlot sector point of view, there is progress being made in improving EFU that is independent of size and composition, so that lean, large targets and high marbling targets can both be achieved. Optimization of resources relative to outputs may be the most profitable method for the industry, while maximization of output relative to input may serve one sector of the industry while critically affecting another.

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Figure I. Contributions of biological mechanisms to variation in residual feed intake as determined from experiments on divergently selected cattle. (After Richardson and Herd, 2004)

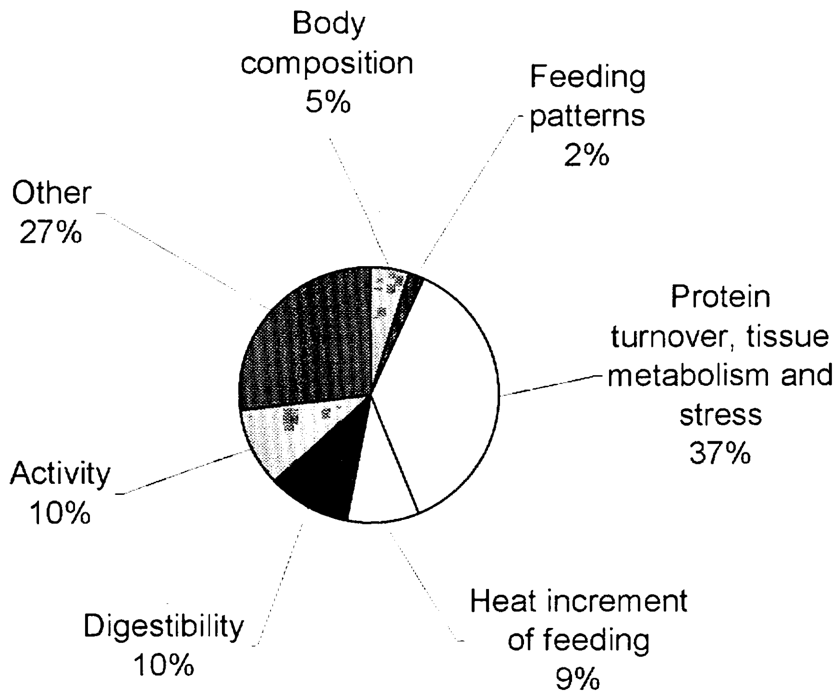
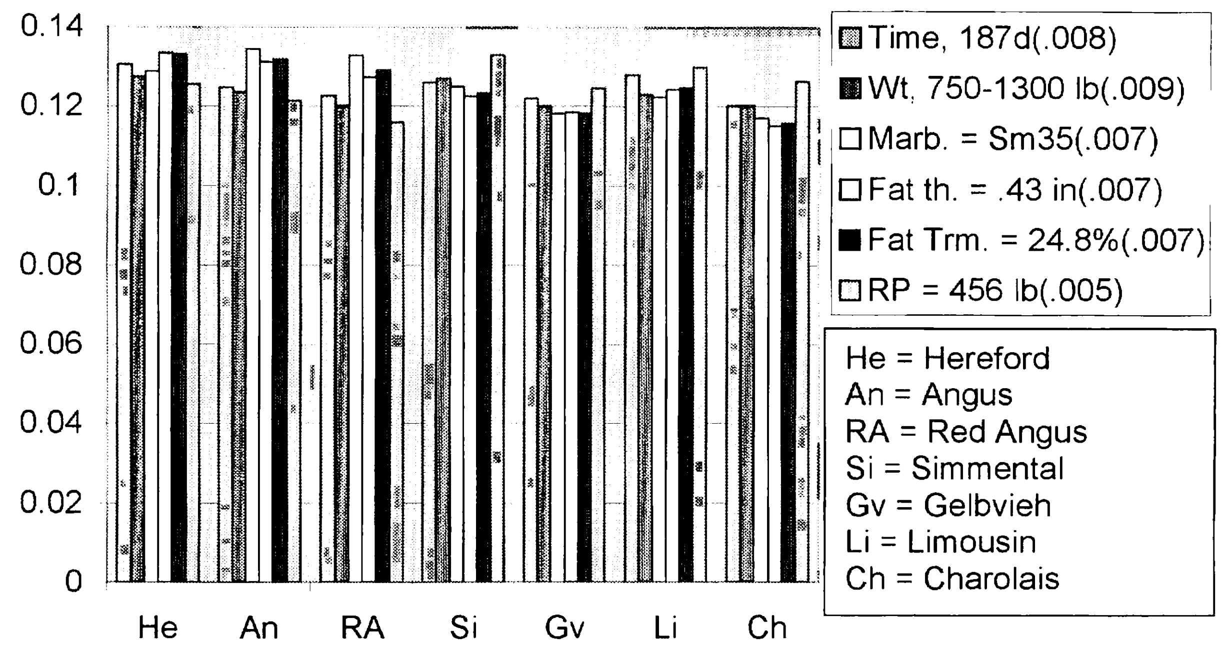


Figure II. Breed of Sire Means for Estimates of Feed Efficiency (Live Weight Gain per Unit Metabolizable Energy Consumed, lb/Mcal) for Alternative Intervals and Endpoints (LSD<.05)



Appendix II: Use of Ratios for Selection

Table 1: Example of cattle with feed conversion of 5.5 lb dry matter intake per lb gain but with differing growth and intake rates.[1]

Growth rate	ADG, lbs/d	Daily DM Intake, lbs/d
High	4.0	22.0
Medium	3.0	16.5
Low	2.0	11.0

[1]Reproduced from Herring and Bertrand, 2001

$$\lim_{adg \to 0} \frac{FI}{ADG} \to \infty \tag{0.1}$$

This limit shows that if ADG is near zero (or substantially low over a test period), the solution for FC can be spurious.

$$\lim_{dfi \neq 0} \frac{ADG}{FI} = solution \tag{0.2}$$

Since the limit of intake will not be near zero over a test period, this limit will produce a solution, thus FE is more stable that FC.

$$\lim_{FIcorr \neq 0} \frac{ADGcorr}{FIcorr} = solution \tag{0.3}$$

This limit shows a recommended method of estimating EFU using FE. Here, *FIcorr* and *ADGcorr* are FI and ADG corrected for differences in FI or ADG due to differences in test length, mature size, body composition, visceral organ mass, digestibility, etc. This approach can be used to calculate FE independent of these correlated traits.

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 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 1973
Robert Miller .... MN... 1973
William F. Borrow................. CA.... 1973
Bert Crame............................ CA.... 1974
Bert Sackman......................... ND ... 1974
Dover Sindelar....................... MT ... 1974
Burwell M. Bates................... OK ... 1974
Charles Descheemacher.......... MT ... 1974
J. David Nichols..................... IA..... 1974
Jorgensen Brothers................. SD 1974
Marvin Bohmont.................... 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 Arbuthnot.................... KS 1975
Robert D. Keefer.................... MT ... 1975
Walter S. Markham................ CA.... 1975
Ancel Armstrong .... VA ... 1976
Gerhard Mittnes..................... KS 1976
Healey Brothers .... OK ... 1976
Jackie Davis........................... CA.... 1976
Jay Pearson .... ID..... 1976
L. Dale Porter .... IA..... 1976
Lowellyn Tewksbury .... 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 Dashiell.......................... WA .. 1977
Wayne Eshelman.................... WA .. 1977
Harold Anderson .... SD ... 1977
William Borror....................... CA ... 1977
A.L. Frau 1978
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 1978
Roy Hunst .... PA ... 1978
Bill Wolfe............................... OR ... 1979
Del Krumweid........................ ND ... 1979
Floyd Metter.......................... MO .. 1979
Frank & Jim Wilson .... SD ... 1979
Glenn & 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 .... UR ... 1980
Floyd Dominy .... VA ... 1980
Frank Felton .... MO .. 1980
Frank Hay.............................. CAN 1980
James Bryany .... MN .. 1980
John Masters........................... KY ... 1980
Mark Keffeler......................... SD ... 1980
Paul Mydland .... 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. Cronwell .... 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 Autfathr...................... MN... 1981
Roy Beeby .... OK ... 1981
Russ Denowh......................... MT ... 1981
Bob Thomas........................... OR.... 1982
Clare Geddes.......................... CAN. 1982
David A. Breiner.................... 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 Borror.............................. 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. Parcel .... KS 1984
Donn & Sylvia Mitchell......... CAN. 1984
Earl Kindig .... VA ... 1984
Floyd Richard .... ND ... 1984
Fred H. Johnson..................... OH ... 1984
Glen Klippenstein .... MO... 1984
Jack Farmer............................ CA.... 1984
Jerry Chappel .... 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 Schafer .... MN... 1985

