Proceedings

Beef Improvement Federation 35th Annual Research Symposium and Annual Meeting

BIF

May 28-31, 2003
Hyatt Regency Lexington
Lexington, Kentucky

Hosted by

UK
UNIVERSITY OF KENTUCKY
College of Agriculture

Kentucky Department of Agriculture
Building Partnerships For Agriculture's Future

KENTUCKY CATTLEMEN'S ASSOCIATION

BEEF

2002 - 2003 Beef Improvement Federation Board of Directors

2003 Beef Improvement Federation

Hyatt Regency Lexington
35th Annual Meeting
Lexington, KY
May 28-31, 2003

Wednesday, May 28, 2003

5:00 p.m.	Kentucky Welcome Reception
7:30 p.m.	NAAB Symposium
	Management of Young Cows for Maximum Reproductive Performance. *Tom Geary, USDA-ARS, Fort Keogh*
	Using Estradiol Cypionate (ECP®) vs. GnRH in Controlled A.I.-Breeding Programs. *Jeffrey S. Stevenson, Kansas State University*
	Economic Impact of Synchronization. *Les Anderson, University of Kentucky*

Thursday, May 29, 2003

8:00 a.m.	Welcome
8:10 a.m.	Surviving Environmental Challenges. *Moderator: Tom Jenkins, USDA-MARC*
8:15 a.m.	Beef Production in Adverse Environments. *Carl Hoveland, University of Georgia*
9:00 a. m.	Clinical Mode of Action and Genomic Potential in Fescue. *Richard Browning, Tennessee State University*
9:45-10:15 a.m.	Break
10:15 a.m.	Management of Beef Production in Adverse Environments. *Jim Gerrish, Brookfield, Missouri*
11:00 a.m.	Question and Summation
12:00	BIF Recognition Luncheon
2:00-5:00 p.m.	Round Table Discussions
	Emerging Technology. *Chair, Craig Huffhines, American Hereford Association*
	Selection Decisions. *Chair, Bob Weaber, American Simmental Association*
	Cow Herd Efficiencey. *Chair, Robert Hough, Red Angus Association of America*
6:00 p.m.	Kentucky Night Out. *Kentucky Horse Park (Buses leave Hyatt starting at 5:30 p.m.)*

Friday, May 30, 2003

8:00 a.m.	Traits to Dollars. *Moderator: Craig Huffhines, American Hereford Association*
	Panel Discussion: What will the target be? *Jim Norwood (PM Beef Group), Glen Dolezal (Excel), John Tobe (Laura's Lean Beef), and Joe Bill Meng (Creekstone Farms)*
9:00 a.m.	Questions and Discussion
9:30-10:00 a.m.	Break
10:00 a.m.	Available Tools for Making Genetic Change. *Tom Fields, Colorado State University*
10:45 a.m.	How Best to Achieve Genetic Change. *Dorian Garrick, Colorado State University*
11:30 a.m.	Questions and Summation
12:00 p.m.	BIF Awards Luncheon
2:00-5:00 p.m.	Round Table Discussions
	Genetic Prediction. *Chair, Larry Cundiff, USMARC*
	Producer Applications. *Chair, Sally Dolezal, Beef Industry Consultant*
	Live Animal, Carcass, and Endpoint. *Chair, Robert Williams, American International Charolais*

Night on the Town - *Dinner on your own*

Saturday, May 31, 2003

6:30 a.m.-	
7:00 p.m.	Kentucky Beef Industry Tour
	Option 1: Purebred Focus
	Option 2: Commercial Focus

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Management of Young Cows for Maximum Reproductive Performance

T. W. Geary, USDA-ARS Fort Keogh, Miles City, MT

Reproduction is the main factor limiting production efficiency of beef cattle (Dickerson, 1970). Forty years ago, failure to conceive or early embryonic death accounted for the largest loss in calf crop potential (Wiltbank et al., 1961). More recently, Bellows and Short (1994) reported that the greatest production loss in the cow-calf segment of the beef industry results from cows not being pregnant at the end of the breeding season. Have we made any progress in improving reproductive efficiency among beef cows?

Today, the most common reproductive problem that both purebred and commercial beef producers encounter is getting first calf heifers rebred. This is a common problem because we are trying to rebreed a cow that has not yet reached her mature weight and is often faced with the task of consuming enough energy to satisfy needs for growth, lactation, and maintenance when generally only poor quality forage is available (Laster et al., 1973). In most operations, pregnancy rate of either the two or three-year old cows is the lowest in the herd. Economically, the two-year old cow is generally the most expensive/valuable animal on the ranch because of the dollars invested in her and because she has not yet returned any income to the operation. Because of the estimated $950 involved in developing each replacement heifer and carrying her through until calving, producers cannot afford for these cows to fall out of the herd because of reproductive failure as two-year olds. Put another way, producers can easily justify additional expenses to ensure these females rebreed rather than having to develop another replacement heifer.

Over the past 40 years, numerous studies have been conducted to identify the problems and improve the rebreeding efficiency of first calf heifers. While older cows require 40 to 60 days to recover from calving and overcoming a negative energy balance before they begin having regular estrous cycles and can be rebred, 2- and 3-year old cows may require 70 to 90 days. This interval from calving until the re-initiation of estrous cycles is often referred to as a cow's postpartum anestrous interval or more commonly, postpartum interval (PPI). The longer PPI and delayed re-breeding attributable to the negative energy balance of young cows after calving has been magnified by genetic selection for increased productivity. When genetic potential of the female is "out of synch" with the production environment, delayed reproduction is one of the first phenotypic indicators of that asynchrony. This phenomenon has been observed, on an across-breed basis, where Angus-Hereford females had 10% greater pregnancy rate than Simmental-Hereford females and 66% of Angus-Hereford females versus 38% of Simmental-Hereford females remained in the breeding herd at 7 years of age (MacNeil et al., 1994). The keys to increasing pregnancy rate among young cows especially are to shorten the PPI to increase the number of opportunities a cow has to conceive during a defined breeding season and to increase the fertility of cows early during the breeding season (Wiltbank et al., 1961). Improved re-breeding efficiency can be achieved through additional inputs in feed resources and labor, management alternatives, or selection to reduce nutrient requirements of cows.

A part of the reason that producers are advised to breed heifers to calve 3 weeks ahead of the cow herd is to provide additional time to overcome the longer PPI before the start of the subsequent breeding season. While this works well in theory, it can backfire. Cows calving earlier in the spring have longer PPI due to true seasonal effects related to changes in light (Hansen and Hauser, 1984). In addition, calving heifers ahead of the cowherd generally means calving earlier in the spring and a longer interval until when green grass is available. If sufficient nutrients are not provided to heifers with newborn calves, they can actually be further behind (still in a negative energy balance) at the start of the breeding season. Thus, it is essential to provide these females with the best resources available and can be afforded. It is difficult if not impossible to provide sufficient feed to cows after calving to avoid the negative energy balance, so we need to prepare them for this period by allowing them to develop energy stores before calving and ensure they are in adequate body condition at calving (Houghton et al., 1990; Short et al., 1990). Adequate body condition means a body condition score of 5 to 6 (moderate) at calving. In general prepartum nutrition (especially the last 50 to 60 days before calving) is the primary controller of length of the PPI, while postpartum nutrition primarily affects fertility (Bellows and Short, 1978; Henricks and Rone, 1986; Randel, 1990). However, cows on a low plane of nutrition postcalving will also have a longer PPI. A summary of 5 studies suggests that feeding ionophores such as Bovatec® or Rumensin® after calving increases feed costs less than two cents per day, but shortens the PPI in cows by an average of 18 days provided adequate energy is available.

If producers are unable or choose not to calve heifers ahead of the cowherd, then it is essential that heifers calve early in the calving season. That means heifers must be adequately developed to be cycling at the beginning of the breeding season. The old rule of thumb that heifers should be 65% of mature weight at the beginning of the breeding season still stands. The biggest difference is that producers translate this into meaning 650 –700 lbs, which was adequate when we were kids and mature cow weights were 1,000 – 1,100 lbs. Mature cows in today's herds' often weigh 1,250 lbs or more, meaning heifers should be at least 800 lbs at the onset of breeding. Synchronization of estrus (even with natural service) should be considered in every heifer development program to increase the percentage of heifers calving early. Developing more heifers than are needed as replacements and retaining only those that conceive early, during the first 25 days of the breeding season, may increase rebreeding pregnancy rates. A simple and cheap method of synchronizing heifers for natural service is to feed MGA in pellets to heifers for 14 days, and turn in the bulls two weeks after the last feeding of MGA (Patterson et al., 1990).

Identification of early pregnancies among heifers may require earlier pregnancy diagnosis than producers are accustomed to and may require pregnancy diagnosis with ultrasound to improve accuracy of fetal aging. Heifers that calve late as two-year olds, often fail to rebreed or calve later as three-year olds and may fail to conceive as three-year olds (Lesmeister et al., 1972). In most herds, a replacement female will not pay for herself until she has weaned her 4th calf as a five-year old.

Dystocia is more common among first calf heifers and increases the PPI and delays rebreeding (Brinks et al., 1973; Laster et al., 1973; Bellows and Short 1978). One of the reasons artificial insemination has become so popular among heifers is the ability to avoid dystocia by breeding heifers to calving ease proven sires. In a survival analysis of 1,382 CGC (1/2 Red Angus, 1/4 Charolais, 1/4 Tarentaise) females, Rogers et al. (2003) reported that heifers experiencing dystocia were at 35% greater risk of being culled, primarily due to subsequent reproductive failure, than herd mates that calved without assistance. When calving assistance is needed, earlier assistance greatly decreased the interval from calving to the subsequent pregnancy. After a heifer has spent 1.5 hours in stage II labor (hooves visible), every 30-minute delay in providing assistance resulted in a 6 day longer interval to pregnancy (R. A. Bellows, personal communication).

Exposing first calf heifers to either sterile bulls or androgenized cows following calving helps re-initiate estrous cycles (Zalesky et al., 1984; Burns and Spitzer, 1992). Researchers have demonstrated that a bull pheromone is involved, that approximately 30 days of bull exposure is required, and that the return to cyclicity is quicker if exposure is initiated 55 days after calving (Joshi, 2002). When bull exposure began at either 15 or 35 days after calving, the return to cyclicity was delayed compared to bull exposure begun at day 55 after calving, but well ahead of first calf heifer not exposed to bulls. Most studies have utilized bull or androgenized cow to heifer ratios of 1:20 to produce this effect.

Estrous cycles can be induced in cows after calving with hormones used for synchronization. Most cows have a short estrous cycle or may ovulate without expressing estrus just before they begin having regular estrous cycles. This short cycle produces progesterone for 5 to 8 days that helps synchronize hormonal control of the cow's estrous cycle. We can mimic this short cycle by administering progesterone to anestrous cows in the form of a CIDR inserted into the vagina, which releases progesterone until it is removed 7 days later. When we administered CIDRs to early postpartum cows last year, estrous cycles were initiated in 90% of cows and almost 60% were in estrus within 4 days after it was removed. Cows were not bred at this estrus, so we don't know anything about the fertility of this estrus. In this same study, neither a normal dose nor a high dose of MGA induced estrous cycles. Another hormone, referred to as GnRH, can also be used to induce estrous cycles following calving. An injection of GnRH initiates a short estrous cycle in anestrous cows by eventually causing release of progesterone for 5 to 7 days. The estrous cycle following this short estrous cycle is generally very fertile. With either of the hormonal induction methods, heifers need to be at least 30 days since calving before any benefit will be achieved.

Over the years, we've learned that the demand lactation places on a cow represent the single greatest factor affecting the postpartum anestrous interval. As indicated earlier, this is especially true for first calf heifers, as they are still diverting energy for growth as well as lactation. Short-term (48-hour) calf removal helps induce release of GnRH within a cow and helps induce estrous cycles (Smith et al., 1979). This is very effective in anestrous cows, but is less effective in anestrous two-year olds, perhaps due to the "depth" of anestrus (Geary et al., 2001). However, **early and permanent weaning holds more promise for improving reproductive efficiency in first calf heifers than probably all of the other methods combined.** Early weaning has received considerable attention within the last few years, particularly because of regional areas of drought and low grain prices. While each operation may define early weaning differently, if it is to impact reproduction, then it must occur before the end of the breeding season and preferably before the beginning of the breeding season. As one might expect, early weaning completely eliminates the energy that was needed for lactation, so now the cow can divert extra energy to reproduction. Several studies have been reported in which early-weaned two-year olds experienced dramatic increases in pregnancy rates and/or increases in the percentage of calves born early the subsequent year (Table 1). Depending on how early your heifers' calve, this may mean weaning calves that are less than 60 days old. Calves that are 40 days old can outperform suckled calves as long as a highly palatable ration that is dense in energy is provided. Rations for early weaned calves should be designed to provide at least 2.7 lb/d gain and contain at least 50 to 70% concentrates (wheat middlings / corn / barley mixtures have worked best) and 30 to 50% grass hay (alfalfa hay is not recommended).

While early weaning seems like a rather drastic measure, if facilities, labor, and cheap feed resources are available, the benefits to first calf heifers may have lasting effects. Getting these young cows to conceive and calve early as 3-year olds

Table 1. Benefits observed in three herds that compared reproductive performance of cows whose calves were weaned early or at approximately 200 days of age.

Early vs normal weaning	2-yr olds	3-yr olds	Mature cows
Study 1. Weaned 8 d before a 42-d breeding season[a]			
Increased pregnancy rate	26%	16%	8%
Study 2. Calves weaned at 50 d of age[b]			
Increased pregnancy rate	38%		19%
Increased cow weight at normal weaning	87 lbs		80 lbs
Study 3. Calves weaned at 56 d of age[a]			
Increase calving first 30 d of subsequent year	35%		

a Adapted from "Management of early weaned calves" NebGuide G83-655.

b Adapted from "Early weaning for the beef herd" OSU Extension Facts No.3264.

may mean longer and greater lifetime productivity. In the past few years, grain prices have been low enough that early weaning has been profitable through increased weight gains alone. Remember when grain prices are higher, that each two-year old that successfully rebreeds translates into a $950 savings in heifer replacement cost.

In the past 40 years, researchers have investigated and developed several methods of improving the rebreeding performance of 2- and 3-year old cows. However, producer adoption of these methods has not occurred at a very rapid pace. While it is possible to use combinations of the methods below to improve rebreeding performance, the overall benefit of each one may not be additive. In summary, the following methods may improve the rebreeding performance of young beef cows.