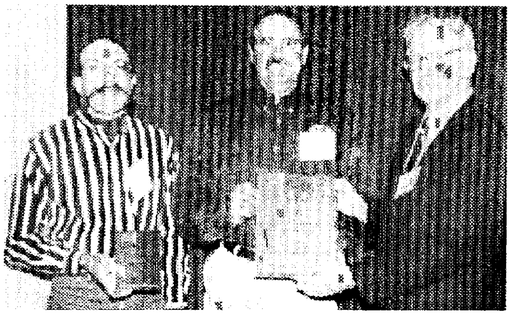
Everett & Ron Batho	CAN.	1985
Fred Killam	IL	1985
George B. Halteman	WV	1985
Glenn L. Brinkman	TX	1985
Gordon Booth	WY	1985
J. Newbill Miller	VA	1985
Marvin Knowles	CA	1985
R.C. Price	AL	1985
Tom Perrier	KS	1985
A. Lloyd Grau	NM	1986
Clarence VanDyke	MT	1986
Clifford & Bruce Betzold	IL	1986
Delton W. Hubert	KS	1986
Dick & Ellie Larson	WI	1986
Evin & Verne Dunn	CAN.	1986
Gerald Hoffman	SD	1986
Glenn L. Brinkman	TX	1986
Henry & Jeanette Chitty	FL	1986
J.H. Steward/P.C. Morrissey	PA	1986
Jack & Gini Chase	WY	1986
John H. Wood	SC	1986
Lawrence H. Graham	KY	1986
Leonard Lodden	ND	1986
Leonard Wulf	MN	1986
Matthew Warren Hall	AL	1986
Ralph McDanolds	VA	1986
Richard J. Putnam	NC	1986
Roy D. McPhee	CA	1986
W.D. Morris/James Pipkin	MO	1986
Charles & Wynder Smith	GA	1987
Clayton Canning	CAN.	1987
Eldon & Richard Wiese	MN	1987
Forrest Byergo	MO	1987
Gary Klein	ND	1987
Harold E. Pate	IL	1987
Henry Gardiner	KS	1987
Ivan & Frank Rincker	IL	1987
James Bush	SD	1987
Larry D. Leonhardt	WY	1987
Lyall Edgerton	CAN.	1987
R.J. Steward/P.C. Morrisey	MN	1987
Tommy Brandenberger	TX	1987
Bill Bennett	WA	1988
Darold Bauman	WY	1988
David and Carol Guilford	CAN.	1988
David Luhman	MN	1988
Don and Dian Guilford	CAN.	1988
Donn & Sylvia Mitchell	CAN.	1988
Douglas D. Bennett	TX	1988
George Schlickau	KS	1988
Gino Pedretti	CA	1988
Glann Debter	AL	1988
Hansell Pile	KY	1988
Jay P. Book	IL	1988
Kans Ulrich	CAN.	1988
Kenneth Gillig	MO	1988
Leonard Lorenzen	OR	1988
Robert E. Walton	WA	1988
Scott Burtner	VA	1988
William Glanz	WY	1988
Bob R. Whitmire	GA	1989
Donald Fawcett	SD	1989
Ed Albaugh	CA	1989
Glynn Debter	AL	1989
Harry Airey	CAN	1989
Jack & Nancy Baker	MO	1989
Jerry Allen Burner	VA	1989
Kenneth D. Lowe	KY	1989
Leonard A. Lorenzen	OR	1989
Lester H. Schafer	MN	1989
Lynn Pelton	KS	1989
Orrin Hart	CAN	1989
Ron Bowman	ND	1989
Sherm & Charlie Ewing	CAN	1989
Tom Mercer	WY	1989
Bob Thomas Family	OR	1990
Boyd Broyles	KY	1990
Charles & Rudy Simpson	CAN	1990
Doug Fraser	CAN	1990
Douglas & Molly Hoff	SD	1990
Dr. Burleigh Anderson	PA	1990
Gerhard Gueggenberger	CA	1990
John & Chris Oltman	WI	1990
John Ragsdale	KY	1990
Larry Erahart	WY	1990
Otto & Otis Rincker	IL	1990
Paul E. Keffaber	IN	1990
Richard Janssen	KS	1990
Steven Forrester	MI	1990
T.D. & Roger Steele	VA	1990
Ann Upchurch	AL	1991
Dave & Carol Guilford	CAN	1991
Jack & Gini Chase	WY	1991
Jack Cowley	CA	1991
James Burnes & Sons	WI	1991
James R. O'Neill	IA	1991
Jim Taylor	KS	1991
John Bruner	SD	1991
Larry Wakefield	MN	1991
N. Wehrmann/R. McClung	VA	1991
R.A. Brown	TX	1991
R.M. Felts & Son Farm	TN	1991
Ralph Bridges	GA	1991
Richard & Sharon Beitelspacher	SD	1991
Rob & Gloria Thomas	OR	1991
Steve & Bill Florschcuetz	IL	1991
Summitcrest Farms	OH	1991
Tom Sonderup	NE	1991
A.W. Compton, Jr.	AL	1992
Bill Rea	PA	1992
Bob Buchanan Family	OR	1992
Calvin & Gary Sandmeier	SD	1992
Dennis, David, & Danny Geffert	WI	1992
Dick Montague	CA	1992
Eugene B. Hook	MN	1992
Francis & Karol Bormann	IA	1992
Glenn Brinkman	TX	1992
Harold Dickson	MO	1992
Leonard Wulf & Sons	MN	1992
Robert Elliot & Sons	TN	1992
Tom & Ruth Clark	VA	1992
Tom Drake	OK	1992
Bob Zarn	MN	1993
Clarence, Elaine, & Adam Dean	SC	1993
Collin Sander	SD	1993
D. Eldridge & Y. Aycock	OK	1993
Harrell Watts	AL	1993
J. David Nichols	IA	1993
J. Newbill Miller	VA	1993
Joseph Freund	CO	1993
Lynn Pelton	KS	1993
Miles P. "Buck" Pangburn	IA	1993
Norman Bruce	IL	1993
R.A. Brown	TX	1993
R.B. Jarrell	TN	1993
Rueben, Leroy, & Bob Littau	SD	1993
Ted Seely	WY	1993
Wes & Fran Cook	NC	1993
Bobby F. Hayes	AL	1994
Bruce Orvis	CA	1994
Buell Jackson	IA	1994
Calvin & Gary Sandmeier	SD	1994
Dave Taylor & Gary Parker	WY	1994
Jere Caldwell	KY	1994
John Blankers	MN	1994
John Pfeiffer Family	OK	1994
Ken & Bonnie Bieber	SD	1994
Mary Howe di'Zerega	VA	1994
Richard Janssen	KS	1994
Ron & Wayne Hanson	CAN.	1994
Bobby Aldridge	NC	1995
Chris & John Christensen	SD	1995
Donald J. Hargrave	CAN.	1995
Gene Bedwell	IA	1995
Gordon & Mary Ann Booth	WY	1995
Howard & JoAnne Hillman	SD	1995
John Robbins	MT	1995
Mack, Billy, & Tom Maples	AL	1995
Mary Howe de'Zerega	VA	1995
Maurice Grogan	MN	1995
Thomas Simmons	VA	1995
Tom Perrier	KS	1995
Ward Burroughs	CA	1995
C. Knight & B. Jacobs	OK	1996
C.W. Pratt	VA	1996
Cam, Spike, & Sally Forbes	WY	1996
Chris and John Christensen	SD	1996
D. Borgen and B. McCulloh	WI	1996
Frank Felton	MO	1996
Frank Schiefelbein	MN	1996
Galen & Lori Fink	KS	1996
Gerald & Lois Neher	IL	1996
Ingrid & Willy Volk	NC	1996
Mose & Dave Hebbert	NE	1996
Robert C. Miller	MN	1996
William A. Womack, Jr.	AL	1996
Alan Albers	KS	1997
Blaine & Pauline Canning	CAN.	1997
Bob & Gloria Thomas	OR	1997
Darel Spader	SD	1997
E. David Pease	CAN.	1997
Gregg & Diane Butman	MN	1997

Harold Pate .... AL 1997
James I. Smith .... NC 1997
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
Airey 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
Kramer Farms .... IL 1999
Lynn & Gary Pelton .... KS 1999
Noller & Frank Charolais .... IA 1999
Rausch Herefords .... SD 1999
Steve Munger .... SD 1999
Terry O'Neill .... MT ... 1999
Tony Walden .... AL 1999
Alan & Deb Vedvei .... SD 2000
Banks & Margo Herndon .... AL 2000
Blane & Cindy Nagel .... SD 2000
Galen, 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
Kent 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
Dale, 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
& 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

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

2004 Seedstock Producer of the Year
Camp Cooley Ranch – Texas



Matt Jones, director of research, and Mark Cowan, president, of Camp Cooley Ranch receive the Seedstock Producer of the Year Award from S.R. Evans, 2004 BIF President.

The Beef Improvement Federation is proud to present the 2004 Seedstock Producer of the Year award to Camp Cooley Ranch, Franklin, Texas. A progressive beef operation set on gently rolling hills, the 11,750 acre ranch is picturesque and home to Brangus, Angus and Charolais cattle.

Klaus Birkel purchased Camp Cooley Ranch in October 1991. In 1993, he purchased the Brinks Brangus cowherd and moved the cattle from Kansas to Texas. Eventually, he added the complimentary genetics of Angus and Charolais cattle. Today, the Camp Cooley Ranch umbrella has grown to include nearly 1,500 registered, breeding age females at the ranch and an additional 1,000 breeding age females at joint ventures in Mexico, Bolivia, Argentina and Brazil.

The combination of Brangus, Angus and Charolais cattle offer Camp Cooley Ranch customers the opportunity to utilize the positive contributions of each breed in their programs. In rotational cross breeding systems, the three breed make up provides options of environmental adaptability, maternal genetics, carcass traits, and performance for our customers.

Camp Cooley Ranch has taken progressive measures to support and encourage ultrasound use by funding and participating in numerous research projects across the nation. Today, they continue to stay on the forefront of the industry with carcass research and the collection and analysis of carcass data.

During the calendar year 2004, Camp Cooley Ranch will market over 1,000 bulls through their annual production sale and by private treaty. At the annual sale and throughout the year, efforts are made to provide learning/educational opportunities for customers and cooperators.

The International Brangus Breeders Association nominated the Camp Cooley Ranch for this award.

Congratulations to the Camp Cooley Ranch.

2005 SEEDSTOCK PRODUCER AWARD NOMINEES

ALTENBURG SUPER BALDY

William and Sharon Altenburg
Colorado

Altenburg Super Baldy is a family-owned seedstock operation started in 1975 and is located in northern Colorado. Today, Altenburg's utilize both Simmental and Angus genetics, including red and black segments of each breed, as well as developing half bloods which they designate as "Super Baldy's". A friend and customer raising commercial cattle recognized the advantages of Altenburg's breeding program and coined the name "Super Baldy". Currently, Altenburg Super Baldy sells 55-60 bulls annually to commercial breeders in Colorado, Wyoming and western Nebraska. The cowherd consists of 85 Simmental, 40 Red Angus and 10 Angus cows. A cooperator herd of 25 Angus cows provides bulls for the annual bull sale. Simmental genetics are utilized for additional growth, muscle and yield while maintaining a strong, maternal female. Angus genetics (both red and black) provide marbling, strong maternal traits and calving ease for use on first-calf heifers.

Altenburg attempts to utilize "all the tools" available to improve the genetic offering. Artificial insemination, embryo transfer, and ultrasound are utilized. The major goal of the Altenburg operation is to provide "simple to use" genetics that can be used in progressive crossbreeding programs. These crossbreeding programs are designed to produce common sense products that allow commercial customers to take advantage of proven genetics.

Altenburg Super Baldy is located in close proximity to Colorado State University, Fort Collins. This location allows animal science students to live and complete an internship while attending CSU. Students provide much of the day-to-day labor requirements while Willie travels as Associate Vice President of Beef Marketing for Genex Cooperative. Each student becomes responsible for individual sectors of the operation (i.e. bull development, replacement heifer development, cow herd calving). Approximately 10 CSU students have served in this capacity. They have gone on to a wide array of positions within the beef industry including: two veterinarians, a university beef cattle instructor, a livestock judging team coach, an embryo transfer technician, while others have returned to manage family-owned beef cow herds.

Altenburg Super Baldy was nominated by the Colorado Cattlemen's Association.

BAR S RANCH

Ken and Pat Stielow
David and Stephanie Dickerson
Kansas

Bar S Ranch, Inc. is located in Russell County in North Central Kansas. Ken and Pat Stielow, along with their daughter and son-in-law, David and Stephanie Dickerson, and grandchildren: Grady, Ethan, and Jayce, share management responsibilities.

The ranch consists of 6,000 acres owned and 6,000 acres rented. Over 3,000 acres are farmed to produce wheat, feed grain and forage. Bar S Ranch calves about 500 Angus females and 50 Charolais females each spring. Genetic selection emphasizes low birth weight, high growth, and moderate mature size through the diligent use of EPDs. Local demand has grown for Bar S Ranch bulls and, in response; an annual production sale began in 1991. The Charolais breed was added in 1999 to serve as a terminal complement to Angus.

Bar S Ranch also operates a 1,000-head grower yard, which uses ranch-raised grains and forages to prepare cattle to be sent to Ward Feed Yard, in which Ken owns a minority interest.

Ken's grandfather, Frank Stielow, Sr., as a young German immigrant homesteaded the quarter section where the ranch headquarters is located in 1900. Frank Sr. struggled through the 1920's market collapse and the 1930's extreme drought to grow the ranch in small, steady increments. Frank Stielow, Jr., Ken's father, came back to the ranch in 1945. His first livestock purchase was a group of purebred Angus heifers. Frank Jr. had a deep appreciation of quality cattle. He developed a commercial Angus herd known regionally for its high-quality feeder calves as well as a small registered Angus herd.

In 1975, Ken and Pat joined the ranch after graduating from Kansas State University. At that time, the business was incorporated as Bar S Ranch, Inc. Additional registered Angus females were purchased from Minert Angus Ranch in Nebraska in 1985 and an extensive artificial insemination program was started.

Bar S Ranch was nominated by the Kansas Livestock Association.

ELLIS FARMS
Phil and Joyce Ellis
Illinois

Ellis Farms originated as R.H. Ellis & Sons in 1948 with the purchase of registered Polled Hereford females and a bull to replace a commercial cowherd. These cows became the nucleus of a registered cattle venture that has continued for 57 years. The ranch has been located just one mile from the original Ellis homestead since 1964. Today, it is remains a family-owned operation with Phil and Joyce Ellis and their son's families: Matt and Lisa Ellis, Joe and Lauri Ellis. In addition, son-in-law Joe Seward serves as veterinarian, while daughter Cathy assists in public relations. This is a fifth-generation (with the 6^{th} generation on the ground) cattle operation and they plan on leaving it in good hands for the next generation.

Today, a spring calving herd of approximately 190 Herefords, 15 Salers and percentage-Salers and 15 Angus females is maintained. The operation includes 1,400 acres of row crop corn and soybeans, 200 acres of hay and 400 acres of pasture situated in two states. Initially, Ellis Farms was strictly a single-breed cattle operation. However, with the construction of a feedlot and the need to diversify into a more complete supplier of genetics for the commercial bull customer, Ellis Farms added two additional breeds during the 1980's. The first Angus cow was purchased in 1978 and the first Salers genetics were introduced in 1983. These decisions were based on the need to supply the commercial cattleman with outcross genetics.

Ellis Farms sells 60 percent of its offspring as seedstock replacements or commercial bulls. The remaining 40 percent are fed out and either merchandised through a membership in the Illinois Crown Beef branded meat program or sold on an incentive-based grid. The marketing arrangements allow data collection to begin at birth and end with carcass information. Hence, birth, weaning, and yearling weights; frame score, scrotal measurements, yearling ultrasound data, and complete carcass data are recorded.

The American Hereford Association nominated the Ellis Farms.

INGRAM CATTLE COMPANY
Owner: D. R. Ingram
Manager: Mike Wood
Mississippi

Ingram Cattle Company began operation in 1949 and is located in northern Mississippi near Water Valley. This family-owned and operated enterprise is an integrated farming and cattle operation. Row crops include cotton, soybeans, corn and small acreages of wheat and oats. The warm-season forage base is complemented with the cool-season forages of annual ryegrass and tall fescue. Registered cattle have been an integral part of the operation since its inception. Ingram Cattle Company was one of the leading Polled Hereford breeders in the Southeast for many years. Small herds of registered Angus and Gelbvieh cattle were added in the mid 1980's.

The Gelbvieh herd was dispersed in the mid 1990's and the Polled Hereford herd was sold in 2002. This has allowed Ingram Cattle Company to concentrate on the development and expansion of the registered Angus herd. From its beginning in 1985 with the purchase of 25 cows, the Angus herd has grown to 300 females. Artificially insemination is used on all cows and heifers before a clean-up bull is turned out. The September/October calving season allows for the marketing of 16-18 month old bulls in the spring when demand is the greatest. Bulls are primarily marketed private treaty and through state-sponsored BCIA Sale. Ingram Cattle Company also helps support the Mississippi Angus Association sale, breed promotion, and breed improvement efforts.

The Mississippi Beef Cattle Improvement Association nominated the Ingram Cattle Company.

MOORE FARMS
Dr. Billy S. and Trudy Moore
Alabama

Moore Farms is located northeast of Huntsville, Alabama on Moores Mill Rd, north of Hwy 72 East. The farm includes 172 acres, all of which is in pasture, except for the residence. Members of the Moore family perform all day-to-day farming duties, as there are no salaried employees. Moore Farms has been raising cattle in this location since 1975. They started with a few Angus cows which were crossbred with Simmental bulls. Beginning in 1980, Moore Farms began to acquire purebred Simmentals, and in the early 1990's, the focus of the operation was limited to fullblood Simmentals.

During the last 11 years, the focus of the operation has been further refined to concentrate primarily on the production of full-Fleckvieh Simmentals which presently make up approximately 70% of the herd. In 1999, Moore Farms purchased a full South African Fleckvieh bull from Bar 5 Stock Farms in Brandon, Manitoba, Canada. Since that time, South African pedigrees have been strongly emphasized in the Moore Farms program.

Moore Farms makes extensive use of artificial insemination and embryo transfer in order to take maximum advantage of the most exclusive bloodlines available in North America. Moore Farms has marketed these exclusive bloodlines throughout the United States and in several foreign countries. The operation currently maintains about 65 breeding age females, and primarily utilizes a fall calving season. However, some spring born calves are born each year in order to take maximum advantage of the embryo transfer program.

Alabama Beef Cattle Improvement Association nominated Moore Farms.

MORRISON STOCK FARM

Bob and Tom Morrison
Ohio

Bob Morrison started raising Polled Hereford cattle 45 years ago on his Morrow County farm, located in North Central Ohio. Today Morrison Stock Farm consists of 1,100 acres of both owned and rented ground and approximately 80 Hereford cows. The family farm has grown to include three generations; Bob and Karen Morrison, their son Tom and his wife Nikki, along with Tom and Nikki's two children, Cody and Paige.

Morrison Stock Farm holds a production sale every other year or when the numbers dictate they can offer more of their cattle for sale. They also sell cattle private treaty and are very successful in utilizing state and regional Hereford consignment sales. Two prominent herd bulls that have helped Morrison Stock Farm sell cattle, semen, and embryos into 45 states include: Feltons 492 and Feltons Legend 242.

Morrison Stock Farm uses the show ring as an integrated part of their total marketing plan. The most recent example of the high quality cattle bred and shown by Morrison Stock Farm comes from the 2004 Ohio State Fair. The Morrisons were named the Premier Breeder, Premier Exhibitor and Outstanding Herdsman for the Hereford show.

Bob and Tom Morrison have both served on the Board of Directors and are Past Presidents of the Buckeye Hereford Association and the former Buckeye Polled Hereford Association. Bob was Vice President of the American Hereford Association in 1999 and a Board Member when the American Polled Hereford and American Hereford Associations merged.

Morrison Stock Farm was nominated by the Ohio Cattlemen's Association

PANGBURN STOCK FARM

Buck and Beverly Pangburn
Iowa

This is a Century Family Farm started in 1860. The operation is composed of Buck's mother, Marjorie, 92, who now resides in a retirement home; wife Beverly; son, Don, and wife, Bryn, and grandchildren, Grayson, 17, Paige, 14, and Peyton, 3.

The seedstock operation started when Buck was a high school sophomore and purchased a purebred Duroc hog. The purebred Duroc hog business lasted for 52 years. After graduation from Iowa State College and returning to the family farm in 1957, improvement in the cow herd was started. River bottom pasture was an important part of the farming and cattle operation.

Genetic improvement began in late 1950 with the purchase of a Hereford bull from Montana, followed by Charolais and Angus bulls in the 1960's. The first Simmental bull was purchased in 1971. Field records confirmed that the Simmental bull increased weaning weights by 50 to 75 pounds.

Artificial insemination was started in the early 1970's and weaning weights continued to dramatically increase. The operation relies on Don's AI skills during all breeding seasons. Pangburn Stock Farm strives to keep abreast of new technology, for example, embryo transfer was started in the spring of 1990.

Usually about 100 cows are maintained in the operation; with approximately 70 percent purebred and 30 percent commercial. Their calving season is from Jan. 1 to Aug. 1. The AI and embryo transfer work is done from late March to the first of August, after that clean-up bulls are turned used for 60 days. The operation plans to reduce the cow herd to about 80 cows in the near future.

Pangburn Farms was nominated by the Iowa Cattlemen's Association.

RISHEL ANGUS

Bill and Barb Rishel
Nebraska

Rishel Angus is a family-owned purebred Angus operation that has been in business since 1966. The Rishel Angus mission statement reads: *to* *produce superior Angus genetics based on economically important traits that provide profit for our customers, create value for all segments of the beef industry, and ensure a satisfying eating experience for the consumer.*

Rishel Angus is known in the seedstock industry as one of the very first breeders of Angus cattle to make a substantial commitment to identifying and improving carcass merit. The belief at Rishel Angus, then and now, is that the real focus should be directed toward the acceptance of the consuming public for beef's end product. Because of these efforts, many of the leading sires for carcass merit in the Angus breed now carry Rishel Angus', "B/R" prefix. In fact, currently, 40 proven sires and 9 young sires listed in the National Angus Sire Evaluation Summary are Rishel Angus bred bulls. One of these sires, B/R New Design 036, ranks third among all Proven Angus sires for Pathfinder daughters and has the top 10 Pathfinder sons in the breed, and records the highest percentage of Pathfinder daughters of those eligible.

Rishel Angus has collected and used complete performance records on all cattle since the inception of the herd. These records have allowed them to not only identify many outstanding sires, but also to identify and perpetuate numerous outstanding cow families and individual cows. The Rishel Angus herd consists of 300 Angus cows and 100 Angus heifers. For the last 23 years, a yearling bull sale has been held the fourth Monday in March and for the last 26 years a female sale has been held the first Sunday in October. Rishel Angus operates on a combination of 11,000 deeded and leased acres with wintering and calving at the headquarters located 10 miles south of North Platte, Nebraska.

Rishel Angus was nominated by the Nebraska Cattlemen and the University of Nebraska.

ROGERS BAR HR

Owner: Harlan and Dorotheann Rogers
Manager: Doug Rogers
Mississippi

Rogers Bar HR is located in South Mississippi less than 100 miles from the Gulf of Mexico. There has been a Rogers's cattle operation at this location since 1926. Seventy-nine years ago 27 acres were inherited and over the years the operation has grown to approximately 1,650 acres of owned land and an additional 2,100 acres of lease property. Four sons: Oby, Bernie, Doug, and Joey, and one grandson, Levi, are involved in the cattle business and own and lease large tracts of land in this area. A Family Limited Partnership is utilized to manage the operations that also include timberland and other assets.

Registered purebred Charolais are the foundation of our 300 plus cowherd. The operation utilizes both fall (from November to December) and spring (from February to April) calving seasons. Cattle are maintained primarily on grass with very little grain.

Because of easy access to large quantities of inexpensive chicken litter, it is used to build pasture soil fertility. This greatly reduces the cost of fertilizer necessary to assure an abundance of high quality forage. They also use by-products made available by the Mississippi River grain business. Grain dust, corn screenings, rice bran and cotton tailings are readily available if supplemental feed is needed. The climate is mild with about 67 inches of rain per year. Marshall ryegrass grows extremely well in this area, probably as well as any place in the United States, even in January and February. The ryegrass is normally grazed from November 1st to May 20th and allows the cows to wean off very heavy calves. Some rotational grazing is used. Most pastures are permanently fenced and contain between 25 and 40 acres.

Rogers Bar HR was nominated by the American-International Charolais Association.

SOLDIERS' HILL ANGUS FARM

Dennis Pearson
Virginia

Soldiers' Hill Angus Farm, of Warrenton, Virginia, is owned and operated by Dennis Pearson and his father Harvey. It began in the early 1970's as a 4-H heifer project. With roots established through a commercial cow-calf enterprise, Soldiers' Hill has concentrated on registered Angus since 1990 and has evolved into a leading performance Angus herd.

Soldiers' Hill's breeding program has been focused on providing practical, balanced performance genetics to the commercial cow-calf sector. This has been accomplished through the use of highly proven AI sires. Soldiers' Hill practices whole-herd AI and embryo transfer to rapidly propagate superior bloodlines. Sire selection emphasizes a balance of calving ease, growth, maternal traits, and carcass merit.

Sine 1990, Soldiers' Hill has utilized the Virginia BCIA Central Test Station at Culpeper for bull development and marketing. Over the past 15 years, they have developed a strong reputation and have become known as a source for predictable performance genetics. Highlights of the Soldiers' Hill program include the breeder group award at

Culpeper in both 1999 and 2004, the Bartenslager and Premier Angus Breeder Award from Virginia BCIA in 2000, and the high ADG bull in the 47 year history of the Culpeper BCIA test in 1998. An active marketing program and customer service have been key to the success of their modest size operation, which consists of 65 breeding age females. Select Soldiers' Hill females have been offered through state association sales and private treaty sales.

Dennis Pearson, a 1983 graduate of Virginia Tech in Animal Science, has been an active beef industry leader. He is currently president of Virginia BCIA and Chairman of the Culpeper Test and sale committee. He serves as vice president of the Northern Virginia Angus Association. Additionally, environmental stewardship has been a priority at Soldiers' Hill, and for their efforts they were the 2000 recipient of the Conservation Farmer Award for Fauquier County. Soldiers' Hill has hosted several tours, field days, and educational events.

The Virginia Beef Cattle Improvement Association nominated Soldiers' Hill Angus Farm.