- Develop heifers to 65% of mature weight at breeding
- Synchronize heifers to conceive early during a short breeding season
- Artificially inseminate heifers with semen from calving ease proven sires
- Provide additional energy during the last 50 days of gestation so that heifers calve at a minimum body condition score of 5
- Provide early calving assistance when intervention is needed
- Provide young cows with the best feed resources available after calving
- Provide ionophores to cows after calving to improve utilization of feed
- Expose young cows to sterile bulls or androgenized cows during the last 30 days before the start of breeding
- Induce/synchronize estrous cycles in young cows even with natural service
- Consider early weaning during drought and cheap feed availability

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Using Estradiol Cypionate (ECP®) vs. GnRH in Controlled A.I.-Breeding Programs

Jeffrey S. Stevenson, Kansas State University

K-STATE RESEARCH & EXTENSION

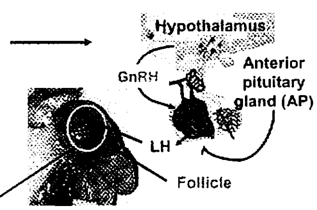
1

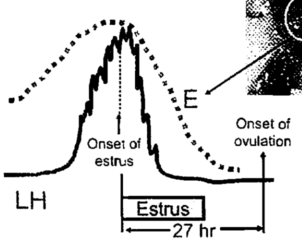
Why Substitute Estrogen for GnRH?

2

How Do Estrogen and GnRH Work?

GnRH is secreted by the hypothalamus and induces release of **LH** and FSH from the AP.



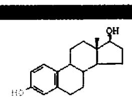


GnRH induces the **LH** surge in response to increased **estrogen** (**E**) associated with the onset of estrus.

3

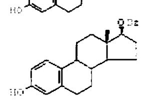
Estrogens

Estradiol-17



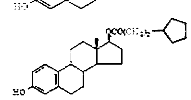
Principal estrogen secreted by the follicle

Estradiol benzoate



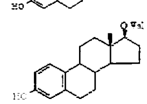
Mimicks estradiol-17 most closely (half-life nearly equal)

Estradiol cypionate



Longer-acting estrogen (sold as ECP®)

Estradiol valerate



Longest-acting estrogen; was part of Syncro-Mate B® estrus-synchronization protocol (not available)

4

Extra Label Use of Drugs

- Extra label use means a drug is used for purposes NOT listed as one of its Indications on the bottle label or bottle insert.
- For example, the label for each GnRH product indicates that its approved use is for the treatment of ovarian follicular cysts.

CYSTORELIN®
Factrel®
FERTAGYL®
OvaCyst®

- Use of GnRH in any estrus-synchronization or ovulation control program is considered to be an <u>extra label</u> use.

5

Extra Label Use of Drugs

- GnRH products have therapeutic approvals for use in cattle in the U.S.
- Strict interpretation of Animal Medicinal Drug Use Clarification Act (AMDUCA) is that GnRH products cannot be used for production purposes in cattle.
- However, GnRH products are being used extensively for estrus-synchronization programs by veterinarians and academic researchers who have published their results in scientific journals and producer press.

6

Extra Label Use of Drugs

- GnRH is a peptide (very small protein with a short blood half life) with no known health concerns.
- FDA must have minimal concerns regarding use of GnRH products in estrus-synchronization programs because no known prosecutions have been initiated.

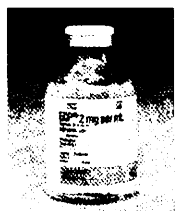
7

Illegal Use of Drugs and Compounding of Products

- Estradiol benzoate (EB) has no human or animal approval in the U.S.
- Strict interpretation of AMDUCA is that EB cannot be used for production purposes in cattle.
- Therefore, use of EB in cattle for estrus-synchronization programs is illegal.
- Use of EB also is illegal when compounded with any other approved product.
- Use of the Eazi-Breed™ CIDR® Cattle insert plus Lutalyse® is an **approved** compounding of products.

8

What Estrogen is Approved?

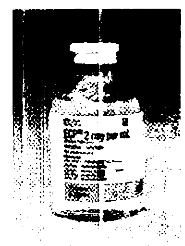


- Estradiol cypionate (ECP) has a therapeutic label for use in cattle in the U.S.
- It is the only estrogen approved for use in cattle is ECP® (Pharmacia)
- ECP has multiple label indications including "to correct anestrus [absence of heat period] in the absence of follicular cysts" at 3 to 5 mg doses.

9

Use of ECP in Breeding Programs

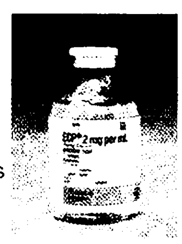
- Strict interpretation of AMDUCA is that ECP cannot be used for production purposes in cattle.
- Because ECP is an estrogen, it is of concern to the U.S. Food and Drug Administration-Center for Veterinary Medicine relative to human health and safety.



10

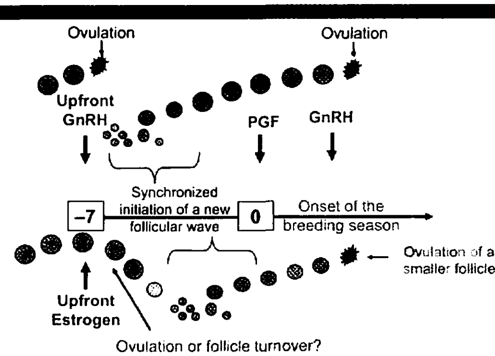
Use of ECP in Breeding Programs

- ECP is being used extensively for estrus-synchronization programs by veterinarians and academic researchers who have published their results in scientific journals and producer press.
- FDA has not initiated prosecutions of either researchers or veterinarians using ECP in cattle estrus-synchronization programs.



11

Follicle Control



12

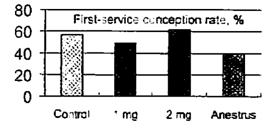
What Must Estrogen Do To Replace GnRH in Breeding Programs?

- Estrogen must induce upfront follicle turnover in a synchronization program in cycling cows.
- Estrogen must induce upfront ovulation in anestrous cows.
- Estrogen must induce ovulation after PGF.
- Estrogen must not produce "hyper-estrus" activity to prevent injury of cows caused by excessive riding and standing behavior.
- Estrogen must be easy to administer.

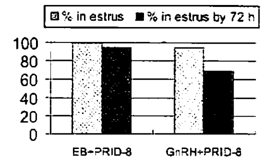
13

Upfront Follicular Control?: Cycling

- Upfront EB (1 vs. 2 mg) at CIDR-7 insertion was effective for lactating cycling cows (Day et al., 2000).



- Upfront EB vs. GnRH at PRID-8 insertion was effective in cycling replacement heifers (Lane et al., 2001).



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Upfront Follicular Control?: Anestrus

- Use of EB at 0.5 or 1.0 mg dose at the time of CIDR insertion did not induce ovulation effectively in seasonally anestrous dairy cattle (Verkerk et al., 1998). Beef cattle?
- EB + CIDR reduced formation of persistent follicles in lactating anestrous dairy cows, but delayed follicular development in some anestrous cows (Rhodes et al., 2002). Beef cattle?
- Immature dominant follicles in suckled anestrous cows were less likely to ovulate after EB (Burke et al., 2001).

15

Ovulation after PGF-induced Luteolysis?

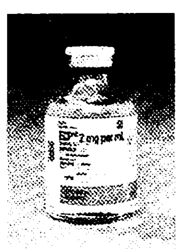
Response	Kansas	Florida
ECP to LH surge, h	19.1 ± 2.6	
Onset of estrus after ECP, h	27.8 ± 3.2	29.0 ± 1.8
Duration of estrus, h	6.9 ± 0.7	12.5 ± 1.8
No. of standing events	17.1 ± 5.2	20.3 ± 2.8
Total standing timed, sec	36.3 ± 12	47.6 ± 7.5
Ovulation after estrus onset, h	29.9 ± 2.4	27.5 ± 1.1
Ovulation after ECP, h	60.0 ± 1.8	55.4 ± 2.7

After luteolysis, ECP induces ovulation in lactating dairy cows and in replacement heifers (Lopes et al., 2000).

16

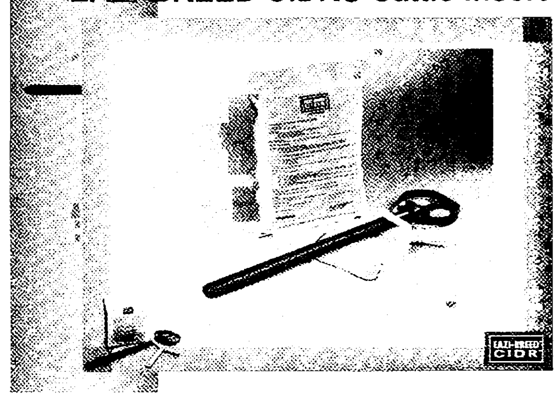
Easily Administered?

- ECP is dosed at 2 mg per mL.
- A small syringe is required to deliver 1 mg of ECP i.m. in a volume of 0.5 mL (0.5 cc).
- When injecting cows, follow Beef Quality Assurance (BQA) guidelines to reduce carcass bruising and injection site lesions (i.e., use neck injection sites).



17

EAZI-BREED CIDR® Cattle Insert



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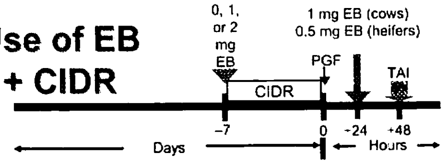
Use of EB + CIDR



EB dose	Pregnancy rates		
	Heifers	Parity 1	Parity 2+
0 mg	43% (56)	28% (37)	64% (73)
1 mg	51% (54)	41% (34)	51% (69)
2 mg	48% (56)	32% (36)	63% (72)

Courtesy of Les Anderson, Univ. of Kentucky

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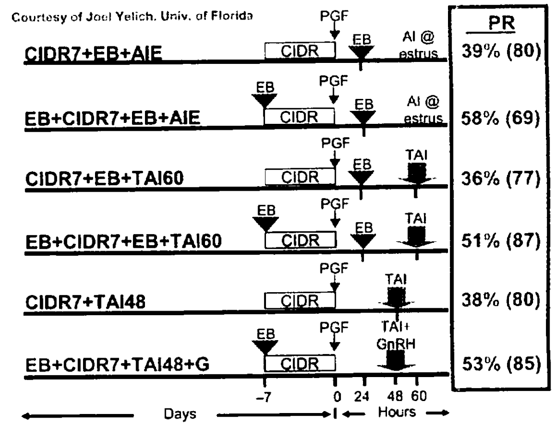

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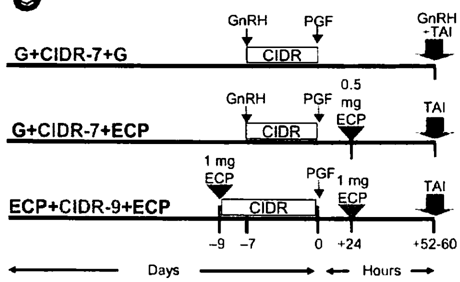
Use of ECP + CIDR

courtesy of SELECT SIRES



When using ECP upfront, the CIDR must be in place for 9 days

21

courtesy of SELECT SIRES

Pregnancy Rates in Suckled Angus Cows

Treatment*	Parity 1	Parity 2+	Total
G + CIDR-7 + G	56% (45)	52% (63)	54% (108)
G + CIDR-7 + ECP	61% (44)	72% (60)	67% (104)
ECP + CIDR-9 + ECP	44% (43)	52% (62)	51% (105)

*TAI at 52 to 60 hr

22

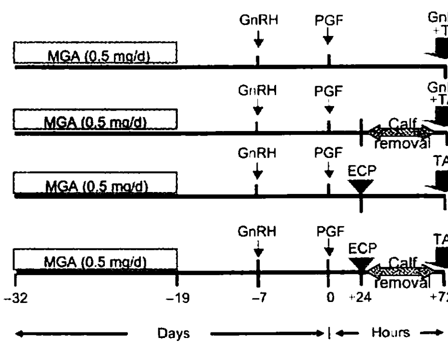
courtesy of SELECT SIRES

Pregnancy Rates in Angus Replacement Heifers

Treatment*	Herd B	Herd K	Total
G + CIDR-7 + G	50% (24)	31% (98)	34% (122)
G + CIDR-7 + ECP	33% (25)	39% (99)	38% (124)
ECP + CIDR-9 + ECP	38% (26)	39% (109)	39% (135)

*TAI at 52 to 60 hr

23



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ECP vs. GnRH

Calf removal	ECP	GnRH	Total
Yes	49% (94)	51% (97)	50%* (191)
No	51% (90)	38% (88)	44% (178)
Total	50%+ (184)	44% (185)	47% (369)

*Different (P<0.05) from no calf removal.
+Different (P<0.05) from GnRH.

K-STATE RESEARCH & EXTENSION

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Summary

- ECP is an alternative to GnRH for upfront follicle control, but may not be as effective as GnRH for anestrous cows.
- If ECP is used upfront at CIDR insertion, the CIDR must be in place for 9 days, rather than 7 days when using GnRH.
- After CIDR removal, ECP is an alternative to GnRH after luteolysis for TAI systems.
- Pregnancy rates to TAI tended to be greater in suckled cows when treated after PGF with ECP than GnRH.

26

Resynchronization of Estrus

- Increase opportunity for more A.I.-sired calves
- Take full advantage of previous synchrony with little additional cost
- Facilitate heat detection of first eligible heat after A.I.

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Protocols for Resynchronization of Estrus

- Previously used progestin-releasing inserts or implants
- Feeding of a progestin (e.g., MGA)
- Combination progestins with estrogen injections
- Use of Ovsynch and Heatsynch

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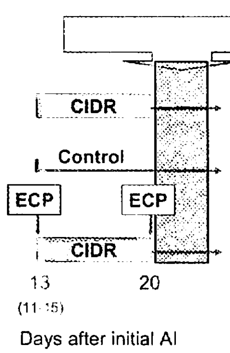
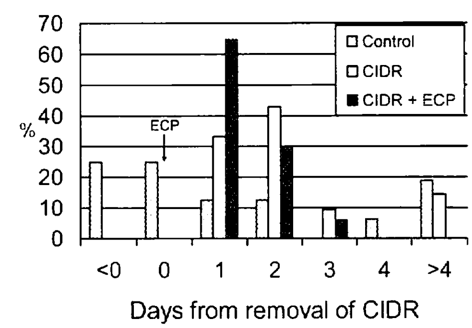


Exp. 1:
68 dairy heifers
62 beef heifers

29



Stevenson et al., 2003. J. Anim. Sci. in press.