SUNNYHILL ANGUS FARM

Kent, Wendy & Emily Schleich
Junior & Melba Schleich
Illinois

Sunnyhill Angus Farm is located three miles north of Fairview, in Fulton County, Illinois. An Illinois Centennial Farm, Sunnyhill has been in existence for over 125 years, in addition to being a historic Angus herd maintaining Angus cattle for over 50 years.

The farm has expanded from the original 215 acres to an operation in excess of 1,400 acres producing cattle, corn, soybeans, small grains, and hay.

The cowherd has expanded from 70 cows in 1977 to over 200 registered Angus cows. Calving has always been primarily in the spring, but in recent years, 15% of the herd has been moved to fall calving.

The herd has been performance tested through AHIR since 1976. Weights and measurements are taken to make sure meaningful data is collected for their customers and the Beef industry. Therefore, close attention to contemporary groups is maintained.

Management practices, including strict biosecurity, have led to a closed herd for the last decade. AI sires are selected by EPDs, pedigree and performance. To best utilize their forage resources, intensive grazing has been practiced for over 10 years.

Breeding stock is marketed through a production sale held the 2nd Saturday in March since 1991. Additionally, cattle are marketed by private treaty. Steer progeny are sold at weaning to a local farmer who assists with collecting carcass information.

Sunnyhill Angus Farm was nominated by the University of Illinois Extension.

WAUKARU FARMS, INC.

Carl Jordan and Families
Indiana

Waukaru Farms, Inc. has been incorporated for nearly thirty years; however, the Jordan family has been raising purebred Shorthorn cattle in northwestern Indiana for over 100 years since Walter Jordan first purchased Shorthorn bulls in 1902. Presently, Waukaru consists of 250 purebred Shorthorn and Durham Red composite breeding females, 1,400 acres of cropland, and 360 acres of pasture and hay ground. Seventy-five percent of the cows calve in the spring and the remainder in the first 60 days following the first of September. Waukaru genetics can be found in 38 U.S. states, 4 Canadian provinces, Mexico, Argentina, Brazil, Uruguay, China, Australia, New Zealand, South Africa, and Ireland. Waukaru is currently involved in sire tests in Australia, Argentina, and the United States with the purpose of objectively quantifying the profitability of Waukaru genetics.

The breeding objective of the Waukaru program is to produce profitable, efficient genetics that can flourish on minimal inputs, reap profits for their customers and subsequent phases of the beef industry and provide a valuable eating experience for consumers. They meet this objective through performance-based management and objective decision making. Aggressive usage of artificial insemination and embryo transfer facilitated by the natural service of AI sires creates a mass propagation of superior genetics. Waukaru enhances the adaptability of their cattle by utilizing a rotational, forage-based production system in which cows are wintered on crop residue and growing cattle are supplemented with a high-fiber ration. Waukaru strives to be a full-service genetic provider by building personal relationships with each client and prides themselves in profitably matching the correct genetics with their customers' needs.

Waukaru Farms, Inc. was nominated by the American Shorthorn Association and the Indiana Beef Evaluation Program.

Commercial Producer Honor Roll of Excellence

Chan Cooper	MT	1972
Alfred B Cobb, Jr.	MT	1972
Lyle Eivens	IA	1972
Broadbent Brothers	KY	1972
Jess Kilgote	MT	1972
Clifford Ouse	MN	1973
Pat Wilson	FL	1973
John Glaus	SD	1973
Sig Peterson	ND	1973
Max Kiner	WA	1973
Donald Schott	MT	1973
Stephen Garst	IA	1973
J.K. Sexton	CA	1973
Elmer Maddox	OK	1973
Marshall McGregor	MO	1974
Dave Matti	MT	1974
Lloyd DeBruycker	MT	1974
Gene Rambo	CA	1974
Jim Wolf	NE	1974
Henry Gardiner	KS	1974
Johnson Brothers	SD	1974
John Blankers	MN	1975
Paul Burdett	MT	1975
Oscar Burroughs	CA	1975
John R. Dahl	ND	1975
Eugene Duckworth	MO	1975
Gene Gates	KS	1975
V.A. Hills	KS	1975
Robert D. Keefer	MT	1975
Kenneth E. Leistritz	NE	1975
Ron Baker	OR	1976
Dick Boyle	ID	1976
James Hackworth	MO	1976
John Hilgendorf	MN	1976
Kahau Ranch	HI	1976
Milton Mallery	CA	1976
Robert Rawson	IA	1976
William A. Stegner	ND	1976
U.S. Range Exp. Stat.	MT	1976
Maynard Crees	KS	1977
Ray Franz	MT	1977
Forrest H. Ireland	SD	1977
John A. Jameson	IL	1977
Leo Knoblauch	MN	1977
Jack Pierce	ID	1977
Mary & Stephen Garst	IA	1977
Todd Osteross	ND	1978
Charles M. Jarecki	MT	1978
Jimmy G McDonnal	NC	1978
Victor Arnaud	MO	1978
Ron & Malcom McGregor	IA	1978
Otto Uhrig	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	IL	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. Feldmann	IA	1981
Henry Gardiner	KS	1981
Dan L. Weppler	MT	1981
Harvey P. Wehri	ND	1981
Dannie O'Connell	SD	1981
Wesley & Harold Arnold	SD	1981
Jim Russell & Rick Turner	MO	1981
Oren & Jerry Raburn	OR	1981
Orin Lamport	SD	1981
Leonard Wulf	MN	1981
Wm. H. Romersberter	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 Bergen	CAN	1982
Kent Brunner	KS	1983
Tom Chrystal	IA	1983
John Freltag	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 Coyner & Sons	VA	1984
Franklyn Esser	MO	1984
Edgar Lewis	MT	1984
Boyd Mahrt	CA	1984
Neil Moffat	CAN	1984
William H. Moss, Jr.	GA	1984
Dennis P. Solvie	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 Richarson	FL	1986
Mr. & Mrs. Clyde Watts	NC	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 Maize	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
Jerry Adamson	NE	1989
J.W. Aylor	VA	1989
Jerry Bailey	ND	1989
James G. Guyton	WY	1989

Kent Koostra ... KY ... 1989
Ralph G. Lovelady ... AL ... 1989
Thomas McAvory, Jr. ... GA ... 1989
Bill Salton ... IA ... 1989
Lauren & Mel Schuman ... CA ... 1989
Jim Tesher ... ND ... 1989
Joe Thielen ... KS ... 1989
Eugene & Ylene Williams ... MO ... 1989
Phillip, Patty, & Greg Bartz ... MO ... 1990
John C. Chrisman ... WY ... 1990
Les Herbst ... KY ... 1990
Jon C. Ferguson ... KS ... 1990
Mike & Dianna Hooper ... OR ... 1990
James & Joan McKinlay ... CAN. 1990
Gilbert Meyer ... SD ... 1990
DuWayne Olson ... SD ... 1990
Raymond R. Peugh ... IL ... 1990
Lewis T. Pratt ... VA ... 1990
Ken and Wendy Sweetland ... CAN. 1990
Swen R. Swenson Cattle ... TX ... 1990
Robert A Nixon & Sons ... VA ... 1991
Murray A. Greaves ... CAN. 1991
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
Ken Stielow ... KS ... 1991
John E. Hanson, Jr. ... CA ... 1991
Charles & Clyde Henderson ... MO ... 1991
Russ Green ... WY ... 1991
Bollman Farms ... IL ... 1991
Craig Utesch ... IA ... 1991
Mark Barenthsen ... ND ... 1991
Rary Boyd ... AL ... 1992
Charles Daniel ... MO ... 1992
Jed Dillard ... FL ... 1992
John & Ingrid Fairhead ... NE ... 1992
Dale J. Fischer ... IA ... 1992
E. Allen Grimes Family ... ND ... 1992
Kopp Family ... OR ... 1992
Harold, Barbara, &
Jeff Marshall ... PA ... 1992
Clinton E. Martin & Sons ... VA ... 1992
Loyd and Pat Mitchell ... CAN. 1992
William Van Tassel ... CAN. 1992
James A. Theeck ... TX ... 1992
Aquilla M. Ward ... WV ... 1992
Albert Wiggins ... KS ... 1992
Ron Wiltshire ... CAN. 1992
Andy Bailey ... WY ... 1993
Leroy Beiterspacher ... SD ... 1993
Glenn Valbaugh ... WY ... 1993
Oscho Deal ... NC ... 1993
Jed Dillard ... FL ... 1993
Art Farley ... IL ... 1993
Jon Ferguson ... KS ... 1993
Walter Hunsuker ... CA ... 1993
Nola & Steve Kielboeker ... MO ... 1993
Jim Maier ... SD ... 1993
Bill & Jim Martin ... WV ... 1993
Ian & Adam McKillop ... ON ... 1993
George & Robert Pingetzer ... WY ... 1993
Timothy D. Sufphin ... VA ... 1993
James A. Theeck ... TX ... 1993
Gene Thiry ... MB ... 1993
Fran & Beth Dobitz ... SD ... 1994
Bruce Hall ... SD ... 1994
Lamar Ivey ... Al ... 1994
Gordon Mau ... IA ... 1994
Randy Mills ... KS ... 1994
W.W. Oliver ... VA ... 1994
Clint Reed ... WY ... 1994
Stan Sears ... CA ... 1994
Walter Carlee ... AL ... 1995
Nicholas Lee Carter ... KY ... 1995
Charles C. Clark, Jr. ... VA ... 1995
Greg & Mary Cunningham ... WY ... 1995
Robert & Cindy Hine ... SD ... 1995
Walter Jr. & Evidean Major ... KY ... 1995
Delhert Ohnemus ... IA ... 1995
Henry Stone ... CA ... 1995
Joe Thielen ... KS ... 1995
Jack Turnell ... WY ... 1995
Tom Woodard ... TX ... 1995
Jerry and Linda Bailey ... ND ... 1996
Kory M. Bierle ... SD ... 1996
Mavis Dummermuth ... IA ... 1996
Terry Stuard Forst ... OK ... 1996
Don W. Freeman ... AL ... 1996
Lois & Frank Herbst ... WY ... 1996
Mr. & Mrs.
George A. Horkan, Jr. ... VA ... 1996
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
Ken Risler ... WI ... 1996
Merlin Anderson ... KS ... 1997
Joe C. Bailey ... NC ... 1997
William R. "Bill" Brockett ... VA ... 1997
Howard McAdams, Sr.
& Howard McAdams, Jr. ... NC ... 1997
Rob Orchard ... WY ... 1997
David Petty ... IA ... 1997
Rosemary Rounds &
Marc & Pam Scarborough ... SD ... 1997
Morey and Pat Van Hoecke ... MN ... 1997
Randy and Judy Mills ... KS ... 1998
Mike and Priscille Kasten ... MO ... 1998
Amana Farms, Inc ... IA ... 1998
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 Kitley ... 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
Iris, Bill, & Linda Lipscomb ... AL ... 1999
Amana Farms, Inc. ... IA ... 2000
Tony Boothe ... AL ... 2000
Glenn Clabaugh ... 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 Unsicker ... IL ... 2000
Billy H. Bolding ... AL ... 2001
Mike and Tom Endress ... IL ... 2001
Henry and Hank Maxey ... VA ... 2001
2001 Paul McKee
3-R Ranch ... CO ... 2002
Agri-Services Division,
Oklahoma Department of
Corrections ... OK ... 2002
2002 Alpine Farms
Amana Farms ... IA ... 2002
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
Voyles 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
Namminga Angus ... SD ... 2004
Nellwood Farms ... GA ... 2004
Olsen Ranches, Inc. ... NE ... 2004
Prather Ranch
(Ralphs Ranches Inc.) ... CA ... 2004
Blair Porteus 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 ... KS ... 2005
Dover Ranch ... MT ... 2005

Gaines Farm............................AL....2005
Hillwinds Farm.......................VA...2005
Krupps Farm...........................IL.....2005
Jack & Ila Mae Larson...........CO...2005
Mule Creek Ranch.................KS....2005
Paxton Ranch..........................NE....2005
Pontious Farms.......................OH...2005
Prather Ranch.........................CA...2005
Shovel Dot Ranch..................NE....2005
Wintergreen Farm..................IA.....2005

Commercial Producer of the Year

Chan Cooper	Montana	1972
Pat Wilson	Florida	1973
Lloyd Nygard	North Dakota	1974
Gene Gates	Kansas	1975
Ron Baker	Oregon	1976
Mary & Stephen Garst	Iowa	1977
Mose Tucker	Alabama	1978
Bert Hawkins	Oregon	1979
Jess Kilgore	Montana	1980
Henry Gardiner	Kansas	1981
Sam Hands	Kansas	1982
Al Smith	Virginia	1983
Bob & Sharon Beck	Oregon	1984
Glenn Harvey	Oregon	1985
Charles Fariss	Virginia	1986
Rodney G. Oliphant	Kansas	1987
Gary Johnson	Kansas	1988
Jerry Adamson	Nebraska	1989
Mike & Diana Hopper	Oregon	1990
Dave & Sandy Umbarger	Oregon	1991
Kopp Family	Oregon	1992
Jon Ferguson	Kansas	1993
Fran & Beth Dobitz	South Dakota	1994
Joe & Susan Thielen	Kansas	1995
Virgil & Mary Jo Huseman	Kansas	1996
Merlin & Bonnie Anderson	Kansas	1997
Mike & Priscilla Kasten	Missouri	1998
Randy & Judy Mills	Kansas	1998
Giles Family	Kansas	1999
Mossy Creek Farm	Virginia	1999
Bill & Claudia Tucker	Virginia	2000
Maxey Farms	Virginia	2001
Griffith Seedstock	Kansas	2002
Tailgate Ranch	Kansas	2003
Olsen Ranches, Inc	Nebraska	2004

2004 Commercial Producer of the Year
Olsen Ranches, Inc. - Nebraska

Art Olsen (left) of Olsen Ranches receives the Commercial Producer of the Year Award from S.R. Evans, 2004 BIF President.

The Beef Improvement Federation is proud to present the 2004 Commercial Producer of the Year award to Olsen Ranches, Inc.

The promise of plentiful land brought Lars Olsen to Banner County in the western Panhandle of Nebraska in 1885. The Olsen family has raised Hereford cattle and farmed in Banner County ever since. Four generations later, the operation Lars founded, now known as Olsen Ranches, Inc., is managed by Lars's grandson, Arthur Olsen, and his great-grandson, Douglas Olsen.

Today, the progressive Olsen operation focuses on its commercial cow-calf herd, with 750 cows comprised primarily of Hereford genetics with crossbreeding of Red Angus genetics. Located in a region that receives approximately 14" of moisture annually, Olsen Ranches has 11,000 acres of native range and 5,500 acres of tillable ground (both dryland and irrigated) on which they raise wheat, corn, alfalfa, millet, peas, barley and small grain hay. The Olsens also offer custom backgrounding and AI services for an increasing number of customers.

The Olsens are very involved in programs designed to improve Hereford genetics and grow the market for Hereford beef. The Olsens are one of the key Hereford breeders participating in the American Hereford Association's National Reference Sire Program (NRSP) and the National Cattlemen's Beef Association tenderness project, as well as in the international study sponsored by the American Hereford Association to standardize Hereford breed EPDs between the United States, Canada and Australia.

The Olsens believe in the strength of the Hereford breed and have a passion for promoting the beef industry. Most especially, the Olsens have a deep appreciation for the blessing of the rural lifestyle they enjoy and the incredible opportunity they have to be involved in this business.

The American Hereford Association nominated Olsen Ranches, Inc.

Congratulations to the 2004 BIF Commercial Producer of the Year – Olsen Ranches, Inc.

2005 COMMERCIAL PRODUCER AWARD NOMINEES

CK Ranch
Owner – John Vanier
Manager – Ray Negus
Kansas

CK Ranch is located in the Smoky Hills region of Saline and Ellsworth counties. This particular region of Central Kansas 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, dry land crop and alfalfa ground. Crops grown include grain sorghum, oats and triticale, all for supplementing the cowherd. CK Ranch was founded by JJ Vanier, Father of Jack and Grandfather of John. He was a salesman for Abilene Flour Mill and eventually became owner of Western Star Mill in Salina. His first purchase of land was made in Ellsworth County in 1933 when he purchased the 5,600 acre Root Ranch. This is now the ranch headquarters. As additional ranches became available, they were obtained and now CK contains about 15,000 acres, most of which are continuous.

CK was first stocked with steers. The first Herefords arrived on the ranch in 1936. In the 1950's the ranch had almost 2,000 head of registered cows and registered approximately 1,200 calves. Now the commercial herd runs from 600 to 950 Hereford and Red Angus cows, depending on market and grass conditions and 175 to 200 registered Hereford and Red Angus cows. The cows calve in the spring with 100 to 200 heifers calving in January and February, the seedstock herd in February and March, and the commercial cows in March and April. Depending on economics, steers are either retained through harvest, back-grounded and sold, or sold at weaning directly to buyers. Heifers not retained for in-herd replacements are sold to other ranchers as replacements or sold as feeder heifers. One of the primary purposes of the commercial cows is to provide a testing herd for both Hereford and Red Angus genetics.

CK participates in the American Hereford Association's Whole Herd Total Performance Records (TPR) and the National Reference Sire Program (NRSP), and does structured carcass testing with Mill Creek Ranch.

CK Ranch was nominated by the American Hereford Association.

Diamond V Ranch
Butch and Renei Jochim
North Dakota

Diamond V Ranch is located near Selfridge, North Dakota. The ranch lies just across the stateline in the rolling grasslands and breaks north and west of McLaughlin, South Dakota. Butch Jochim and his family have operated the Diamond V Ranch at this location since 1975, when he joined his father, Valentine, who started ranching at this location in 1958. The ranch includes both deeded land and land leased from the Bureau of Indian Affairs at the Standing Rock Reservation. In addition to the cattle, Butch plants 1,200 acres of wheat each year.

The cowherd is made up of approximately 700 head of Angus based cows, both red and black. Purebred Limousin bulls are used on the cowherd with the resulting calves born in April and May each year. Calves are marketed annually on the day after Columbus Day at the McLaughlin Livestock Auction. For the past several years, the red calves have been fed for the Laura's Lean Beef program by Wulf Limousin Farm of Morris, Minnesota where Butch has purchased a number of herd bulls. The Diamond V calves top the market each year which is a testament to the quality of seedstock that Butch demands for his commercial program.

Diamond V Ranch is nominated by the North American Limousin Foundation.

DOVER RANCH
Dover Sindelar and son, Frank
Montana

The Dover Ranch was founded in 1881 when John Dover homesteaded on an island in the Yellowstone River several miles below Billings, MT. John's wife, Mary, homesteaded other area land in 1904 which became the present site of the Dover Ranch.

Shorthorn cattle were purchased from a neighbor in the 1880's and have been run continuously on the ranch for over 100 years. The present operators grew up with Shorthorn cattle, make their living from them, and in doing so have developed a very strong ideal of the breeds purpose, abilities and potential.

Dover Ranch operates on 12,000 acres; 1500 acres are seeded with Crested Wheatgrass and divided into 20 separate breeding pastures. Another 1,000 acres produce hay and grain for cattle. The remainder is in native pastures. Fifteen miles of pipeline supply stock-water to all pastures. After being reduced by years of drought, the cowherd is at 300 head. The first calf heifers are AI'ed to light birth weight Red Angus bulls to start calving Feb. 1st, three weeks ahead of the cowherd. Most of the Shorthorn bulls used on the cowherd are raised at Dover Ranch.

A comprehensive pre-conditioning program is followed prior to shipping weaned calves. Top bull calves and heifers are fed a growing ration through the winter for with-in herd replacements and outside sales.

Selection of cattle using objective data, rangeland improvements, and stock-water development has all been major contributions to the success and longevity of Dover Ranch.

The American Shorthorn Association nominated Dover Ranch.

GAINES FARM
Hank and Harold Gaines
Alabama

Gaines Farms is located nearly two miles north of the Alabama River close to Autaugaville, Alabama. This family-owned and operated diversified farm produces beef cattle, cotton, peanuts, hay, timber, and small grains. Gaines Farms has been in business for over 30 years managing cattle and row crops on 1,600 acres of owned and leased land. The cow herd is made up of about 250 mature females, which are predominantly Angus, Simmental, and Charolais crosses, grazing approximately 600 acres of pasture land. Angus, Charolais, Simmental, or SimAngus bulls are utilized for the crossbreeding program.

Calving begins in late September with first calf heifers and continues with mature cows through the first of November. Fall calving allows for cereal grains, which are over-seeded on row crop land, to be utilized during peak lactation for the cow herd. This matches by-product feed resources and forage production for optimal marketing of feeder cattle. Replacement heifers are chosen from within the herd, where approximately 30-40 heifers are retained for breeding each year.

Comprehensive performance and financial information is analyzed on this herd annually to assist in selection and culling decisions. This diversified operation intermingles all of the agricultural entities to the benefit of all, but each segment of Gaines Farm is managed separately. All cattle are raised under beef quality assurance guidelines to ensure a safe consistent product for the consumer. Gaines Farms is continually implementing innovative programs into the operation. It is the dedication of the family that accounts for the success of the operation.

The Alabama Beef Cattle Improvement Association nominated Gaines Farm.

HILLWINDS FARM
Tim and Cathy Sutphin
Virginia

Hillwinds Farm is located near Dublin, Virginia, in the southwestern portion of the state. As part of the Blue Ridge Mountains, cattle thrive on the native grasses and legumes.

While growing up on a farm with a small cowherd Tim acquired his interest in beef production. Tim owned his first cow when he was five years old, and has continued to build his herd size every year since. Tim and Cathy have built their lives around beef cattle. Today, the operation consists of 1,047 owned acres and 800 leased, all in pasture and hay.

Currently Hillwinds Farm maintains 625 brood cows, of which 390 calve in the spring and 235 calve in the fall. The cows are commercial and crossbreds. Angus, Simmental and Angus x Simmental cross bulls are used. Ideally, the operation strives to produce a ¾ Angus x ¼ Simmental calf. Hillwinds makes extensive use of estrous synchronization, artificial insemination, and retained ownership to slaughter. Tim and Cathy also purchase, background, and retain ownership an additional 500 source-verified calves each year.

In 2004, as operator of the Southwest Virginia Bull Test Station, Hillwinds Farm contract fed 200 bulls for 43 consignors. Another enterprise is a 160-head ewe flock which started as a 4-H project. Tim and Cathy have four children: Laura, Allison, Caroline and Heath, all of which are involved in agriculture through 4-H, FFA, and the farm. The children are Hillwinds Farm's main value-added commodity.

Hillwinds Farm was nominated by the Virginia Beef Cattle Improvement Association.

KRUPPS FARM
David and Steven Krupps
Illinois

Krupps Farms is a partnership between brothers, David and Steven Krupps, consisting of 2,375 acres of which 700 acres are permanent pasture in Brown County. Two hundred commercial beef cows are maintained by David and Steven. The Krupps Brothers have been farming since graduating with business degrees from Spoon River College and Illinois State University.

Though initial emphasis was placed on swine production, economics caused them to expand their cattle operation. David and Steven increased both the cow-calf herd and the grain farming operation. The business degrees have been a valuable asset as grain and livestock prices stabilized and efficiency became increasingly important.

The beef cattle operation started with purebred Angus cows with mostly continental breeds of bulls (Simmental, Charolais, and composites) used on the Angus cows to increase growth and maternal milk. Recently, they have utilized Angus bulls to increase the consistency and carcass desirability of their calf crop. Most of the bulls used in the breeding herd were purchased from the Western Illinois University Test Station.