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Exp. 1. Reproductive Traits

Item	Con	CIDR	CIDR + ECP
No. of heifers	44	42	44
PR after 1st A.I.	53%	47%	60%
Return 18-26 days	73%	84%	90%
CR of repeat A.I.	60%	33%	35%
26-day PR	72%	60%	73%

Stevenson et al. 2003 J. Anim. Sci. in press

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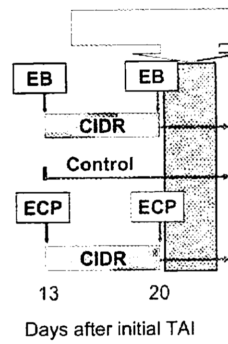
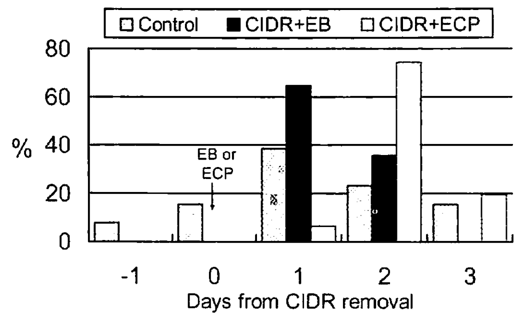


Exp. 3:
588 suckled beef cows

32



Stevenson et al. 2003 J. Anim. Sci. in press

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Exp. 2. Reproductive Traits

Item	Con	CIDR + EB	CIDR + ECP
No. of cows	292	151	145
PR after 1st A.I.	52%	44%	52%
Return 20-23 days	29%	84%	65%
CR of repeat A.I.	65%	52%	65%

Stevenson et al. 2003 J. Anim. Sci. in press

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Summary

Resynchronization of repeat estrus:

- Had no negative effect on established pregnancies.
- Increased synchrony of repeat estrus.
- Tended to reduce resynchronized conception rates after resynchronization in dairy and beef heifers .
- Produced normal conception rates at the resynchronized estrus in suckled beef cows when ECP + CIDR were used.

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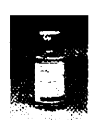
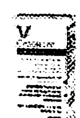
Thanks to the following for their financial or product support:




- **Select Sires**
- Pharmacia Animal Health
- Fort Dodge Animal Health
- Intervet
- Merial

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Economics of Estrus Synchronization and Artificial Insemination

Dr. Les Anderson and Paul Deaton, University of Kentucky

Introduction

Few beef producers would disagree that the genetic potential available for use in their herds via artificial insemination is greater than that of most natural service sires. However, less than 10% of the beef cows in the United States are artificially inseminated each year (NAHMS, 2000). Many reasons exist for the low rate of implementation of estrus synchronization and AI (ESAI) into beef cow-calf operations. One reason is the extensive nature of beef production. Most cows are pastured in large acreages and the labor necessary for handling the cows is too great. Additionally, many producers lack adequate facilities to enable safe and easy cattle handling. Beef production is a minor enterprise on many farms. The income from the beef enterprise in most small and medium-sized operations is secondary to other enterprises or to off-farm income. However, the primary reason for the limited inclusion of ESAI is economics. Little information is available to aid producers in making decisions regarding return on investment and profitability when considering using ESAI. Many producers may incorporate ESAI if it would improve their profitability both short- and long-term. This paper examines the costs of pregnancy for both natural service and AI, the short-term returns on investment of AI and the long-term effects of incorporating AI into a breeding system

Costs per Pregnancy

Few producers understand the costs associated with producing a pregnant female. Sandy Johnson and coworkers (2003) from Kansas State University recently published an excellent article discussing the costs associated with pregnancy using either natural service or a variety of estrus synchronization protocols. Table 1 illustrates the costs per pregnancy for bulls that range in price from $1,500 to $3,000 and bull-to-cow ratios from 1:15 to 1:50. Assumptions of the model

Table 1. Cost per Pregnancy Using Natural Service

Purchase Price	1,500.00	1,700.00	2,000.00	2,300.00	2,500.00	3,000.00
Salvage Value	860.00	860.00	860.00	860.00	860.00	860.00
Summer Pasture	104.13	104.13	104.13	104.13	104.13	104.13
Crop Residue	7.50	7.50	7.50	7.50	7.50	7.50
Hay	90.61	90.61	90.61	90.61	90.61	90.61
Protein, mineral	25.00	25.00	25.00	25.00	25.00	25.00
Labor	50.00	50.00	50.00	50.00	50.00	50.00
Vet	21.00	21.00	21.00	21.00	21.00	21.00
Repairs	31.00	31.00	31.00	31.00	31.00	31.00
Misc.	7.00	7.00	7.00	7.00	7.00	7.00
Interest	15.13	15.13	15.13	15.13	15.13	15.13
Total Variable	351.37	351.37	351.37	351.37	351.37	351.37
Depreciation on Equipment	12.39	12.39	12.39	12.39	12.39	12.39
Depreciation on bull	160.00	210.00	285.00	360.00	410.00	535.00
Interest on bull	212.40	230.40	257.40	284.40	302.40	347.40
Death loss	15.00	17.00	20.00	23.00	25.00	30.00
Total Fixed	399.79	469.79	574.79	679.79	749.79	924.79
Total cost/year	751.16	821.16	926.16	1,013.16	1,101.16	1,276.16
Purchase Price	1,500.00	1,700.00	2,000.00	2,300.00	2,500.00	3,000.00
Cows Exposed Per Year			**Cost Per Pregnancy ($)**			
15	53.27	58.24	65.69	73.13	78.10	90.51
20	39.96	43.68	49.26	54.85	58.57	67.88
25	31.96	34.94	39.41	43.88	46.86	54.30
30	26.64	29.12	32.84	36.57	39.05	45.25
35	22.83	24.96	28.15	31.34	33.47	38.79
40	19.98	21.84	24.63	27.42	29.29	33.94
50	15.98	17.47	19.71	21.94	23.43	27.15

Reprinted with permission from Johnson et al. 2003 included use of the bull for 4 seasons; 10% death loss; 9% interest rate; and a 94% pregnancy rate. Annual bull maintenance costs are variable and increasing the feed costs by $100 increased cost per pregnancy from $2.22 to $7.41 for high and low bull-to-cow ratios, respectively. Costs per pregnancy ranged from $15.98 to $90.51 depending predominantly upon the purchase price and bull-to-cow ratio. Certainly, the ability to identify bulls with a high serving capacity could reduce costs associated with impregnating females.

Use of ESAI will alter cost per pregnancy. Producers can use a partial budget (Table 2) for enterprise analysis of ESAI. Implementation of ESAI can increase returns by increasing the weaning weight of the calves (both age and genetic effects), altering market price by increasing the uniformity of the calf crop, and improving cow productivity by enhancing the number of high-quality replacement heifers. Alternatively, ESAI can reduce potential income because fewer bulls are available to sell as cull bulls. Estrus synchronization and AI increases costs because of costs for synchronization products and supplies, labor, technician, and perhaps facilities. However, ESAI can reduce costs by lowering the number of bulls needed for natural service and reducing the labor hours at calving due to a more concentrated and predictable calving season.

Several factors affect the cost per pregnancy of an estrus synchronization and AI program. Conception rate to the AI influences the cost per pregnancy (Table 3). As conception rate to AI increases, the cost of pregnancy of the system decreases. Cost per pregnancy is also influenced by total labor hours associated with the ESAI system (Table 4), the cost of labor, and the cost of semen. If pregnancy rate is held constant (Table 4), the cost per pregnancy of ESAI exceeds that of natural service especially for smaller herds. However, if the costs are adjusted for the expected increase in weaning weight of the calves resulting from the ESAI, the cost of pregnancy for Select Synch and MGA-PG is lower to produce a 500 pound equivalent weaned calf (cost per cwt of calf). The cost per pregnancy of CO-Synch to produce a 500 pound equivalent calf was only $.51 per cwt higher than that of natural service. If conception rate to AI increases to 60% (Table 5), then the cost per 500 pound equivalent calf is not different between CO-Synch and natural service.

From these data it seems apparent that the costs of pregnancy are not significantly different between natural service and most ESAI protocols. Of course, if labor is high, if semen costs are excessive, or if conception rate to the AI is low, the cost per pregnancy of ESAI can dramatically increase.

Short-term Return on Investment

Little data can be found in the literature that examines the return on investment of incorporating estrus synchronization and AI. Therefore, the following trial was designed to determine if implementation of estrus synchronization and AI is cost effective and enhances net return. Crossbred postpartum cows (n = 351) were randomly assigned by age and calving date to one of two breeding systems. Approximately two-

Table 2. Partial Budget for Synchronization of Estrus Synchronization Plus AI

Budget Effect	Source	Budget Effect	Source
Increased Returns	Heavier calves (earlier average birth date) Improved genetics (calves and replacement females) Uniformity of calf crop (fewer sires could be used, total breeding season could be shorter)	Decreased Returns	Fewer cull bulls to sell
Decreased costs	Fewer bulls to purchase and maintain Less labor for more concentrated calving season More predictable calving ease	Increased costs	Planning and management for synchronization of estrus and AI Synchronization products and supplies Labor Improved facilities?

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Table 3. Effect of Changing Pregnancy Rate on Breeding Cost per Pregnant Female in a Select Synch Protocol

Calving herd size	AI pregnancy rate (%)	No. of bulls for natural service	Breeding cost ($) per pregnancy	Proportion % of total cost attributed to:			
				Bulls	Semen	Labor	Treatments
100	75	1	42.06	20	37	19	15
100	55	2	46.08	37	24	18	14
100	48	3	53.01	48	19	15	12
300	65	5	40.90	35	33	11	16
300	55	6	41.49	41	27	11	15

Adapted with permission from Johnson et al. 2003

Table 4. Breeding System Costs and 500lb Equivalent Weaned Calf Breeding Cost per cwt

System	Days Worked	Preg. Rate (%)	Total Labor Hours: Herd Size 30	100	300	No. of Bulls: Herd Size 30	100	300	Cost ($) per pregnancy: Herd Size 30	100	300	500 lb. equivalent weaned calf breeding cost ($) per cwt.: Herd Size 30	Diff[a]	100	Diff[a]	300	Diff[a]
Natural Service						2	4	12	56	34	34	12.91	-	7.79	-	7.79	-
Select Synch	9	50	45	82	142	1	2	6	67	45	40	12.75	0.16	7.74	0.05	6.68	1.11
MGA + PGF	6	50	37	67	116	1	2	6	60	39	35	11.20	1.71	6.47	1.32	5.56	2.23
CO-Synch	3	50	26	47	82	1	2	6	70	51	48	13.41	(0.51)	9.04	(1.25)	8.32	(0.53)

[a] Diff = difference between natural service and breeding system, S/cwt
Adapted with permission from Johnson et al. 2003

Table 5. Breeding System Costs ($) and 500 lb Equivalent Weaned Calf Breeding Cost (S) per Cwt at Various AI Pregnancy Rates

System	Days Worked	Preg. Rate (%)	No. of Bulls: Herd Size 30	100	300	Cost ($) per pregnancy: Herd Size 30	100	300	500 lb. equivalent weaned calf breeding cost ($) per cwt.: Herd Size 30	Diff[a]	100	Diff[a]	300	Diff[a]
Natural Service			2	4	12	56	34	34	12.91	-	7.79	-	7.79	-
CO-Synch	3	40	1	3	7	70	59	50	13.93	(1.02)	11.50	(3.71)	9.48	1.11
	3	50	1	2	6	70	51	48	13.41	(0.51)	9.04	(1.25)	8.32	(0.53)
	3	60	1	2	5	70	51	45	12.90	0.01	8.53	(0.74)	7.16	0.63
MGA/PGF	6	40	1	3	7	58	46	36	11.20	1.71	8.41	(0.63)	6.21	1.58
	6	50	1	2	6	60	39	35	11.20	1.71	6.47	1.32	5.56	2.23
	6	60	1	2	5	62	42	35	11.20	1.71	6.46	1.33	4.91	2.88
Select Synch	9	40	1	3	7	65	51	41	12.75	0.16	9.68	(1.90)	7.33	0.45
	9	50	1	2	6	67	45	40	12.75	0.16	7.74	0.05	6.68	1.11
	9	60	1	2	5	69	47	40	12.75	0.16	7.73	0.06	6.03	1.76

[a] Diff = difference between natural service and breeding system, S/cwt
Adapted with permission from Johnson et al. 2003

thirds of the cows (n = 251) were subjected to an estrus synchronization protocol suitable for a fixed-time insemination (SYNC). On Day -9, cows were administered gonadotropin-releasing hormone (GnRH; 100 ug; Cystorelin®, Merial) and 7 days later were administered 25 mg of prostaglandin $F_2\alpha$ (PG; Lutalyse®, Pharmacia & UpJohn, Kalamazoo, MI). Cows were administered a second injection of GnRH and were artificially inseminated on Day 0. On Day 10, cows were exposed to natural service for 50 days. Bull-to-cow ratio was 1:50 females in the SYNC group. The remaining cows (n = 100) were exposed to natural service for 60 days (NAT). The bull-to-cow ratio in the NAT treatment was 1:25. The bull-to-cow ratio was different between the SYNC and NAT groups because we anticipated that approximately one-half of the cows in the SYNC group would conceive to AI. To verify date of conception, pregnancy was diagnosed on Day 90 using transrectal ultrasonography.

To determine return on investment, all costs associated with the estrus synchronization and AI were recorded and are summarized in Table 6. Labor was determined by recording amount of time required to bring the cattle to the corral, work the cows and then return them to the breeding pastures. Four laborers were used, three trips through the chute, and an hourly wage of $7.00 per hour. To determine differences in revenue, calves were weighed at weaning and the differences in weight available to market were determined. Calves from both treatments were given a value of $80 cwt.

Table 6. Cost of AI

Item	Cost per cow
GnRH	$4.00
Prostaglandin	$4.00
Technician	$5.00
Semen	$10.00
Labor[a]	$2.88
Total	**$29.88**

[a] 8.6 hours X 3 working days X 4 workers X $7.00 per hour for 251 cows

Differences between treatments were determined using GLM procedures of SAS. Differences between treatments in proportional data were determined using Chi Square analysis.

The results of this trial are shown in Table 7. More (P > .05) cows calved in the SYNC group than in the NAT group and more (P > .05) cows calved in the first 30 days of the calving season in the SYNC versus the NAT treatment. The average date of calving was earlier (P > .05) in the cows in SYNC than in the NAT group. The average weaning weight of calves was heavier (P > .05) from cows in the SYNC than from those in the NAT group. The increase in percent calf crop weaned and weaning weight increased the pounds of calf weaned per cow exposed by nearly 110 pounds.

Return on investment is shown in Table 8. Revenue increased by $99.62 in the SYNC group. This increased revenue was achieved by investing $29.88 per cow. Therefore the return on investment for the estrus synchronization and AI was $69.74. This return does not include savings associated with reduced bull costs. One-half the number of bulls was used per cow in SYNC group than in the NAT group. If savings on bull purchases are included, the return on investment increases to $129 per cow. These short-term increases in revenue are quite attractive, but the long-term effects of increasing cow productivity by retaining the heifers sired by proven sires are not apparent.