The 700 acres of permanent pastures consist of grass-legume mixtures with rotational grazing used to increase pasture carrying capacity. Following two crops of hay production, these fields are grazed in the late summer and early fall. Corn crop residue is utilized in the fall to extend the grazing season prior to fall tillage. Several of the pastures could be used as part of their grain farming; however, they have been left in grass to prevent erosion on the soils that have more slope.

Calves are weaned at five to six months and processed through a preconditioning program. After the calves are processed they are backgrounded for a short time prior to selling through a preconditioned feeder cattle sale. Annually, their calves are sought by feedlots because of their genetics for growth and health status.

The predominate winter-feed is corn silage with supplementation of grass-legume hay. Feed bunks have been constructed on several farmsteads to winter the cows, for calving and development of the replacement heifers. The brothers are continuing to monitor cost in their operation and strive to reduce the cost to produce a calf without sacrificing reproduction and production efficiency.

Conservation of the land and community involvement is of utmost importance to David and Steven Krupps. They utilize no till for all of their corn and soybean production.

David and Steve enjoy being involved in the beef industry and share their involvement through industry and community boards include serving on the Western Illinois University Bull Test Station boards for many years. In addition, several of the boards they are associated with their local fire district, school, cemetery, hunter association, Farm Bureau, Farm Service Agency, Selby Creek Hydrologic Area, 4-H advisory, Two Rivers FS and others.

The Illinois Beef Association and the University of Illinois Extension nominated Krupps Farms.

JACK AND ILA MAE LARSON
Colorado

Home base of the operation is approximately two miles east of Gill, Colorado. The cow herd is run on summer pastures several miles north of the home base. They are brought to the home base for winter grazing of cornstalks, wheat, and alfalfa. They are also calved out, branded and vaccinated before being returned to summer pastures. Weaned calves are put in our feedlot at the home base, along with about 400 purchased calves from local ranchers that they have been buying calves from for 12-15 years. Normally, their cow herd would be 500 head, but due to the drought herd inventory is down to about 400 head. They farm about 1,000 acres of irrigated land which grows corn, wheat and alfalfa. All crops except wheat are used in the cattle feeding operation. Spring-calving normally is in February and March, spreading out the family's work load. The Hereford cowherd started in 1961. In 1973 they started crossing with Charolais bulls: experimented with a few Simmental bulls, used Gelbvieh as a cross for seven years and have basically been using Angus bulls for the past 15 years.

The Colorado Cattlemen's Association nominated Jack and Ila Mae Larson.

MULE CREEK RANCH
Owner – Ron Williams
Manager – Kim Leeper
Kansas

Mule Creek Ranch is located in the unique grass country of eastern Comanche County near Wilmore, KS. For the past nine years, Kim and Sharon Leeper, and their son Cade, and his wife, Jody, have been managing Mule Creek for owner Ron Williams of Denver, CO.

The ranch runs 950 commercial Angus cows, which have been selectively bred to work in the rugged terrain of South Central Kansas. All females are bred to calve in April and May using synchronization and an intensive artificial insemination (AI) program. They keep the majority of females produced for replacement heifers; placing a lot of demand on efficiency, fertility, and marketability. The overall goal of the operation is to consistently develop sound, reproductively efficient females.

To produce this type of cattle, an intensive breeding program based on proven genetics is used. Being very disciplined in sire selection, only proven Angus bulls from Gardiner Angus Ranch are used on the commercial cowherd. Maternal EPDs are major selection criteria. Combining proven sires with an intensive AI program has allowed the development an economically efficient cowherd.

The cowherd is grazed year-round, using a rotational non-intensive grazing system. The all-grass operation consists of warm season native grasses including big bluestem, little bluestem, Indiangrass, switchgrass, sideoats grama, buffalo grass and native Eastern Gama grass. Additional supplement is provided only during winter months.

The steer calves have been marketed in a variety of ways over the past years, including retaining ownership and feeding at a commercial feedyard and selling calves on a value-based grid. They also sell a select few replacement heifers yearly through an auction of known genetics.

The Kansas Livestock Association nominated Mule Creek Ranch.

PAXTON RANCH
John and Jessica Warren
Nebraska

The Paxton Ranch headquarters are located 20 miles South of Thedford, NE, on Highway 83 and includes another ranch 14 miles west of the headquarters. The operation consists of 36,000 deeded acres and a 9,500 acre grazing permit giving the Warren's a total carrying capacity of 1,500 mother cows. Six hundred cow/calf pairs are trailed 14 miles north on June 1st, to be summered on the Halsey National Forest. The west place is home to 300 first calf heifers and 300 second calvers. An additional 300 pairs besides yearling steers and heifers are summered on the main ranch. The steers and cull heifers are then sent to the feedlot. Bulls are turned out around June 12th for a 55-day breeding season.

The Paxton Ranch was established in 1933 by Jessica's father, Chester Paxton, with the purchase of 640 acres, now part of the West Place. Chester, his wife, Ida, and later John and Jessica built and expanded the ranch holdings making it what it is today – a model for successful, sustainable Sandhills cattle operations.

By studying the natural and human resources available, understanding cattle and their behavior and utilizing a little common sense, John has been an innovator in Sandhills management practices.

The Red Angus Association of America nominated the Paxton Ranch.

PONTIOUS FARMS
Robert, Dan and Steve Pontious
Ohio

Pontious Farms is a family run beef operation that includes Robert along with sons Dan and Steve. The original 120 acres of the farm was purchased in 1955 and over the years has expanded to its current size of over 300 acres. The farm is located three miles east of Lancaster in central Ohio. The terrain of hills and hollows is best suited for cattle grazing instead of crop production.

The cow herd consists of 140-150 head of commercial Angus beef cows. Replacement heifers are bred by artificial insemination to start calving March 10th and the mature cows are bred to start calving in the last week of March. Artificial insemination has been used to some extent every year since the farm was purchased in 1955. A feedlot was built by the family in 1982.

Replacement heifers are selected from within the herd with the remainder of the calf crop retained and fed out on the farm. Additional feeders are purchased to achieve the feedlot's capacity. Total head marketed ranges from 300 to 350 per year. Fed cattle are normally sold to the Excel or Smithfield plants in Pennsylvania on a high-quality based grid.

Pontious Farms was nominated by the Ohio Cattlemen's Association.

PRATHER RANCH

Ralphs and Rickert Families
Manager - Jim and Mary Rickert
California

The 28,555-acre Prather Ranch is a vertically integrated cattle business that operates in five northern California counties. The ranch headquarters was founded in the 1870's and acquired by Walter Ralphs in 1964. Jim and Mary Rickert formed an association with the ranch in 1979.

The ranch operates a "closed herd" of 1,550 English crossbred cows. The cow herd is about 20% Angus, 20% Hereford, and approximately 60% black baldies. About 60% of the cows calve in the spring near Macdoel, California for our natural beef program. The remaining 40% calve in the fall and are certified organic. The organic herd is maintained separately, summering in the Fall River Valley and wintering in the northern Sacramento Valley. This facilitates the unique marketing programs of the Prather Ranch.

This "closed herd" concept is based on the need to maximize biosecurity. Prather Ranch supplied bovine raw materials to various pharmaceutical companies and, as a requirement, extensive record keeping and Standard Operating Procedures are in place. On the cow side, the herd was closed in 1975. Since 1990, the herd has been bred by artificial insemination or ranch raised bulls. The ranch has implemented and participates in a young sire progeny-testing program, known as Gen-Scan, by working with purebred breeders and the American Hereford and American Angus Associations.

In 1995, the ranch built a USDA inspected on-site slaughterhouse and meat processing facility. The ranch direct markets natural and organic dry-aged beef in southern Oregon and northern California. *Prather Ranch Meat Company* also maintains a storefront in the San Francisco Ferry Building.

Prather Ranch is nominated by the University of California – Agriculture and Natural Resources Cooperative Extension, Siskiyou County.

SHOVEL DOT RANCH

Larry and Nickie Buell
Homer and Darla Buell
Nebraska

Shovel Dot Ranch is a commercial cow-calf operation located in North Central Nebraska on the eastern edge of the Sandhills. The ranch was established in 1883 by Benjamin Franklin Buell (Homer and Larry's great grandfather) and presently has the fifth generation-Larry's daughter and son-in-law and Homer's son and daughter-in-law involved in the ranching operation.

Shovel Dot Ranch operates about 30,000 acres, with 25,000 acres owned and 5,000 leased. Of those acres, about 2,000 are sub-irrigated meadow, 240 acres are under center pivot in alfalfa, and the rest is native grazing land.

The ranch operates three livestock enterprises: a commercial cow/calf herd, a backgrounding yard, and a stocker operation. The genetics of the cowherd is a blend of Hereford, Angus, and Hereford x Angus crosses. Cow inventory can vary from year to year but presently stands at 1,403 cows.

Cows begin calving in late April with the calving season for heifers starting a few weeks earlier. The breeding program depends on breed type of the cow. Cows are bred to either Hereford or Angus bulls to produce a cross-bred female. The calves are weaned in late September to early October and grazed on sub-irrigated meadow regrowth until November. They are moved to the backgrounding lots for winter. In early May, calves return to graze pasture until they are marketed at the local sale barn or by private treaty in mid-late summer when yearling prices are traditionally the highest in the area. During the fall, additional steers are purchased with targeted marketing dates from April 15 through August. The cows are grazed most of the year and fed hay and supplement in the winter when the snow is deep or grass runs short.

Our mission statement: "The purpose of Shovel Dot Ranch is to provide a business entity that satisfies the needs, wants, and desires of its owners and their families."

The Nebraska Cattlemen Association and the University of Nebraska nominated the Shovel Dot Ranch.

WINTERGREEN FARM

Martin Green
Iowa

Wintergreen Farm is located in east central Iowa right in the center of "corn-bean" country. Martin's parents, Winston and Teresa, moved to Wintergreen Farm in 1958 and raised nine children on 280 acres. All nine siblings received college degrees, thanks to Winston and Teresa's hard work. Martin is the youngest of the nine and the only one that farms. Martin's parents kept the cow herd going while he was attending Iowa State University. After graduation Martin returned home and with family help purchased his first farm. This particular farm had an abundance of pastureland and since it was "meant for cows" the herd expanded.

Presently Wintergreen Farm has an inventory of about 170 crossbred cows, which is a large operation for the surrounding area. The genetic foundation of the herd is made up of blends of Angus, Red Angus, Simmental, and Gelbvieh genetics. Calving starts March 20-25 each spring and calves are grouped by two-week intervals. Calves are ID-tagged, weighed, and the bull calves are banded. Calving information is recorded and entered into the "Cow Sense" computer program. Cows are control-grazed on cool and warm season forages.

All heifers and some cows are artificially inseminated. Calves are preconditioned and weighed at weaning in early September. They are then backgrounded and sold in early November. Replacement heifers are kept based on "Cow Sense" records and phenotype. Cows are pregnancy-checked, vaccinated, and poured in mid-October before moving to cornstalks. Open cows are sold in October.

Wintergreen Farm was nominated by the Iowa Cattlemen's Association.

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

2004 Ambassador Award
Kindra Gordon – South Dakota

The Beef Improvement Federation (BIF) named Kindra Gordon winner of its 2004 Ambassador Award during the organization's 36th annual meeting May 25-27 in Sioux Falls, S.D. The honor is given to a member of the media each year for efforts in helping cattle producers understand cattle performance testing and genetic prediction tools.

Gordon is a regular contributor to numerous beef industry publications, including BEEF, Angus Journal, Angus Beef Bulletin, Western Cowman, and Hay & Forage Grower. She is editor of the Grazing Lands Conservation Initiative (GLCI) newsletter, which is produced six times a year and distributed in all 50 states.

Gordon says she strives to present practical industry information to assist beef producers in making decisions that will increase efficiency and profitability. In 2003 she was awarded the Diamond Award for publications writing and the Peerless Award for writing, the top writing award bestowed by her peers in the Livestock Publications Council (LPC).