Table 7. Results of Short-Term ESAI Trial

	SYNC	NAT	Diff
Cows	251	100	
Calving Rate	90%	81%	9%
% Calving 1st 30 days	85%	62%	23%
Mean Julian date of calving	74 ± .4	84 ± .7	10d
% calf crop weaned	88%	79%	9%
Weaning age	210 ± 9	200 ± 12	10 d
Weaning Weight	576.9 ± 18.1	504.8 ± 21.2	72.6 lbs
Lbs. calf weaned/cow exposed	507.9	398.4	109.5 lbs

Table 8. Increased Revenues from ESAI

	Revenue
Weaning Weight	72.6 poundsx $80 cwt = $58.08
% Calf crop	9% more calves x $80 cwt = $41.54
Total Revenue	**$99.62**
Return on Investment	**$99.62 – 29.88 = $69.74**

Long-term Effects of Estrus Synchronization and AI

No data is available that addresses the long-term impact of estrus synchronization and AI in commercial beef cow-calf operations. A trial was designed to examine the long-term effects of incorporating estrus synchronization and AI into a beef cow-calf operation. The data were collected on a single cow-calf operation from 1991 to 2003. Data collected from 1991 to 2000 serve as the baseline or control. During this time period, approximately 45 females (35-40 cows and 5-8 heifers) were exposed to a 60-day natural service season. Two bulls were used each year. The breeding system used was a two-breed rotational system using Angus and Charolais bulls. The average performance of this herd is illustrated in Table 9.

The breeding system was changed to determine the effects of estrus synchronization and AI. All females were subjected to an estrus synchronization protocol suitable for fixed-time insemination (CO-Synch). Females were inseminated to bulls from maternally-oriented breeds (Angus and Hereford). Charolais-cross cows were inseminated to the Angus sire and Angus-cross cows were inseminated to Hereford bulls. Ten days after AI, cows were exposed to a 50-day natural service season. The natural service sire was from a terminally-oriented breed (Charolais). Replacement heifers with AI-sires were retained. All calves sired by the terminally-oriented sire were marketed. This trial is in the third year of a ten year study. Data reported were analyzed using the Cow Herd Appraisal System (CHAPS) and the Standardized Performance Analysis (SPA) software programs.

Table 9. Effects of ESAI on Production Efficiency and Profitability in a Medium-Sized Herd

	Avg from 1991 to 2000	2001	2002
No. of females exposed	45	45	44
Calving Rate Percentage (# Cows Calving/# Cows Exposed)	82 %	95%	93%
% Calf Crop Weaned	74.5%	91%	86%
WW Average (pounds)			
Steers	525	542	556
Heifers	484	514	482
Sale Weight[a]			
Steers	554	588	600
Steer Sale Price (per cwt)	$77.00	$88.00	$83.00
Lbs of calf weaned per cow exposed	381.2	481.4	448.2
# Cows Sold	5	9	6
Cash Cow Costs	$235.38	$285.82	$292.26
Net Profit per Cow Exposed (Cash sales per cow- cow cost)	$57.75	$116.62	$76.83

[a] Calves were backgrounded for approximately 25 days prior to marketing

The results from the first two years of the trial are shown in Table 9. Incorporation of estrus synchronization and AI increased the percentage of cows that calved, percent calf crop weaned, and the average weaning weight of the steer calves. These increases lead to a marked improvement in pounds of calf weaned per cow exposed. The increases in production efficiency led to increased profitability. Net profit per cow exposed to the bull doubled in the first year and was $20 per cow higher in 2002. We anticipate that productivity and profitability will continue to increase as the AI-sired females enter the breeding herd.

Conclusions

Inclusion of estrus synchronization and AI is a profitable enterprise for commercial beef cow-calf operations. The short-term returns on investment were approximately $70 per cow simply by increasing reproductive efficiency and thus the pounds of marketable calf. Additional short-term increases in revenue exist if the producer retains ownership. Data from the Angus Association demonstrated that the carcass value was $206 per head greater for sires from the top 10% than the bottom 10% for carcass value. Therefore, if the calves produced from the herds used in the above trials were from sires that were only average and the bulls used for AI were in the top 10% and the cattle were marketed on the grid, an additional $100-$125 per calf is profited. The key to capturing the greatest potential profit is to utilize alternative marketing systems. However, even in a commodity market, inclusion of ESAI is a profitable rather than costly venture.

The Fescue Toxicosis Story—An Update

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Origin of Tall Fescue

Tall fescue (*Festuca arundinacea*) is the most important cultivated pasture grass in the USA, occupying over 35 million acres. It is a native of Europe but is of minor importance there. It is not known when tall fescue was first introduced into the USA but it was being tested in several states by the late 1800s (Buckner et al., 1979). However, tall fescue usage remained low until release of the Kentucky 31 cultivar. It is an ecotype found growing in a steep mountain pasture of eastern Kentucky which was known to have been there prior to 1890. Dr. E.N. Fergus, a professor at the University of Kentucky, saw this pasture in 1931 and was impressed that the grass remained green all winter so obtained seed for trials. Kentucky 31 was released as a cultivar in 1943 (Fergus, 1952). This grass was dependable, adapted to a wide range of soils, and provided grazing over much of the year. As news spread that this wonder grass persisted across the southern USA where no other cool season perennial grass was adapted, demand for seed exploded as it was widely planted during the 1940's and 1950's. This was a remarkable ecological change as tall fescue transformed the landscape which was previously mostly barren and brown during the winter season. In addition to the widespread planting of tall fescue for pasture and hay, it also became popular for roadside and turf use.

Fescue Toxicity Problems

Tall fescue soon gained a reputation for livestock health problems, resulting in poor performance (Pratt and Haynes, 1950). Over time, three separate syndromes were associated with tall fescue (Ball et al., 2002):

a. Fescue foot. In the upper South and Midwest, cattle symptoms include elevated respiration rate, and gangrene that resulted in loss of hooves, tails, and ears. This syndrome occurs mainly during cold weather.

b. Bovine fat necrosis. Hard fat accumulate along the intestinal tract, resulting in upset digestion and difficult births. It is associated with high rates of nitrogen fertilization mainly from poultry litter or other manure.

c. Fescue toxicity. This syndrome is much more widespread over the entire tall fescue region with general symptoms in cattle of failure to shed the winter hair coat, intolerance to heat, poor animal gains, and reduced pregnancy rates. These symptoms are most severe in warmer weather. In horses, mares have serious reproduction problems with prolonged gestation, dystocia, agalactia, and abortions.

Determining the Cause of Toxicity Problems

J.K. Underwood and co-workers in Tennessee noted with great insight that the animal symptoms were similar to ergotism but they eliminated this possibility because there was no ergot in tall fescue seed heads (unpublished, 1954). Surprisingly, this clue was not followed up. Instead, research was concentrated on external plant fungi, plant alkaloids, anions, and toxins produced in the rumen during the 1950's-1970's (Bush et al., 1979). This consumed a great deal of scientific time and money with nothing to show for it. The breakthrough came when Dr. Joe Robbins, a toxicologist at the USDA Russell Research Laboratory in Athens, GA, examined a tall fescue pasture with cattle suffering fescue toxicity symptoms and found 100% of the plants infected with a fungal endophyte while pastures with cattle in good condition had a much lower infection rate (Bacon et al., 1977). This evidence of the fungal endophyte as the causal agent of toxicity was confirmed in two central Alabama replicated grazing trials having low and high endophyte infection levels (Hoveland et al., 1980; Hoveland et al., 1983).

Vasoconstriction with decreased blood flow to peripheral tissues and reduced blood serum prolactin, typical of fescue toxicity, suggested an alkaloid as the problem (Cross, 2000). A number of ergot alkaloids were isolated from endophyte-infected plants (Bacon and Siegel, 1988) and ergovaline was assumed to be the one most responsible for animal toxicity (Lane et al., 1997). However, research by Hill et al. (2001) indicates that transport of the ergopeptine alkaloid ergovaline across ruminal gastric tissue is low as compared to the simple ergoline alkaloids lysergic acid and lysergol. This indicates that we are closer to defining the toxic agent or agents responsible for fescue toxicity and possibly developing some blocking technique in the animal rumen.

Beef Cattle Response to the Endophyte

Beef steer gains in six grazing trials on low endophyte tall fescue were 30% to over 100% more than on grass with a high level of endophyte infestation (Stuedemann and Hoveland, 1988). Unfortunately, none of the grazing trials had endophyte-free (E-) and infected (E+) tall fescue from the same genetic source which may partially account for the large variation in animal response. Where the same seed source was used in a 3-yr central Georgia grazing trial, steers on the Jesup cultivar with 1% endophyte infection had an ADG of 2.27 lb but with 89% infection it was 0.81 lb, or only about one-third (Hoveland et al., 1997). Steers on E- tall fescue are tolerant of heat, graze throughout the day, shed their winter hair coats in spring, and are more active than steers on E+ grass. Visible signs of the syndrome increase with higher temperatures, but poor gains occur throughout the year on E+ tall fescue. The effects of grazing E+ versus E- tall fescue pasture during stockering on subsequent gains in the feedlot are not clear.

Several studies indicate that beef steers previously grazing E+ tall fescue had compensatory gains in the feedlot (Cole et al., 1987; McDonald et al., 1988; Lusby et al., 1990). However, other scientists (Hancock et al., 1987: Duckett et al., 2001) found no compensatory gains in steers previously grazed on E+ pastures.

Beef cows on E+ tall fescue are often thin and in poor condition, caked with mud, and spend excessive amounts of time in shade or water. Pregnancy rate of beef cows (especially first-calf heifers) may be reduced by 40 to 60% (Essig et al., 1989; Gay et al., 1988; McDonald, 1989; Porter and Thompson, 1992). Calf weaning weights may be decreased by 60 to 70 lb, a result of both reduced milk production by cows and consumption of toxic tall fescue forage by calves. Milk production of beef cows on E+ grass may be reduced by 30% or more. Beef cattle losses in the USA have been conservatively estimated at well over $600 million annually from reduced calf numbers and lower weaning weights (Hoveland, 1993).

Biology of the Fungal Endophyte

The fungus (*Neotyphodium coenophialum*) lives its entire life cycle within the plant, thus being called an endophyte. Unlike most fungi, this one is not visible externally on the tall fescue plant. Nearly all tall fescue pastures have a high level of infected plants. It is spread only through infected seed. This means that tall fescue pastures free of the endophyte will remain that way for a long time if well managed. However, invasion of an E- pasture can occur from introduction of infected seed in hay or by cattle that have previously grazed seed in an E+ tall fescue pasture. Storage of E+ seed under ambient temperature and humidity generally results in death of the endophyte within a year.

A mutualistic relationship exists between the endophyte and host plant, (Bacon and Siegel, 1988). The benefits for the endophyte include food, protection within the plant, and dissemination through the seed. In return, the host plant receives improved drought tolerance through better root development and better water conservation in the plant, tolerance to pests, improved utilization of nitrogen, and greater seedling vigor and growth potential (Latch, 1997). Dry matter intake by cattle grazing cattle E+ tall fescue is 24 to 44% less than for cattle grazing E- tall fescue, resulting in less severe grazing pressure (Stuedemann et al., 1989). In addition, crowns of E+ tall fescue plants are buried deeper in the soil than E- plants, giving added grazing protection (Hill et al., 1990) With all the benefits of the endophyte, it is obvious that E- tall fescue is handicapped in a stressful pasture environment and less competitive with other plant species.

Endophyte-free Tall Fescue Cultivars

When the first E- tall fescue cultivar, 'AU Triumph' was released, it appeared to offer a solution to the livestock toxicity problem (Hoveland et al., 1982). Animal performance was excellent but cattle producers who planted it reported that seedling vigor, grazing tolerance, and drought resistance were much less than typical Kentucky 31 E+ tall fescue, resulting in stand losses, especially when overgrazed in stressful environments. Improved cultivars are better but require careful management to avoid overgrazing during summer, a problem that is much worse in southern areas of tall fescue adaptation where heat and drought stress are often severe.

Novel Endophyte (Non-Toxic) Endophyte Tall Fescue

Bacon and Siegel (1988) first proposed that fungal endophytes might be modified to produce only beneficial properties such as improved stress tolerance when inserted into an E- tall fescue plant to produce a superior forage grass without any toxicity problems. The discovery in New Zealand (Latch, 1997) of non-toxic endophyte strains made this possible. The first novel (non-toxic) endophyte tall fescue cultivar for commercial use was developed in cooperative research between scientists in Georgia, USA and New Zealand (Bouton, 2000; Bouton et al., 2000). This is a difficult procedure as there are many strains of naturally occurring non-toxic endophytes, and they vary in their ability to work effectively with different tall fescue cultivars, making lengthy testing necessary to determine the stress tolerance of a particular endophyte/tall fescue cultivar combination.

Grazing trials to ascertain animal performance of particular endophyte/cultivar combinations are necessary but more important are grazing tolerance trials for 3 yr under stressful conditions to ascertain stand persistence and competitive ability. An effective method to do this is planting the various endophyte/cultivar combinations along with toxic E+ and E- tall fescue in replicated small plot trials into bermudagrass sod and imposing continuous close grazing by cattle throughout the growing season for a minimum of 3 yr (Bouton et al., 2002). Unless potential novel endophyte cultivars have been evaluated under rigorous testing over time, there is no assurance they will be durable in farm pastures where overgrazing and competition from other grasses is likely to occur.

MaxQ was the first novel endophyte tall fescue cultivar available to cattle producers. Grazing trials with lambs, beef steers, and beef cows have shown that animal performance is similar to that on E- tall fescue. Beef steers on MaxQ gained 0.9 lb/day and 200 lb/A more during spring than steers grazing toxic E+ grass in Georgia for 2 yr (Bondurant et al., 2001a). Grazing behavior on MaxQ, toxic E+, and E- tall fescue pasture were collected on steers equipped with automatic jaw and leg movement sensors, and data recorders (Bondurant et al., 2001b). Steers on MaxQ and E-, as compared to toxic E+ tall fescue, had 8% more time grazing, 25% more bites per day, and 25% higher intake. The E+ steers spent 28% more time idling in the shade and consumed 40% more water. With beef cows the calf weaning weights on MaxQ, as compared to toxic E+ tall fescue pasture, were 75 lb higher for steers and 60 lb for heifers (Watson et al., 2001). MaxQ stand persistence in closely grazed bermudagrass in four trials at two Georgia locations have ranged from 80 to 90% of toxic E+ tall fescue as compared to 20% for E- tall fescue (Bouton et al., 2002; also unpublished data).

Marketing of Novel Endophyte Tall Fescue Seed

Distribution of novel endophyte tall fescue seed poses potential problems for the livestock producer and additional costs for seed firms. Endophyte survival in tall fescue seed gradually declines to about zero during normal storage in warehouses for a year. Thus, unsold seed which are carried over for sale the following year will, in addition to reduced vigor and germination, not contain the living novel endophyte with its benefits to the plant. For the buyer, it is imperative that he/she knows the level of living novel endophyte in the seed at time of purchase and that it be guaranteed by the seed firm. For the seed company to do this, the price of novel endophyte seed will need to be higher to cover losses from unsold carryover seed which can only be sold as cheaper common E- tall fescue seed with no claim to superiority. Seed companies unwilling to make such a guarantee should be avoided; however, it is likely that they will have customers because they can offer novel endophyte seed at a lower price.

Practical Solutions to the Toxicity Problem

Livestock toxicity problems on tall fescue pastures vary greatly among farms. Since most Kentucky 31 tall fescue pastures have a high level of endophyte infection, the main reason for this variation is probably a result of differences in amount of pasture dilution by other plant species. Tall fescue pastures may be mixed with varying amounts of bermudagrass, orchardgrass, timothy, Kentucky bluegrass, or white clover. Palatable winter weeds such as chickweed and little barley dilute pastures in late winter and early spring. During summer, volunteer crabgrass is often an important component of tall fescue pastures. There is no question that fescue toxicity problems would be much more serious if crabgrass were absent from pastures.

Various options can be used with a range in cost and effectiveness (Ball et al., 2002). The choice will depend on the type of livestock operation, expectations, and management ability. Some of the least expensive options are often adequate for beef cow herds and greatly ameliorate or eliminate cattle toxicity problems.

a. Pastures can be managed to favor other grass species such as bermudagrass to dilute the toxic E+ tall fescue (Chestnut et al., 1991).
b. Mowing of seed heads in spring will reduce intake of the highly toxic seed by cattle (Rottinghaus et al, 1991). Infected tall fescue seed are substantially more toxic than leaf tissue (Schmidt et al., 1982).
c. Seeding of legumes such as white clover, red clover, annual lespedeza, or alfalfa into pastures will dilute the toxicity problem and greatly improve animal performance (Ellis et al., 1983; Hoveland et al., 1981; McMurphy et al., 1990).
d. Moving cattle off toxic tall fescue pastures to warm season grasses during late spring and summer may be a viable alternative (Joost, 1995).
e. Feeding hay other than toxic tall fescue such as orchardgrass, timothy, bermudagrass, alfalfa, or red clover greatly reduces the toxicity problem in winter.
f. Ammoniation can reduce the alkaloid content of toxic E+ tall fescue hay and improve animal performance (Chestnut et al., 1987; Kerr et al., 1990).
g. Grain feeding is also beneficial for cattle grazing toxic E+ tall fescue (Aiken and Piper, 1999; Crawford et al, 1989).
h. The most effective but also the most costly solution is replanting pastures with novel endophyte (non-toxic) tall fescue (Ball et al., 2002). This is a major decision as it involves completely destroying existing toxic pastures and replanting them. The time required for destruction and establishment may prevent use of the pasture for six to nine months. Where pastures are being used for growing animals as in a beef stocker operation, replanting is highly desirable as the cost is quickly repaid.

Implications

Although tall fescue pastures support more beef cattle than any other grass in the USA, the fungal endophyte which contributes to its success in stressful environments adversely affects animal performance. The various syndromes caused by toxic alkaloids from the fungal endophyte are widespread and a serious economic problem in the USA beef cattle industry. Most cattle producers suffer losses and many accept them as a normal part of their operation. Fortunately, much progress has been made in research on this problem and finding solutions. Today, a number of options are available to cattle producers that can eliminate the problem or greatly ameliorate it.

Low cost options include diluting toxic pastures with clovers or other grasses, mowing off seedheads, moving cattle to warm season grass pastures during summer, ammoniation of hay, or feeding hay other than toxic tall fescue. The most effective and most costly option is destroying toxic pastures and replanting with novel (non-toxic) endophyte tall fescue, a dependable solution to eliminate the toxicity problem.

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Tall Fescue Endophyte Toxicosis in Beef Cattle: Clinical Mode of Action and Potential Mitigation through Cattle Genetics

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Introduction

Tall fescue (*Festuca arundinacea* Schreb.) is the most commonly used cultivated grass in the United States to feed beef cattle. Tall fescue is a cool-season perennial grass that many cattle producers 'can't live with, but can't live without' because of its hardiness and good forage yields, but adverse effects on cattle well-being and yields. The history of this forage and its effects on animal performance have been extensively reviewed (Hemken et al., 1984; Bacon et al., 1986; Stuedemann and Hoveland, 1988; Porter and Thompson, 1992; Stuedemann and Thompson, 1993; Porter, 1994; Bacon, 1995; Paterson et al., 1995). Tall fescue was unintentionally introduced from Europe sometime in the 1800s. Early university research on growing tall fescue in the U.S. began between 1907 and 1918 in Oregon and in Kentucky in 1931 (Alderson and Sharp, 1993). Tall fescue, primarily the Kentucky-31 variety, was planted across the U.S. throughout the 1940s and 1950s because of its excellent growth under various environmental stressors. Tall fescue may be found across the eastern half of the U.S. and the Pacific Northwest covering an estimated 25 to 40 million acres of pasture and hayland. It has been estimated that over 90% of tall fescue pastures in the U.S. are infected with the fungal endophyte *Neotyphodium coenophialum* (Bacon and Siegel, 1988; Glenn et al., 1996). Tall fescue and the endophyte share a natural, symbiotic relationship. The endophyte protects the host plant from environmental stressors such as drought, insects, nematodes, disease pathogens, and grazing by herbivores such as cattle.

After widespread adoption of tall fescue in the 1940s, managers started to notice problems with the well-being and performance of their cattle. These problems began to be documented during the 1950s (Walls et al., 1970; Stuedemann and Hoveland, 1988). The three general problems associated with endophyte-infected tall fescue consumption by cattle are fescue foot, fat necrosis, and fescue toxicosis. Fescue foot is a condition in which cattle become lame with potential sloughing off of the hoof. The tips of the tail and ears may also be lost. Insufficient blood flow to the extremities results in fescue foot and generally occurs during winter months. Fat necrosis is the development of hard fat deposits in the abdomen that can interfere with digestion or parturition. Fescue foot and fat necrosis are relatively infrequent occurrences. Fescue toxicosis is a multifaceted syndrome that is pervasive in tall fescue-based beef production systems across the Southeast and Midwest, extending west to eastern regions of the southern Great Plains. Cattle experiencing fescue toxicosis may exhibit rough hair coats, heat stress, suppressed appetite, poor growth, or reduced calving rates.

Fescue toxicosis is not a lethal condition and may be subclinical with the only sign being poor growth or low pregnancy rates. Although endophyte infection of tall fescue was first recognized in the early 1940s (Neill, 1941), it was not until the late 1970s that the link was made between poor animal performance and presence of the endophyte in tall fescue (Bacon et al., 1977). Numerous studies have since demonstrated the adverse effects that endophyte-infected tall fescue can have on beef cattle performance (Table 1; Paterson et al., 1995; Ball, 1997). The nutritional quality of endophyte-infected tall fescue is comparable to other similar forages and is not an influential factor in most studies. Fescue toxicosis costs the U.S. beef industry an estimated $500 million to $1 billion annually in lost revenue because of reduced reproductive and growth rates in cattle herds.

Clinical Mode of Action

The search for the causative agent(s) of tall fescue toxicosis has been ongoing since animal disorders were first recognized. These efforts preceded identification of the fescue endophyte as a key component of the toxicosis scenario (Jacobson et al., 1963; Walls et al., 1970). It is now understood the endophyte produces numerous chemical compounds responsible for the hardiness of tall fescue under environmental stress (TePaske et al., 1993; Porter, 1994, 1995). Various compounds isolated from endophytic fescue have been

Table 1. Post-weaning growth and pregnancy rates for beef cattle on high endophyte-infected tall fescue versus low endophyte-infected forage[a] averaged across studies.

Reference	Studies reviewed	Low Infection	High infection
		Growth Rate, pounds per day	
Thompson et al., 1993	12	1.52	1.11
Paterson et al., 1995	12	1.63	0.92
Multiple reports[b]	8	1.69	0.81
		Pregnancy Rate, %	
Paterson et al., 1995	4	87	59
Burke et al., 2001	16	78	60
Multiple reports[c]	3	83	64

a Low-infected forage = low endophyte-infected tall fescue, endophyte-free tall fescue, or alternative forage.
b Cole et al., 2001; Bouton, 2002; Andrae, 2003.
c Fanning et al., 1992; Peters et al., 1992; Best et al., 2002.

tested over the years to determine their likely contribution to toxicoses in cattle (Thompson and Porter, 1990; Strickland et al., 1993). Ergot alkaloids have emerged as the generally accepted toxic agents of the tall fescue endophyte. Of the ergot alkaloids, ergopeptides and lysergic acid amides have received the most research attention, primarily the ergopeptides.

The basic chemical structure of ergot alkaloids is very similar to dopamine, noradrenaline, and serotonin (Berde and Strumer, 1978; Muller-Schweinitzer and Weidmann, 1978). These three compounds are neurotransmitters normally found in the body that regulate a myriad of physiological traits such as appetite, cardiovascular function, endocrine activity, gastrointestinal motility, muscle contraction, and temperature regulation. Ergot alkaloids have diverse pharmacological properties because they are able to interact with dopaminergic, alpha-adrenergic, and serotonergic receptors in the body (Berde and Strumer, 1978; Muller-Schweinitzer and Weidmann, 1978; Pertz and Eich, 1999). Some neurotransmitter-regulated physiological traits are altered after grazing endophyte-infected tall fescue because of the pharmacological activities of ergot alkaloids consumed (Oliver, 1997).

Ergovaline is the most abundant ergopeptide detected in endophyte-infected tall fescue (Belesky et al., 1988). As such, testing of fescue samples for ergovaline concentration is done in an attempt to indicate the toxic potential of tall fescue pasture or hay (Schnitzius et al., 2001). In the laboratory, ergovaline caused vasoconstriction in isolated bovine tissue (Dyer, 1993). Vasoconstriction is considered the reason animals suffering from fescue toxicosis experience lowered peripheral skin temperature. Peripheral vasoconstriction reduces blood flow to the skin, thus lowering skin temperature. Reduced blood flow to the extremities can also result in fescue foot. Purified ergovaline, administered intravenously, altered cardiovascular function, reduced skin temperature, and induced heat stress in sheep wethers and horse geldings (Bony et al., 2001; McLeay et al., 2002). Similar studies of purified ergovaline effects on cattle have not been published.

Ergotamine is an ergopeptide found in endophyte-infected tall fescue at lower levels than ergovaline (Yates et al., 1985). Ergotamine and ergovaline have similar structures and pharmacodynamic properties (Porter, 1994; Larson et al., 1999; Schoning et al., 2001). McLeay and co-workers (2002) found that ergotamine and ergovaline had similar effects on cardiovascular and thermoregulatory function in sheep. Several studies have been conducted where cattle have been treated with purified ergotamine. Ergotamine administered to cattle intramuscularly lowered tail skin temperature (Carr and Jacobson, 1969). In the lab, ergotamine caused vasoconstriction in isolated bovine tissue (Solomons et al, 1989). Vasoconstriction would explain lowered tail skin temperature. Osborn et al. (1992) demonstrated that consumption of ergotamine by steers induced physiological changes that were similar to responses in steers that consumed endophyte-infected tall fescue. These changes included decreased feed intake and peripheral skin temperature, increased rectal temperatures and respiration rates, and reduced weight gain (Table 2). In a series of studies where cattle were administered ergotamine intravenously, the ergopeptine alkaloid significantly altered vital signs (e.g., increased blood pressure and respiration rates, reduced tail skin temperature; Browning and Leite-Browning, 1997; Browning, 2000) and plasma concentrations of metabolic hormones (e.g., increased thyroid hormone, reduced insulin; Browning et al., 1998a, 2000) and reproductive hormones (e.g., increased prostaglandin F_2alpha, reduced luteinizing hormone; Browning et al., 1998b, 2001).

The effects of purified ergovaline and ergotamine on cattle physiological status are generally consistent with the performance problems observed in cattle grazing endophyte-infected tall fecsue. These research finding help to justify the monitoring of ergovaline levels in tall fescue intended for use in cattle diets. The ability of dietary ergovaline or any other ergot alkaloid in endophyte-infected tall fescue to affect an animal is dependent on the alkaloid crossing the gastrointestinal tract after ingestion and entering the bloodstream. One of the frustrations in the area of bovine fescue toxicosis research has been the inability to detect ergovaline or similar ergot alkaloids in the blood of cattle grazing endophytic fescue. Recent work suggests that very little ergopeptide crosses the gastrointestinal tract and the primary ergot alkaloids transported across gastrointestinal tissue are lysergic acid and lysergic acid amides (Hill et al., 2001). Lysergic acid amides (ergine, ergonovine) elicit similar physiological responses as ergopeptides in terms of vasoconstriction in isolated bovine tissue (Oliver et al., 1993) and altered vital signs and hormone profiles in cattle (Browning and Leite-Browning, 1997, Browning et al., 1997, 1998a,b). The results of Hill and coworkers (2001) have caused some to question the validity of a commonly held position that ergovaline is the primary toxin of endophyte-infected tall fescue. Data showing that orally administered ergotamine induced signs of fescue toxicosis (Osborn et al., 1992; Table 2) suggest that dietary ergopeptides or bioactive ergopeptide metabolites enter the bloodstream and tend to support the view that ergovaline is a significant toxin of endophyte-infected tall fescue to contend with.

Table 2. Signs of fescue toxicosis induced in steers fed endophyte-free tall fescue with ergotamine added to the diet.[a]

	Ergotamine in the diet	
Traits[b]	**No**	**Yes**
Skin temperature (tail tip), °F	96.1	91.4
Rectal temperature, °F	103.1	104.5
Respiration rate, breaths per minute[c]	72	90
Feed intake, pounds per day	12.5	6.4
Weight gain, pounds per day	1.23	-1.03

[a] Adapted from Osborn et al., 1992.

[b] Difference between diets for each trait was statistically significant ($P < 0.05$).

[c] At high ambient temperature (89.6°F).

Control Through Cattle Genetics

Direct economic impact of fescue toxicosis is generally limited to cow-calf and stocker operations. Cattle from endophyte-infected tall fescue grazing systems do not exhibit poor performance when moved to the feedlot (Beconi et al., 1995; Drouillard and Kuhl, 1999; Cole et al., 2001). Some fescue-grazed cattle exhibit compensatory gains that are economically beneficial to feedlot operators. Thus, the seedstock, commercial cow-calf, and yearling/stocker segments have a financial incentive to seek ways of minimizing or eliminating the problem. Researchers have sought to devise methods of alleviating fescue toxicosis on two fronts, forage management and animal management.

Forage Management.

The pasture management approach is aimed at reducing or eliminating dietary ergot alkaloids. Suggested forage management strategies used by producers to combat fescue toxicosis include: 1) replacing endophyte-infected tall fescue with low-endophyte tall fescue, endophyte-free tall fescue or other grass species for grazing or hay, 2) diluting endophyte-infected tall fescue with other grasses or legumes, 3) ammoniating fescue hay, and 4) increasing stocking rates on endophytic fescue pastures to prevent plant maturation and seedhead formation (Stuedemann and Thompson, 1993; Ball, 1997). Ergot alkaloids are found throughout the tall fescue plant, but are highly concentrated in seed. These approaches have had limited success. The alkaloid-producing fungus makes endophyte-infected tall fescue a robust grass species that is highly competitive and hard to replace successfully for grazing in many geographic locations.