Gordon grew up on a purebred cattle operation near Bowdle, S.D. In 1994 she earned bachelor's degrees in range science and ag journalism from South Dakota State University (SDSU), where she competed on successful meats and plant identification judging teams. She obtained a master's degree in range resources from the University of Idaho in 1996.

Following college, Gordon worked with the Natural Resources Conservation Service (NRCS) in North Dakota, first as a county range conservationist and then as a public affairs specialist in the state office.

In 1997 she joined BEEF magazine in Minneapolis, Minn., as a journalist covering all segments of the beef industry. She drew from her experiences in seedstock, meats and range science. Her compilation of feature articles on natural resource issues earned her the Oscar in Agriculture in 2001.

In addition to her writing, Gordon is an adjunct faculty member at Black Hills State University where she teaches magazine/newspaper feature writing and newspaper layout and design.

Gordon and her husband, Bruce, live in Spearfish, S.D., and own partial interest in several seedstock sires. They have three children: Bridger, 3; Danika, 2; and Matea, born May 21, 2004.

2004 Continuing Service Award
Robert L. Hough, Ph.D. – Red Angus Association of America (Texas)


Bob Hough (left) receives the 2004 Continuing Service Award from S.R. Evans, 2004 BIF President.

Dr. "Bob" Hough currently serves as the executive secretary of the Red Angus Association of America (RAAA) headquartered in Denton, Texas. Bob was raised on a general livestock farm in Pennsylvania and received his undergraduate degree from Penn State in 1982. He went on to receive his master's degree from University of Connecticut and doctorate from Virginia Tech, all in animal science.

His previous experience includes serving as an Extension Specialist in both Arizona and Maine, and as a marketing coordinator for the RAAA. While at Red Angus, Bob has provided the leadership for developing the industry's first U.S. Department of Agriculture (USDA)-approved and audited Feeder Calf Certification Program (FCCP). Bob also initiated Red Angus' carcass expected progeny differences (EPD) program and negotiated value-based grids with two major packers. He was also involved in the design of the industry's first "Total Herd Reporting" program, which was implemented at Red Angus.

Bob has served on the Beef Improvement Federation (BIF) Board as a representative of the breed associations. He chaired the Whole Herd Reporting Committee in addition to serving on the Program Committee. He was inducted into the Maine Beef Industry's Hall of Fame, and in 1996, received the RAAA's Distinguished Service Award. He also coached intercollegiate livestock judging teams for five years, judged livestock shows in 15 states and three Canadian provinces, and served on the steering committee for the National 4-H Livestock Judging Contest. He has written more than 125 scientific, Extension and popular press articles, and has been invited to speak on programs in 28 states, three Canadian provinces, Argentina and Brazil.

2004 Continuing Service Award
Chris Christensen – Christensen Simmentals (South Dakota)

Chris Christensen, a long-time seedstock producer based at Wessington Springs, S. D., has been a consistent, active force on behalf of the beef cattle industry, the Simmental breed, the American Simmental Association and the Beef Improvement Federation (BIF).

Chris, with his partner and wife, Sheila, rely heavily on performance principles as a foundation for advancing the quality of purebred and composite Simmental cattle. Their focus is squarely on providing superior genetics for the benefit of the commercial industry, realizing that their success is linked directly to the profitability of their commercial customers. Christensen seedstock are widely recognized for their versatility and ability to perform in harsh and stressful environments.

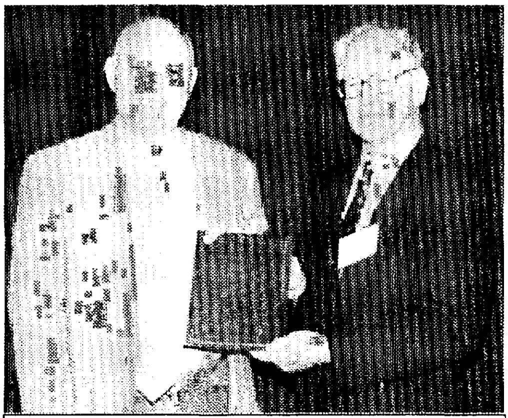
An enthusiastic advocate of performance cattle and performance programs for many years, he was among the earliest proponents of carcass testing. A strong supporter of youth programs, he has been a frequent volunteer at state fairs, field days and other cattle events. As a diligent and active member of several beef cattle organizations, Chris consistently placed the welfare and objectives of the organization above his personal interests.

Christensen is known for his great thirst for beef industry information and has spent countless hours eagerly learning about his favorite subject. He has traveled extensively to attend seminars, conferences and meetings in an effort to increase his personal knowledge and in a search for superior genetics.

In his continuing and unwavering quest for finding better ways to breed beef cattle while applying performance principles, Christensen seldom misses a BIF convention. He has been an involved, active member of BIF throughout his cattle career and has served two terms on the board of directors.

The effective inspiration provided through his quiet leadership has touched many lives and many cattle operations. He is a leader who has earned the respect and admiration of his fellow cattle producers. The BIF congratulates Chris on receiving the BIF Continuing Service Award.

2004 Continuing Service Award
Richard McClung – Wehrmann Angus (Virginia)



Richard McClung (left) receives the 2004 Continuing Service Award from S.R. Evans, 2004 BIF President.

Richard McClung's involvement in the beef industry began on his family's commercial cow-calf and sheep operation near Lewisburg, West Virginia. Upon graduation from the W. Va. University with a degree in animal science in 1964, McClung managed several purebred cattle operations across the country prior to joining Wehrmann Angus in October, 1978. Since that time, McClung has served as managing partner of Wehrmann Angus and together with owner Nick Wehrmann, has developed the Wehrmann herd into the successful performance seedstock operation that exists today.

McClung's focus on meeting the needs of the commercial cow-calf producer have not wavered since he first became involved in the registered Angus business at age 14. His commitment to breeding cattle that benefit the bottom line of commercial clientele has been the basis for McClung's development of the performance brand synonymous with Wehrmann Angus.

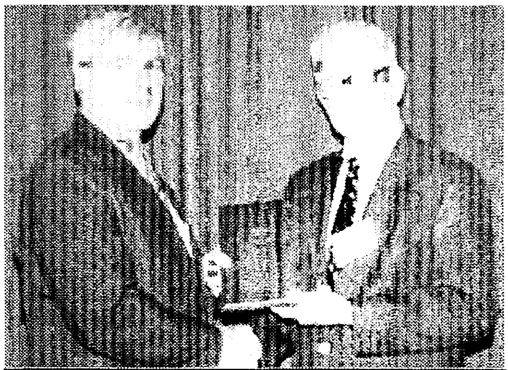
Wehrmann Angus was established in 1975 in southwest Georgia, and started from primarily Rito breeding from Jorgensen Ranches in South Dakota. McClung was responsible for bringing the first Rito cattle east of the Mississippi in 1969, and upon joining Wehrmann Angus, continued the development of these bloodlines. In 1986, Wehrmann Angus relocated from Georgia to its present location outside New Market, Va. Development of a cow herd that worked on fescue and close attention to maternal traits set the foundation for the herd, along with adherence to strict performance principles, utilization of EPDs, and aggressive culling of females that did not reach production standards.

McClung's goal has always been to breed for the complete animal– cattle with a low birth weight expected progeny difference(EPD), enough milk, 80+ pounds of yearling weight EPD, moderate frame size, good fleshing ability, and positive marbling, ribeye, and retail product EPDs. Most importantly, the cattle have been raised and selected to benefit the commercial producer with a focus on efficiency and end product. The acceptance and demand for their genetics in today's industry are a testimony to the vision and dedication of the Wehrmann Angus program under McClung's leadership. Today, bulls are marketed in two annual sales, one in Virginia and the other with Donnell Cattle Co. in Texas. An annual female sale is at the farm each October. Since 1986, Wehrmann Angus has placed 41 bulls in major bull studs, which further exemplifies the genetic superiority of the herd. In 1997, Wehrmann Angus was honored by their peers with the Beef Improvement Federation (BIF) Seedstock Producer of the Year award.

Progressive adaptation of technology and a committed focus to balanced trait selection have been keys to the success of the Wehrmann program. Throughout the years, McClung has cooperated with universities on numerous research projects related to estrus synchronization, embryo transfer, and use of ultrasound as tool for genetic improvement of carcass traits. These projects have proven to benefit the industry, and many have resulted in methods routinely applied today.

McClung has had several state and national beef industry leadership positions. He is past president of BIF, served on the American Angus Association Board of Directors, is past president of Virginia BCIA, and is currently a member of the Virginia Beef Industry Council. He has spoken at numerous field days and symposiums across the country, sharing his philosophy and approach to the beef business. Richard and his wife, Susan, have three children, Dick, Casey, and Becky.

2004 Continuing Service Award
Steve Kappes – USDA-ARS



Steve Kappes (left) receives the 2004 Continuing Service Award from S.R. Evans, 2004 BIF President.

The Beef Improvement Federation (BIF) honored Steven M. Kappes with the Continuing Service Award at the 36th Annual Meeting and Research Symposium in Sioux Falls, S.D., on May 27. The award recognizes individuals whose service in the beef industry and BIF has had a significant effect on genetic improvement of beef cattle.

Kappes was raised on a purebred Simmental and grain farm in North Central South Dakota. He and his wife, Diane, have a daughter, Michelle, and a son, Matthew.

He received a bachelor's degree in animal science in 1980 and a master's degree under the direction of L.A. Slyter in reproductive physiology in 1985 from South Dakota State University. From 1983 to 1989, he served as assistant manager of cattle operations, U.S. Meat Animal Research Center (MARC), Agricultural Research Service (ARS), U.S. Department of Agrilculture (USDA), in Clay Center, Neb., where he managed and supervised two to three cattle crews, coordinated reproduction, nutrition, and genetics experiments, and performed reproductive techniques including pregnancy diagnoses; semen collection and testing, artificial insemination (AI), and embryo transfers (ETs). He received his doctorate under the direction of R.V. Anthony in molecular biology at the University of Missouri in1992.

In 1992, Kappes returned to MARC as a research scientist. He played a key role in the research team that developed a comprehensive bovine linkage map and identified chromosomal regions influencing reproductive traits in beef cattle. In 1999, he joined the national program staff at ARS in Beltsville, Md., to serve as national program leader of Food Animal Production Research. From 2001 to the present, Kappes, has served as center director of MARC. In this role, he provides program and supervisory management leadership for 70 scientists and 225 support personnel engaged in multidisciplinary research efforts focused on food safety, waste management, genomics, and efficiency of production of beef cattle, swine and sheep. Kappes continues to provide leadership at the national and international level in bovine genomics. Presently, he serves as co-chairman of an international effort to determine the DNA sequence of the bovine genome with support or scientific input by the National Human Genome Research Initiative (National Institute of Health), the USDA, the National Cattlemen's Beef Association (NCBA), Texas and South Dakota cattle producers, the state of Texas, Texas A&M University, the University of Illinois, University of Baylor College of Medicine, as well as New Zealand, Australia, the United Kingdom, and Canada.

Kappes' research contributions are documented in more than 90 scientific and technical research papers, several of which have become recognized as landmark scientific contributions in genomics research. He has made many presentations at scientific and industry meetings, including BIF annual meetings and workshops. His contributions as a research scientist and an administrator have had significant effects on recommendations and guidelines being developed by BIF to incorporate molecular genetic approaches into genetic improvement programs for beef cattle.