The current focus of many plant scientists studying tall fescue is on genetic strains of endophyte with altered profiles of alkaloid production (Panaccione et al., 2001; Bouton et al., 2002). These 'non-toxic' or 'novel' endophytes would produce alkaloids that provide pest and drought resistance to the host grass, but not produce ergot alkaloids responsible for fescue toxicosis in livestock. Recently, tall fescue infected with a novel endophyte was commercially introduced that shows promise as a pasture management option for producers (Bouton, 2002; Andrae, 2003). Pasture management strategies, including the planting of tall fescue with novel endophytes, will each be used to some extent in beef cattle operations across the country. However, the time and expense involved in pasture renovation, the vast number of acres covered in endophyte-infected tall fescue, and the general reluctance of some managers to eradicate long-established, vigorous stands of tall fescue in cattle pastures may limit widespread implementation of any one practice.

Animal Management.

A lessor research focus has been on animal management procedures to help alleviate fescue toxicosis. Recent efforts to address the problem through cattle management have explored various options such as ivermectin treatment, feed additives or supplements, estrogen implantation, and vaccine development (Stuedemann and Thompson, 1993; Beconi et al., 1995). Research on these techniques has not progressed to the point of expecting any impending practical applications on an appreciable scale. Unlike endophyte-free tall fescue or the recent emergence of novel endophytes on the plant side of the problem, there have not been developments of similar magnitude on the animal side. However, like in the plant research effort where recent advancements were made by exploiting genetic variability in endophyte populations for alkaloid production, genetic variation in cattle populations may be utilized to manage against fescue toxicosis.

Within-Breed Genetic Selection. One animal genetics approach is to identify and select animals within a herd or breed that may be less responsive to the toxic effects of the endophyte-infected tall fescue. In one study, Angus cows that had been managed on endophyte-infected tall fescue for the better part of 10+ years were screened for susceptibility to fescue toxicosis (Hohenboken et al., 1991). Results were inconclusive. A second study conducted by Gould and Hohenboken (1993) attempted to validate a producer contention that a particular Hereford bull sired calves that were resistant to fescue toxicosis. The producer claim was not supported by the controlled study. More recently, researchers have worked to select and develop inbred lines of mice that would be susceptible or resistant to fescue toxicosis. Indications are that the growth and reproductive rates of 'resistant' mice were affected to a lesser degree compared to the 'susceptible' line after eight to twelve generations of selection (Hohenboken and Blodgett, 1997; Wagner et al., 2000). However, the differences between the lines were not dramatic and post-weaning growth across diets was generally higher for the 'susceptible' mice. An apparent reduction in genetic merit for post-weaning growth in the 'resistant' animals tended to erase any weight advantage gained through their increased tolerance of an endophytic fescue diet. The mouse work did show that modest genetic changes for animal responsiveness to endophyte-infected tall fescue can be achieved.

A limitation of within-breed or within-herd selection for beef cattle improvement and fescue toxicosis resistance, aside from a possible reduction in genetic merit for growth in a resistant line, is the time required to reach eight to twelve generations. There are probably cows herds today that have been managed and selected on fescue pastures for several generations. Individual animals in those herds may have acquired some tolerance to the fescue endophyte indirectly through the selection of replacement breeding stock with desired levels of production within a fescue-based production environment. Identifying those animals would be difficult since no simple diagnostic test is available to meet that objective, but it may be possible. A preliminary report describes the screening of eight-month-old Angus bulls for rectal temperature responses to high ambient temperature and dietary endophyte-infected tall fescue seed (Lipsey et al., 1994). The bulls classified as being most 'sensitive' or most 'tolerant' based on rectal temperature responses were later used in a controlled breeding program. A diet containing ergovaline caused higher rectal temperatures in calves sired by the 'sensitive' bull compared to calves sired by the 'tolerant' bull. The history of the Angus sires used in the trial was not disclosed in the published abstract (Lipsey et al., 1994). Identifying and selecting cattle for resistance to fescue toxicosis is a challenging proposition for the producer and researcher alike, but should not be discounted. Indirect selection is likely occurring on farms using endophyte-infected tall fescue as the primary forage.

Breed Differences on Endophyte-Infected Tall Fescue. Heat stress is a well-documented consequence of fescue toxicosis, especially during summer. Cattle suffering from fescue toxicosis often exhibit elevated respiration rates and open-mouth panting, increased time spent under shade, creation of and lying in mud wallows, and decreased daytime grazing. These behaviors are attempts to dissipate excess body heat. Peripheral vasoconstriction hinders the loss of body heat through the skin, thus creating a build-up of internal body heat resulting in increased internal body temperature (Al-Haidary et al., 2001). Hyperthermia in cattle experiencing fescue toxicosis has led to experimentation on the potential of heat-tolerant germplasm for cattle on endophyte-infected tall fescue.

Research on differences between heat-tolerant and heat-sensitive cattle breeds for responses to the tall fescue endophyte has been limited. The few studies conducted have involved stocker steers (Table 3). Goetsch et al. (1988) tested British breed crosses and Brahman crosses from April to July and from August to November. Reductions in steer growth rates over 12 weeks by endophyte-infection were deemed similar for both breeds in the spring and fall as breed × diet interactions were not significant. An exception was during the first six weeks of the fall season when a breed × diet interaction was noted as the growth of Brahman crosses was statistically less affected by the endophytic forage. Angus, Brahman × Angus, and Simmental × (Brahman × Angus) steers were examined from November to May by McMurphy et al. (1990). A breed × diet interaction was detected for post-weaning growth rates as half-blood Brahman steers were less affected by high endophyte levels than straight Angus or quarter-blood Brahman steers. Cole and coworkers (2001) did not detect a statistically significant breed × diet interaction for the growth of Brahman-cross and Angus steers when grazing fescue pastures with high or low endophyte infection levels from April to August. Numerical differences between the two genotypes for responsiveness to high endophyte diet in the work of Cole et al. (2001) were conspicuous (Table 3). Two preliminary studies comparing Angus × Brahman versus Angus or Hereford × Angus steers on high endophyte versus low endophyte or endophyte-free fescue from winter to summer did not find breed × diet interactions (Stuedemann et al., 1989; Greene et al., 1994). Unfortunately, post-weaning growth rates for each experimental steer group were not provided in the published abstracts.

The lack of statistically significant breed × diet interactions in most individual studies with Brahman crossbred steers implies that high endophyte-infected tall fescue adversely affected the growth of Brahman-crossbred steers the same as in steers without Brahman influence. However, a consistent trend is apparent if individual breed evaluation studies are assessed collectively (Table 3). High endophyte infestation invariably reduced growth rates of Brahman-cross steers to a lesser degree than it did in steers without Brahman influence. Brahman genetics reduced the adverse effects of endophyte-infected tall fescue on steer growth by an average of 26% (range = 10 to 65%). The actual growth rates of Brahman-cross steers on high endophyte pastures were equal to or greater than steers without Brahman influence that grazed low or noninfected pastures, with one exception for the quarter-blood Brahman steers (Goetsch et al., 1988; McMurphy et al., 1990; Cole et al., 2001). A summary of Table 3 leads to a reasonable conclusion that heat tolerant genetics, Brahman germplasm in particular, would be a useful animal management option to lessen the impact of fescue toxicosis in beef cattle herds.

Rectal temperatures were measured by McMurphy et al. (1990) and Cole et al. (2001). In both reports, Angus steers on high endophyte-infected tall fescue diets had elevated rectal temperatures at the end of the grazing period, whereas rectal temperatures Brahman × Angus steers were unaffected by diet. McMurphy and coworkers (1990) also noted that rectal temperatures in steers with lower Brahman influence, (i.e., Simmental × [Brahman × Angus]), did have elevated respiration rates on high endophyte fescue. Rectal temperatures were not affected by diet in any breed during cooler intermediate measurement periods between December and April, although breed × diet interactions showed the weight gain of Brahman × Angus to be less inhibited by high endophyte tall fescue during some of those same intermediate time intervals (McMurphy et al., 1990).

The studies cited in Table 3 encompass every month of the year, suggesting that the benefits of Brahman germplasm for reducing the problem of poor growth on endophyte-infected tall fescue may not be limited to the summer months. These

Table 3. Reduced post-weaning growth for *Bos taurus* and *Bos indicus*-crossbred steers fed tall fescue with high endophyte infection compared to low or no infection.

	Bos taurus		***Bos indicus* cross**	
Reference	**lb/d**	**%**	**lb/d**	**%**
Goetsch et al., 1988[a]	- 0.46	- 38	- 0.42	- 22
Goetsch et al., 1988[b]	- 0.20	- 16	- 0.09	- 06
McMurphy et al., 1990[c]	- 0.72	- 39	- 0.29	- 14
McMurphy et al., 1990[d]	- 0.72	- 39	- 0.44	- 26
Cole et al., 2001	- 0.55	- 86	- 0.26	- 21

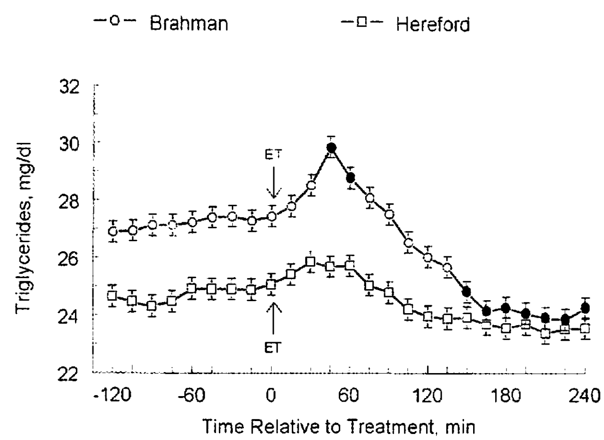
[a] Spring
[b] Fall
[c] *Bos indicus* cross = Brahman x Angus
[d] *Bos indicus* cross = Simmental x (Brahman x Angus)

reports led to work to assess the comparative responsiveness of Brahman to ergopeptides. In one experiment, fullblood Brahman and Hereford steers were similar in immediate cardiovascular and peripheral skin temperature responses to ergotamine administered intravenously (Browning, 2000). The same steers were observed for a slightly longer period of time in a second study of ergotamine treatment (Browning and Thompson, 2002). Over a four-hour period, Brahman steers appeared more sensitive than Hereford steers in terms of several hormones and metabolites (Figure 1). Most notable were the respiratory and thyroid hormone response in which ergotamine increased respiration rates and plasma triiodothyronine concentrations in the Hereford but not the Brahman (Browning and Thompson, 2002). The ergotamine studies involving Brahman steers and the data of Table 3 agree in suggesting that Brahman and their crosses differ in their responsiveness to ergot alkaloids when compared to cattle not carrying Brahman genetics.

Recent studies evaluated the performance of another heat-tolerant breed on endophyte-infected tall fescue (Table 4; Browning, 2002a,b). In one experiment, purebred Senepol and Hereford yearling steers were fed high endophyte-infected tall fescue or orchardgrass (hay + seed) from July to October. Both breeds showed clinical signs of heat stress when consuming tall fescue as respiration rates and time spent under the shade were increased by the fescue diet. The growth rate in Hereford steers dropped by 50% on tall fescue. Considering the heat stress exhibited by Senepol steers on fescue, it was remarkable that their 12-week weight gain was not significantly affected (Table 4). In a second experiment, the same Senepol and Hereford steers, as two-year-olds, were fed high endophyte-infected tall fescue or orchardgrass (hay) from mid-July to early September. In this second test, neither breed showed clinical signs of heat stress when consuming tall fescue. Respiration rates and time spent under the shade did not differ between the diets. Nevertheless, six-week weight gain in the Hereford steers was reduced by over 80% on tall fescue hay, whereas six-week weight gain in the Senepol steers was unaffected (Table 4). In both experiments, breed × diet interactions were clearly evident for daily weight gain. Two points should be noted regarding Senepol responses to fescue immediately after introduction of seed to the diets. First, yearling Senepol steers in Experiment 1 had reduced weight gain during the first month when the fescue seed and hay were introduced, although not as dramatic as seen in the Hereford steers. The Senepol compensated for lost early growth by the end of the four-month fescue toxicosis study. Second, seed was added to the diets of two-year-old steers after the conclusion of Experiment 2 for an additional six-week fall observation period and both breeds had a subsequent cessation of growth during that interval.

Research data on Senepol and Hereford cattle do not indicate that Senepol are resistant of fescue toxicosis. To the contrary, indicator traits in Experiment 1 distinctly show that tall fescue caused the Senepol steers to 'lose their cool' as they appeared heat stressed. Additionally, the growth rates of

Figure 1. Plasma triglyceride concentrations in Brahman (n = 7) and Hereford (n = 7) steers before and after i.v. treatment with ergotamine tartrate (ET). Minute 0 represents the time immediately before treatment. Breed × time affected ($P < 0.01$) triglyceride concentrations. Solid symbols (●, ■) represent post-treatment means within breed that differ from pretreatment means ($P < 0.01$). Ergotamine elicited a bi-phasic triglyceride response in Brahman, but did not significantly alter Hereford triglyceride levels. Divergent breed triglyceride responses to ergotamine agree with other plasma profiles for these steers (Browning and Thompson, 2002).



Senepol dropped immediately after introduction of fescue seed to the diet. Remember that ergot alkaloids are highly concentrated in the endophyte-infected tall fescue seed. Nevertheless, this work does suggest that Senepol are resilient under an endophytic fescue challenge. Basic physiological reasons for this expression in the Senepol steers are currently being investigated. There are a number of unique physiological characteristic of heat tolerance in cattle that may come into play, but an examination of these adaptive traits is beyond the scope of this discussion. What is germane to this discussion is the general conclusion drawn when the fescue toxicosis experiments involving Senepol purebreds is added to the body of information on Brahman crossbred steer responses to endophyte-infected tall fescue. The use of heat tolerant breeds does appear to be a viable animal management option for cattle managers to consider when developing strategies to overcome fescue toxicosis. Moreover, the benefits do not appear to be limited to the summer months.

One caveat to recommending the use of heat-tolerant cattle in breeding programs is that practically all of the fescue toxicosis research published to date involving tropically-adapted breeds has focused on post-weaning, stocker steers. These data could have some relevance for replacement heifer development. Comparable studies have not been published that indicate the potential benefits of heat-tolerant genetics for reducing the negative effects of fescue toxicosis on cow reproductive rates or preweaning calf growth. Fescue toxicosis research evaluating heat tolerant genetics for cow-calf production is needed. Additional studies of post-weaning cattle growth and behavior on high endophyte-infected tall fescue

Table 4. Thermoregulatory traits and weight gain for Hereford (H) and Senepol (S) steers fed endophyte-infected tall fescue (TF) or orchardgrass (OG).[a]

	HOG	HTF	SOG	STF
Experiment 1[b]				
Respiration Rate, breaths per minute	77 [f]	96 [d]	50 [g]	87 [e]
Daytime Shade Use, % of observations	53 [f]	91 [d]	5 [g]	77 [e]
Growth Rate, pound per day	1.28 [d]	0.64 [e]	1.22 [d]	1.16 [d]
Experiment 2[c]				
Respiration Rate, breaths per minute	83 [d]	88 [d]	46 [e]	52 [e]
Daytime Shade Use, % of observations	41 [d]	44 [d]	7 [e]	7 [e]
Growth Rate, pounds per day	1.12 [d]	0.20 [e]	1.25 [d]	1.22 [d]

a Adapted from Browning, 2002a,b.
b Yearling steers fed hay + seed diets from July to October.
c Two-year-old steers fed hay diets from July to September.
d,e,f,g Group averages with different letters within a row differ ($P < 0.01$).

that consider various purebred and crossbred presentations of heat-tolerant beef cattle genetics would also be useful.

Conclusion

Cattle performance is generally dependent on two primary factors: the production environment and the genetic composition of the animal. Tall fescue, as a forage widely used to provide nutrients to a large number of cattle, is a major environmental component of many beef production systems. Most tall fescue is infected with an endophyte that has adverse effects on cattle. Poor cattle well-being and performance on endophyte-infected tall fescue, independent of nutrient content, is usually a consequence of the condition known as fescue toxicosis. Fescue 'endophyte' toxicosis is probably a more appropriate term since it is the endophyte, not the fescue, that is primarily responsible for the condition. Cattle managers can address this economically significant problem by altering the environmental input through consideration of various forage management options.

Alternatively, cattle managers may consider dealing with the problem of fescue toxicosis through the manipulation of animal genetic composition. Evaluating and selecting animals, breeds, breed-crosses, or biological types that perform best in a particular production environment is not a new concept in the beef cattle industry. This report does highlight the potential to exploit beef cattle genetic diversity, especially through tropically-adapted cattle, as a means of enhancing cattle performance in a challenging production environment, the high endophyte-infected tall fescue pasture. Any genetic management decision-making process for beef cattle should, of course, include assessing the general merits of any breed or breed-cross for reproductive, growth and carcass traits, independent of tall fescue considerations. Beyond that, the use of tropically-adapted breeds shows promise as a management option to mitigate problems of fescue toxicosis and improve cattle performance. Additional experimentation will help to further explore the benefits of heat-tolerant bovine germplasm for beef cattle production on endophyte-infected tall fescue. Producers can assist in this endeavor by providing encouragement and support to researchers engaged in this effort and lobbying for additional resources to sustain and possibly expand fescue endophyte toxicosis research activities.

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Management Of Beef Production In Adverse Environments

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Introduction

Environmental adversity can affect beef production on many fronts. Climatic conditions that limit forage availability or place stress on livestock are only two of the more common aspects of environmental adversity. Extremes in either heat or cold and drought or flood affect many other aspects of the animal's environment including presence or absence of parasites and pests, forage composition and nutritional quality, and occurrence of toxic plants. Topography that demands athletic cattle or soils containing excessive or deficient minerals are other forms of environmental adversity. The Upper South and Lower Midwest may look like a very favorable environment to arid-country ranchers from the West, but the presence of endophyte-infected tall fescue in the majority of pastures throughout the region places tremendous stress on cattle grazing in this region. While a serious health and production challenge, fescue toxicosis is rarely ever fatal to cattle. Western ranchers on the other hand face the challenges of many species of toxic plants in their native rangeland that can be highly lethal and act very quickly leaving dead animals strewn over the range. The bottom line is beef production in almost every environment faces challenges on the bio-physical front.

Within any given set of challenges, we can make alternative choices for addressing those challenges. Historically, BIF has focused on genetic adaptation to meet production challenges. The positive benefits of selecting animals of an appropriate genetic makeup to meet the unique challenges of a particular environment cannot be overemphasized. In the long term, genetic adaptation is the first line of defense. Our second line of defense is management of the production system within the context of our environment. While fescue toxicity causes significant economic loss for cattle producers, there are fairly simple management strategies that can help offset the effects of the endophyte. By the same token, consumption of toxic plants on native range can be minimized through well-planned grazing management.

At this point, it is important to note the production environment includes not only the bio-physical characteristics of the environment but the economic and social climate as well. While this paper deals primarily with bio-physical issues of production management, we cannot overlook other challenges. The current trend among beef researchers and producers to identify economically relevant traits and establish criteria for comparisons clearly shows the need for economic relevance in our efforts. There are certain genetic traits that will likely always have economic relevance such as maintenance requirements and overall reproductive efficiency. Other traits may have only transitory economic relevance. It is important to focus our efforts on long term economic relevance. Social issues are becoming an increasing part of the production environment. Questions of animal well-being, multiple use of public lands, and wildlife interface will continue to increase in importance in our decision making over the foreseeable future. How we interact with our bio-physical environment will be tempered by these social issues.

Understanding the challenge

The first step in dealing with beef production in an adverse environment is understanding what the challenges are and what resources are at your disposal to assist you in meeting those challenges. It is easy to say that your farm is all infected fescue or that you ranch in dry country, but those are not the challenges. They are simply environmental conditions. Those same environmental conditions you view as challenges also provide advantages and opportunities. The production challenge is getting cows bred in a timely manner or keeping winter feed costs within some defined level of profitability. Growing yearling cattle on pasture is a similar situation. The challenge is maintaining acceptable rate of gain, not that you live in Arizona or Arkansas. For both the cow and the yearling in any environment, the challenge is maintaining adequate dietary intake while avoiding toxicity.

Getting cows bred in a timely manner is largely a nutritional issue and, in a grazing-based operation, depends on balancing nutritional demands with seasonal variation in forage availability and quality. The nutrient demand of a beef cow is very cyclic and seasonal in nature. Timing of the cycle is driven by when calving occurs and degree of fluctuation in nutrient demand is closely tied to the lactation potential of the cow. Prevailing weather conditions alter nutrient demands on a daily and seasonal basis, but weather-induced demands are also largely predictable based on historic weather patterns. Providing adequate energy cost effectively to support lactation and breeding efficiency is the challenge most cow-calf producers face.

From 1986 through 1993, we collected lactation data from the cow herd at the University of Missouri - Forage Systems Research Center. Lactation curves were determined for one group of cows calving between Feb 15 and March 15 with a mean calving date of March 1 and a second group calving from March 16 through April 15 with a mean calving date of March 26. Later calving cows reached peak lactation more quickly and achieved a higher peak lactation. We believe this response was due to fresh pasture becoming a part of the cow's diet earlier in the lactation period. Depending on milking ability of the cow, net energy demand increases from 30 to 100% over maintenance with the onset of lactation. This is equivalent to increasing stocking rate by those same percentages during the lactation period, placing increased demand on available feed and forage resources. In a cow-calf operation, timing of calving and control of forage supply are our primary means of bringing nutritional demand and forage supply into balance. This basic concept is fundamental to successful beef production in any environment. The more challenging the environment, the more critical establishing balance becomes.

Figure 1 illustrates the lactation curve for beef cows calving on March 1. The daily growth rate of pasture under typical management in north Missouri is also shown. Nutrient demand increases rapidly due to lactation and occurs well before pastures begin growing. Nutrients for the period from March 1 calving until mid-April are typically supplied from harvested forage or feedstuffs. The relative cost of providing energy from hay is generally two to four times greater than supplying energy from standing pasture. Calving March 1 or earlier places the animals highest nutrient demand occurring at the time when feed resources are most costly and quality is frequently the lowest. Pasture production later in the summer is fairly minimal on unimproved pastures resulting in cows losing weight until weaning. Body condition must then be returned to the cows following weaning, again relying on harvested forage.

The pasture growth curve in Figure 1 describes a tall fescue dominant pasture receiving 40 lb N/acre in spring and managed with a minimal 3-paddock rotation. This is the classic perception of cool-season grass growth, excess growth in the spring followed by pasture deficiency from mid-summer on. With late winter calving , the peaks in lactation and forage growth rate do come fairly close together but both before and after the lactation peak forage supply is poor. This same scenario is repeated across many environments all around the world. While pasture daily growth rate is much lower in arid rangeland than shown in this figure, the same pattern of a short season of rapid growth followed by little growth applies.

What can we do to bring animal demand and forage supply into better balance just through improved pasture management? The growth curve in Figure 2 illustrates a tall fescue-legume pasture managed with flexible rotational stocking with target grazing height of eight inches and post-grazing residual of three to four inches. Using a legume in the pasture provides greater summer forage production. Rotational grazing allows grazing to be initiated earlier in the spring and extend later into the fall, thus reducing the need for as many days of supplemental feed. By keeping calving date at March 1, the gap between increasing lactation demand and forage supply is reduced, but the requirement for supplemental feed is still there.

Delaying calving until mid-April minimizes the requirement for nutrients supplied through harvested forages or feedstuffs (Figure 3). While nutrient demand by the cow increases through the last several weeks of gestation, it is at a much slower rate than the lactation demand. Calving in mid-Spring should allow cows to both gain weight prior to calving as well as adequately meet their nutritional needs just from pasture. Research conducted by Adams et al (1996) in Nebraska has shown both economic and reproductive benefit for delaying calving even later.

Another consideration is that early calving requires the breeding season to begin while cows are either still on hay or have been only a few weeks on pasture. Cows are often slow to regain body condition prior to the breeding season in these situations resulting in extended anestrous and a strung out calving season. Cows calving in April or later can be on good quality pasture for two months prior to breeding season and can regain body condition and breed back in a much tighter season.

Figure 1. Lactation response of cows calving on March 1 and daily growth rate of minimally managed tall fescue pasture.

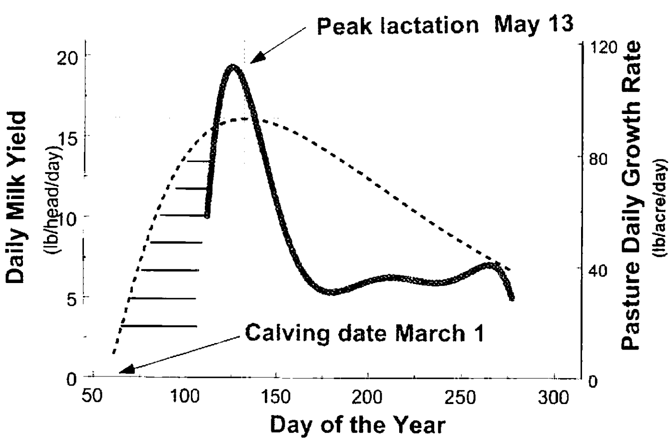
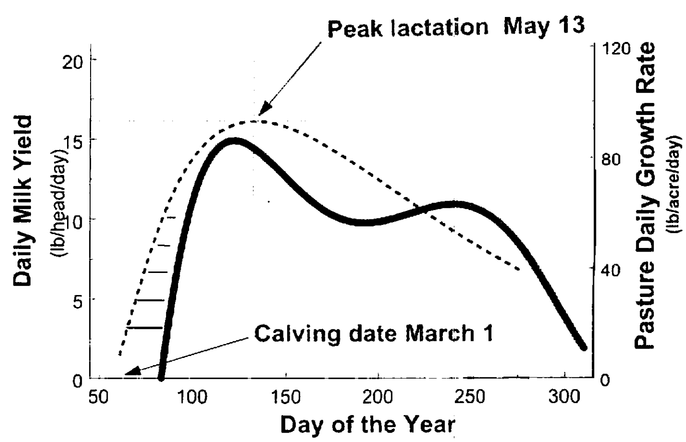


Figure 2. Improved pasture management including interseeded legumes and rotational grazing can reduce need for harvested forage even with early calving.



One major drawback of late spring calving in many parts of the country is that the corresponding breeding season occurs in the hottest part of the summer. Compound potential heat stress with fescue toxicity and the forage utilization benefits from later calving quickly evaporate. With fescue in the picture, animal type becomes increasingly important if considering spring calving with breeding occurring in mid-summer. Cattle with *Bos indicus* influence are more heat tolerant and may be less affected by fescue toxicity (Aiken & Brown, 1994;Brown et al 1997). Animals coming from a fescue-free, low humidity Western environment are much less tolerant of endophyte-infected fescue. Buying what are otherwise high quality bulls from large Western ranches and bringing them to the fescue environment is generally disastrous. By the same token, taking a well adapted fescue-developed bull to the Western range can be equally disastrous as the bull may not have the conformation and endurance to cope with 40-acre per cow rangeland.

The greatest challenge infected tall fescue places on the beef herd is getting cows bred for spring calving (Porter and Thompson, 1992). The main endophyte induced toxin in tall fescue is ergovaline which occurs primarily in seedheads, stems, and leaf sheaths. Some toxicity is present in leaf tissue but is at a much lower concentration than in other plant parts. As seedhead production occurs almost entirely in late spring, this is when fescue is most toxic. With increasing ambient temperature and ergovaline concentration, grazing animals become heat stressed and forage intake is depressed just when nutrient demand is greatest. The first production function to fail when nutritional stress occurs is reproduction. One of the quickest ways to overcome fescue toxicity in a breeding herd is to switch to fall calving. Fall pasture tends to be mostly leaf material so ergovaline content is lower and ambient temperatures are cooler resulting in much less stress on the animal. Breeding occurs mainly in December so heat stress is rarely a problem.

While fall calving significantly reduces the effects of fescue toxicity on breeding, it completely misses the traditional grass growth curve for much of the US (Figure 4). Fall calving is considered by many producers to be far too expensive a program due to the need to provide peak lactation nutrition through harvested forage and concentrate feed. An important concept for cattle producers to understand is that the growing season and the grazing season are two completely different things. The more challenging the production environment or the shorter the growing season, the more important this concept becomes for breeding operations. Stockpiling perennial forages for grazing in the dormant season is a proven management practice for both rangeland and tame pasture environments (Allen et al, 1992). In warm-season rangeland environments, protein supplementation is essential for ruminant livestock to be able to utilize low protein, high fiber range grasses even for maintenance (Lardy et al, 1999). For dry cows, daily cost of standing range even with protein supplement is still considerably cheaper than feeding harvested forage but is unlikely to meet the needs of lactating fall-calving cows. In the cool-season forage environment, especially with tall fescue, protein content rarely drops below the required level for even lactating cows. Energy content is more likely to become limiting, but with proper stockpiling procedures and appropriate grazing management, adequate net energy levels can be maintained throughout the winter to support both lactation and rebreeding. If energy supplementation is required, it usually comes at much lower cost than protein supplementation.

This discussion illustrates the importance of considering the total production system when planning herd structure and the management calendar. Altering the genetic base of the herd, timing of calving, and forage base all affect one another both bio-physically and economically. Fall calving is an economically viable solution for fescue-induced breeding problems only when combined with a low-cost winter forage sys-

Figure 3. Delaying calving to April 15 eliminates the gap between increased nutrient requirement due to lactation and forage supply.