BIF Pioneer Award Recipients

Jay L. Lush	Iowa	1973
Reuben Albaugh	California	1974
Charles E. Bell, Jr.	USDA	1974
John H. Knox	New Mexico	1974
Paul Pattengale	Colorado	1974
Fred Wilson	Montana	1974
Ray Woodward	ABS	1974
Glenn Butts	PRT	1975
Keith Gregory	MARC	1975
Braford Knapp, Jr.	USDA	1975
Forrest Bassford	Western Livestock Journal	1976
Doyle Chambers	Louisiana	1976
Mrs. Waldo Emerson Forbes	Wyoming	1976
C. Curtis Mast	Virginia	1976
Ralph Bogart	Oregon	1977
Henry Holsman	South Dakota	1977
Marvin Koger	Florida	1977
John Lasley	Florida	1977
W. L. McCormick	Georgia	1977
Paul Orcutt	Montana	1977
J.P. Smith	Performance Registry Int'l	1977
H.H. Stonaker	Colorado	1977
James B. Lingle	Wye Plantation	1978
R. Henry Mathiessen	Virginia	1978
Bob Priode	Virginia	1978
Robert Koch	MARC	1979
Mr. & Mrs. Carl Roubicek	Arizona	1979
Joseph J. Urick	USDA	1979
Richard T. "Scotty" Clark	USDA	1980
Bryon L. Southwell	Georgia	1980
F.R. "Ferry" Carpenter	Colorado	1981
Otha Grimes	Oklahoma	1981
Milton England	Texas	1981
L.A. Moddox	Texas	1981
Charles Pratt	Oklahoma	1981
Clyde Reed	Oklahoma	1981
Gordon Dickerson	Nebraska	1982
Mr. & Mrs. Percy Powers	Texas	1982
Jim Elings	California	1983
W. Dean Frischknecht	Oregon	1983
Ben Kettle	Colorado	1983
Jim Sanders	Nevada	1983
Carroll O. Schoonover	Wyoming	1983

Bill Graham	Georgia	1984
Max Hammond	Florida	1984
Thomas J. Marlowe	Virginia	1984
Mick Crandell	South Dakota	1985
Mel Kirkiede	North Dakota	1985
Charles R. Henderson	New York	1986
Everett J. Warwick	USDA	1986
Glenn Burrows	New Mexico	1987
Carlton Corbin	Oklahoma	1987
Murray Corbin	Oklahoma	1987
Max Deets	Kansas	1987
Christian A. Dinkle	South Dakota	1988
George F. & Mattie Ellis	New Mexico	1988
A.F. "Frankie" Flint	New Mexico	1988
Roy Beeby	Oklahoma	1989
Will Butts	Tennessee	1989
John W. Massey	Missouri	1989
Donn & Sylvia Mitchell	Canada	1990
Hoon Song	Canada	1990
Jim Wilton	Canada	1990
Bill Long	Texas	1991
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
James S. Brinks	Colorado	1995
Robert E. Taylor	Colorado	1995
A.L. "Ike" Eller	Virginia	1996
Glynn Debter	Alabama	1996
Larry V. Cundiff	Nebraska	1997
Henry Gardiner	Kansas	1997
Jim Leachman	Montana	1997
John Crouch	Missouri	1998
Bob Dickinson	Kansas	1998
Douglas MacKenzie Fraser	Alberta	1998

Joseph Graham	Virginia	1999
John Pollak	New York	1999
Richard Quaas	New York	1999
J. David Nichols	Iowa	2000
Harlan Ritchie	Michigan	2000
Robert R. Schalles	Kansas	2000
Larry Benyshek	Georgia	2001
Minnie Lou Bradley	Texas	2001
Tom Cartwright	Texas	2001
H.H. "Hop" Dickenson	Kansas	2002
Martin & Mary Jorgensen	South Dakota	2002
L. Dale Van Vleck	Nebraska	2002
George Chiga	Oklahoma	2003
Burke Healey	Oklahoma	2003
Keith Zoellner	Kansas	2003
Frank Felton	Missouri	2004
Tom Jenkins	Nebraska	2004
Joe Minyard	South Dakota	2004

2004 Pioneer Award
Frank Felton, 1940-2003 – Felton Hereford Ranch (Missouri)

The Beef Improvement Federation (BIF) posthumously honored Frank Felton with the Pioneer Award at the 36th annual convention in Sioux Falls, S.D. on May 27. The award recognizes individuals who have made lasting contributions to the improvement of beef cattle.

Frank Felton was a master cattle breeder and steward of the land. He was a national and internationally acclaimed cattleman and a pioneer in the use of performance testing data and genetics. He traveled throughout the world speaking on livestock issues and served as president of numerous agriculture-related groups.

He was a lifelong farmer and resident of Maryville, Mo., and worked diligently to conserve and improve the land on which he and his family made their living. Frank was a devoted husband and father. He and his wife, Lynne, centered their operation in Maryville. There, they raised two sons, Jay and Matthew, and two daughters, Allison and Katherine.

Throughout his career, Felton received countless awards, including BIF's National Seedstock Producer of the Year, Missouri Polled Hereford Breeder of the Year, University of Missouri School of Agriculture Food and Natural Resources Citation of Merit and Missouri's Outstanding Young Farmer Awards.

Felton was a pro-performance breeder and was known for record keeping. In fact, he was one of the first producers that collected and used data in cattle. He took his first weaning weight measurements in 1962, which was unheard of then. When he first began taking scrotal measurements, he used his wife's sewing machine tape because scrotal measuring devices weren't available at the time. He started taking birth weights on his calves in 1965 and, in 1970, began to take pelvic measurements. He used carcass data to evaluate his cattle's usefulness for feedlots. Each year, he invited order buyers from the local sale barn to his ranch so they could see the Felton herd and review his carcass data. He used this activity to find out what type of cattle the order buyers needed to meet their needs and the needs of their customers. Accordingly, he worked hard to make sure his cattle were bred to meet the needs of the beef industry. He was committed to using his mind to produce beef, while preserving the land for future generations.

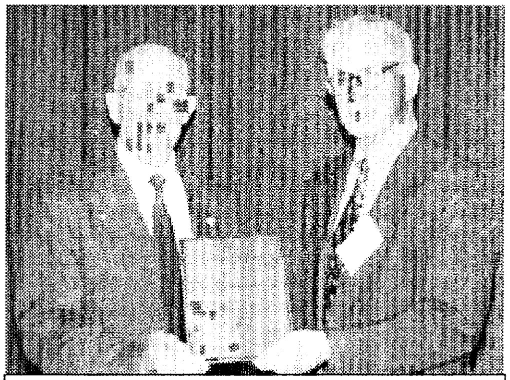
Felton believed that education was key to staying ahead in the cattle business. "We are starting a new era of value-based marketing and alliances. We have to educate cattle people. We can use all this carcass data, and we need to be utilizing it to help our customers and, at the same time, build a genetic base. We also need to educate our customers on how to use EPDs," Felton said in an article printed in Hereford World in 2001. The lessons he taught others were not just about cattle, but about agriculture and life as well.

Felton was considered progressive among his peers — not only did he collect a sizeable amount of data, but he also used it to make his herd one of the best documented anywhere. Dennis Padgitt, animal science professor at Northwest Missouri State University, said his friend was a true geneticist who loved to study production data and breed cattle to develop a quality animal. "Felton developed polled Hereford bulls that are among the elite of the breed. The genetics he developed were used around the world," Padgitt said.

The genetics developed by Frank Felton had a great affect on the Hereford breed, and his contributions to the industry will never be forgotten. The legendary Felton Hereford herd was dispersed on Oct. 30, 2003. More than 130 buyers from 30 states and Canada came seeking Felton genetics to add to their program and affect the future of the breed. When the gavel fell for the final time, 275 lots averaged $3,250.

Felton passed away April 16, 2003, at Heartland Regional Medical Center, St. Joseph, Mo.

2004 Pioneer Award
Joe Minyard – South Dakota



Joe Minyard (left) receives the 2004 Pioneer Award from S.R. Evans, 2004 BIF President.

The Beef Improvement Federation (BIF) honored Joe Minyard with the Pioneer Award at the 36th Annual Meeting and Research Symposium in Sioux Falls, S.D., on May 27. The award recognizes individuals who have made lasting contributions to the improvement of beef cattle.
Joe Minyard was born in Foard County Texas and graduated from Crowell High School. He received his bachelor's degree from West Texas A&M University in Agriculture Education. He then received his master's degree in animal breeding and genetics from South Dakota State University.

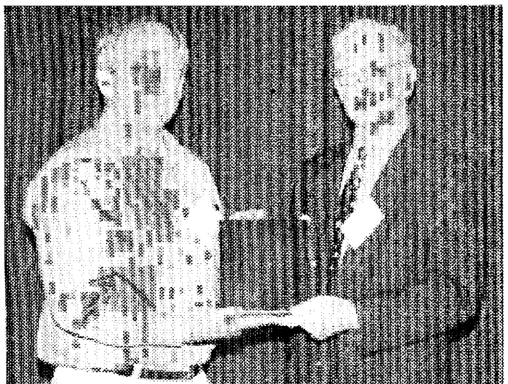
Joe began his career as a school teacher in Dupree, S.D. in 1951, and in 1953, became a county Extension agent for Harding County, SD. Mr. Minyard then served as an Assistant Professor of Animal Sciences at South Dakota State University were he conducting research on economically important traits and improvement in beef cattle performance and efficiency via selection based on performance records. He was instrumental in developing a statewide production records program. Joe also taught the animal breeding course.

In 1961 Minyard moved to the field station at Newell, S.D. and continued his research there. In 1966 he became an Extension beef specialist, associate professor and director of the West River Research and Extension Center where he continued his efforts in production records and selection. He also placed emphasis on crossbreeding systems for commercial herds, range beef nutrition and herd management.

Minyard served three years as head of the Animal and Range Sciences Department at SDSU starting in 1978. In 1981 he resumed his role as an Extension specialist with a statewide educational role. After retirement in 1987 he continued working with the South Dakota Beef Industry Council to promote the adoption of a nationwide beef checkoff program where he served as South Dakota state coordinator for the "pro checkoff" effort.

Minyard has served every capacity as an educator in the South Dakota system. His affect on his students and beef producers is greatly recognized and appreciated.

2004 Pioneer Award
Tom Jenkins – USDA-ARS Clay Center (Nebraska)



Tom Jenkins (left) receives the 2004 Pioneer Award from S.R. Evans, 2004 BIF President.

The Beef Improvement Federation (BIF) honored Thomas Jenkins with the Pioneer Award at the 36th Annual Meeting and Research Symposium in Sioux Falls, S.D., on May 27. The award recognizes individuals who have made lasting contributions to the improvement of beef cattle.

Jenkins was raised in west central Arkansas on a vegetable, swine and beef cattle farm. He and his wife, Barbara, have a daughter, Angela, and a son, Christopher. Following four years of military service, he received his bachelor's. degree in animal science from the University of Arkansas. He earned his M.S. degree in Animal Breeding under the direction of C. J. Brown at the University of Arkansas in 1973. In 1977 he received a doctorate in animal breeding under T. C. Cartwright at Texas A&M University. In 1978, Dr. Jenkins joined the USDA, Agricultural Research

Service (ARS) at the U.S. Meat Animal Research Center (MARC), Clay Center, Neb., where he has made many significant research contributions affecting efficiency of production and genetic improvement of beef cattle.

Throughout his career, Jenkins has engaged in multidisciplinary research to quantify variation in energy requirements among diverse breeds or breed crosses of beef cattle associated with differences in genetic potential for growth, maintenance and lactation. Findings from this research have been incorporated into a decision evaluator for the Cattle Industry (DECI), a software package developed by Jenkins in collaboration with Charles Williams also at MARC, to aid cattle producers in making management decisions. Designed for personal computers, DECI provides managers with a tool for evaluating strategic management and breeding options.

Jenkins' research contributions have been reported in more than 170 scientific publications. In addition, he has made more than 100 presentations at industry meetings throughout the United States and in other countries including Canada, Great Britain, France, Switzerland, Argentina and Australia. He has served BIF as an invited speaker on numerous occasions, as a member of committees planning annual meetings, and as a member of committees responsible for development of guidelines and recommendations for trait measurement and genetic improvement of components of production efficiency.

Edited by Janice M. Rumph, Animal Breeding & Genetics
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