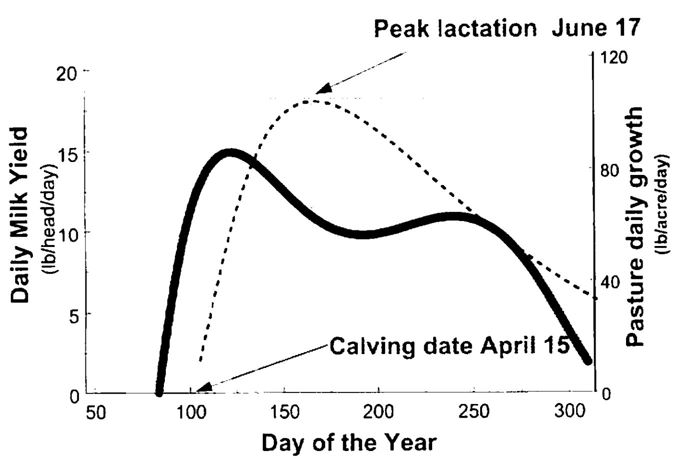
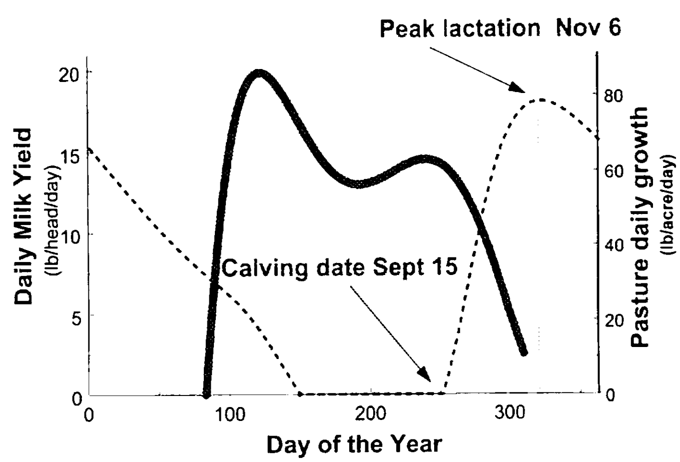


Figure 4. While fall calving reduces effects of fescue toxicity, it totally misses the grass growth curve in many regions



tem. Fortunately, tall fescue is the grass species best adapted to fall stockpiling and winter grazing. It grows more rapidly than any other cool-season species in late summer and autumn, it increases in energy content in response to shorter day length and cooler nights, and it withstands freezing damage better than any other cool-season grass species. So, even though we may first consider getting cows bred on endophyte infected tall fescue to be a challenge, it also provides the best opportunity for a low-cost winter grazing system that allows us to effectively breed cows at a time of year when fescue toxicity is a minimal problem. Similarly, the very aridity of the Western range which seems to be a challenge also virtually eliminates internal parasites as a management problem in mature cows.

Practical Management for Reducing Fescue Toxicity

Management of fescue pastures to reduce endophyte effects can be categorized as dilution, supplementation, avoidance, and replacement techniques. Most fescue graziers use a combination of these factors to deal with the fescue problem.

Interseeding red clover into endophyte-infected tall fescue has already been mentioned as a means of improving forage supply and distribution. This practice is beneficial for all cool-season grasses but is especially applicable with tall clover because of the toxin dilution that occurs when the animal is provided with a more diverse diet. Each bite of red clover effectively replaces a bite of toxic fescue thus reducing the daily ergovaline intake. Any other forage species, grass or legume, warm-season or cool-season, that can be grown in association with fescue is beneficial for reducing toxicity potential. Crabgrass oversown on fescue pastures is proving to be a very good combination for improving summer forage supply and reducing fescue toxicity.

Supplementation is actually another dilution technique but has the additional benefit of providing dietary energy in a form that results in lower rumen temperature and reduces some of the heat stress potential. Because dietary intake reduction is a main effect of fescue toxicosis, providing additional energy in a concentrated form offsets some of the intake reduction. Supplementation at 0.3 to 0.8 % of bodyweight is generally recommended for cattle on infected fescue pastures.

Establishment of alternative pastures to use at the times of greatest fescue toxicity potential is the avoidance process. Often referred to as complementary grazing systems, use of warm-season species from May through August removes livestock from fescue pastures during their most toxic period. In the Midwest, native tall grasses such as big bluestem. Indiangrass, switchgrass, and eastern gama grass are the most common alternatives. In the Upper South, bermudagrass, Old World bluestems, as well as the native species are commonly used. Summer annuals such as crabgrass, millets, and sudangrass can also be used as complementary forages. Summer annuals are especially useful for alternative forage if infected pastures are being renovated.

The final pasture management strategy for dealing with endophyte-infected tall fescue is to eradicate it and replace it with some other pasture species. The feasibility of renovating many fields that are predominantly infected tall fescue may be challenged by topography, soil conditions, or location. These fields are best managed through the options described above. Fields that can be legitimately tilled and cropped or be accessed by sprayer and no-till drill should be given serious consideration for pasture conversion. Endophyte-free fescue varieties have been available for many years but have had disappointing performance in many parts of the country. The endophyte exists in tall fescue for a reason and that reason is improved plant persistence. Chemical compounds generated by or in response to the presence of the endophyte provide the host plant with enhanced insect, disease, and drought resistance. Removal of the endophyte from tall fescue removed these beneficial attributes as well as animal toxicity. Endophyte-free cultivars have performed acceptably north of a line approximated by Interstate Highway 70. They have performed reasonably well south of this line on soils with higher organic matter content and with rotational grazing management. In recent years a new class of tall fescue cultivars has entered the arena: novel or friendly endophyte varieties. These cultivars have an endophytic fungus reintroduced that will provide the protective benefits without animal toxicity. South of the I-70 line, novel endophyte cultivars are probably the better choice. While some producers may have such ill feelings toward fescue that they wish only to plant something entirely different, tall fescue has so many desirable attributes as a pasture species it should be included in most pasture programs throughout the region.

Many producers are intimidated by the cost of complete pasture conversion, especially in light of the current high price of novel endophyte cultivars. The lost production and performance attributable to endophyte toxicity is far more costly than pasture renovation. In the mid-1980's, Dr. Vic Jacobs, University of Missouri economist, clearly showed the cost effectiveness of converting infected fescue to endophyte-free cultivar even with persistence as short as three years.

In addition to pasture management to deal with the fescue problem, animal selection for tolerance to fescue is extremely important. Within any beef cow herd on toxic fescue, we see varying levels of toxicosis. While some animals are completely debilitated on fescue pastures, there will be herd mates who show very little effect. Over time, simply culling the most susceptible animals and keeping replacements only out of those least affected will increase the fescue tolerance of the herd. This is especially true for those herds that do not use supplemental feed to overcome toxicosis as it tends to mask genetic traits. Many cow-calf producers end up with a six month breeding season on infected fescue because they are afraid of having open cows. To create a cow herd with fescue tolerance it is essential to maintain a tightly controlled breeding season of 45 to 60 days. Yes, you will have open cows the first several years but you will also rapidly eliminate the genetics most susceptible to fescue toxicity.

Summary

Successful beef production in adverse environments comes first from understanding the challenges. For cow-calf production the most critical issue is maintaining dietary intake to ensure reproductive success. Fescue toxicosis places tremendous physiological stress on the animal resulting in reduced intake. Ruthless selection against fescue toxicity and maintaining a tight breeding season can significantly improve genetic adaptation for fescue tolerance. Sound pasture management to reduce the amount of fescue in the pasture and provide alternative grazing choices can greatly reduce the impact of endophyte infection of animal performance and herd profitability.

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Traits to Dollars—What Will the Target Be?

PM Beef Group

Jim Norwood

Background

PM Beef Group, a privately held company, was founded 10 years ago in partnership with Ukrop's Supermarkets (Richmond, VA) to deliver a more consistent product to the retail case. A packing plant was purchased in Windom, MN and a fabrication plant was added in Hartley, IA. As the company moved into case ready meats, a central cutting facility was established in Richmond, VA. Feedlots were certified in MN, IA, NE, SD & IL. In addition to Ukrop's, Heinen's Fine Foods (Cleveland, OH) also markets PM's Ranch to Retail™ beef under their own brand name. Approximately 35,000 head of finished steers and heifers are marketed each year in the Ranch to Retail™ program. PM also harvests cattle for other programs including: Zalman's Glatt Kosher Beef™, Preferred Stock™, Amana Beef™, & Shenson. Nearly 75% of PM's production is branded.

Current Climate

From a customer survey conducted by Ukrop's, the following attributes were identified as important to meat purchasing.

Attribute	Extremely Important	Very Important
Food Safety	86%	9%
Quality of Meat	78%	19%
USDA Inspection	79%	13%
Tenderness	69%	27%
Juiciness	63%	30%
Farm Fresh Taste	57%	27%
Price	45%	42%
Ease of Preparation	41%	42%
Local / Regional Brand	29%	41%
Organic	12%	24%

Source: Attracting Consumers to Locally Grown Products report, Oct. 2001

The consumer first and foremost wants safe food. Safe food covers many fronts today including: bacteria, antibiotics, pesticides BSE, etc. Secondly the consumer wants quality which they may define as appearance, taste, tenderness, packaging, leanness, "all natural", organic, source verified, etc. The tenderness issue is harder to solve. Grade alone doesn't provide assurance the product will be tender, as noted in the NCBA Tenderness Study. The study also found that 61% of consumers would buy more product if it was guaranteed tender. Another study by Supermarket News, March 18, 2002, stated: "90% of today's meat buyers would buy more fresh beef if they had product that met their quality expectations for tenderness, juiciness and freshness on a consistent basis, they said."

These trends require increased marketing sophistication and increased coordination, ultimately leading to source-verification and process-verification. PM's Ranch to Retail™ beef program has been source-verified and USDA Process-Verified for several years, and is designed to use the best practices to give the consumer the ultimate eating experience every time.

PM's Features Defining Quality

- All Natural – Residue-tested
- USDA Process Verified
- Source-Verified
- Guaranteed Tender
- Great Taste
- Great Product Appearance and Shelf-life
- Outstanding Yields – perfect for case ready system
- Safety Conscience

Source-verification is a means to the end, not the end. Quality is affected long before cattle move to a processing point. There is no silver bullet that allows a system to deliver tender, great tasting, and safe beef to the consumer. Source-verification is a tool to accomplish the task and Process-Verification is the quality system to back it up. Together, they allowed PM to:

- Eliminate certain breeds
- Standardize cattle types
- Feed Vitamin E
- Standardize feeding plans
- Eliminate injection site blemishes
- Document the entire health history
- Limit animal age
- Provide traceability all the way through the system
- Standardize portion sizing with carcass specs
- Establish guidelines for product aging

USDA Process-Verification is an ISO 9002 quality system model that establishes targets and standardizes practices. There is a verification system that measures compliance to the pre-set standards. It includes complete sharing of data with producers, feeders and customers. Performance is benchmarked and preventative methods are developed. Finally, it is audited by the USDA to provide credibility. A 2002 study by Southeastern Research Institute found that 76% of the respondents (consumers) would pay a higher price for USDA Process-Verification.

Ukrop's and Heinen's both market the beef under their own label – Ukrop's Own Beef and Heinen's Own Beef. Because both retailers are partners in the quality system, they are able to make claims about "their ranchers", "their feeders", "Midwest corn fed" and that "the meat is hand selected according to their specifications". They have developed relationships with the PM producers and feature them in company promotional material.

The following are quotes derived from a focus group of Ukrop's customers:

> "I think Ukrop's Own Beef is more consistent"
>
> "With Ukrop's Own Beef, I have found a more consistent quality. I can trust that when I pull that steak out, its going to be more tender"
>
> "Very tender"
>
> "The first time I cooked it I was amazed, I said to my wife, 'Look! There's no grease in the pan'"
>
> "At Ukrop's even the lean beef is very tender, like prime used to be, and it used to be full of fat. This is lean that Ukrop's carries and it's still tender!"
>
> *Source: Southeastern instate of Research, 1998 Ukrop's Supermarket Focus Group Research*

Producer Application

What does all this mean to producers?

- Increased Accountability – Food safety is at the top of the list.
- Increased use of technology – Animal identification, databases, gene markers
- Decreased room for outliers – for a range of specifications from animal age and handling to yield grade attributes.
- Need for more data analysis....sort through the reams of accumulated data.
- Increased understanding of all segments.
- Understanding of your optimal operational practices and determine best marketing fit.
- BQA enhancements

After you determine your marketing fit:

- Increase your consistency around the bulls-eye!
- Decrease Outliers!
- Know the details behind your carcass data, USDA Yield grade and USDA Quality Grade isn't enough.

We picked two individual steers from our data base. Both were USDA Yield Grade 2 and USDA Quality Grade Select. Both carcasses were tracked through to the box and individual cuts were weighed as was the bone and fat. The difference in Box Value was $85.31. The difference is in the details (the 841# carcass was worth $85.31 more):

Carcass Weight	838#	841#
Rib Eye Area	12.6	14.8
Back Fat	0.2	0.3
Sub Total % Yield on Subprimals	52%	55%
Fat & Bone Weight	188#	181#

Conclusion

As processors are able to follow individual animals through the fabrication (boxed beef) plant, new methods of cattle value and payment will evolve. What can you do now to be ready to be paid on Boxed Beef Yield? The following are adapted from PM's targets for the Ranch to Retail™ program and our best answer to "What will the target be?"

- British/Continental Cross
- 1200 to 1300 pound finished weight
- Heavy muscled, less bone, less external and seam fat
- USDA High Select to USDA Low Choice marbling score
- Less than 0.4 back fat
- No USDA Standards, no rib eyes less than 12" or larger than 16", no back fat greater than 0.6, no carcasses weighing under 700 lbs. or more than 900 lbs.

Excel Corporation

H. Glen Dolezal, Ph.D.

Branded beef programs are key to leading the beef industry out of the commodity business. Brands must "deliver on a promise" to consumers with specific interests and needs. These promises can include various combinations of attributes for eating quality, leanness, diet/health, or convenience. Historically, branded beef programs have focused on breed strengths (marbling, palatability, leanness). Today, greater emphasis is placed on tenderness, leanness, portion size, and price point for retail, food service, and export markets.

Two primary paths for branding beyond commodity beef exist today (Table 1). One is based on the qualitative (marbling-based) approach with pre- and post-harvest management components such as process verification and postmortem technologies to achieve tenderness. The other is more quantitative and is a carry-over from the pork industry where enhancement technology has become the norm.

Several traits are equally important regardless of the path chosen for branded beef. Effective food safety interventions and control of injection sites are critical. Control of carcass (product) weight and ribeye size (steak thickness and price point) are equally important due to the historical portion size and dimension requirements in food service and the increased interest in case-ready packaging at retail.

A primary difference in the Qualitative versus the Quantitative approach is the emphasis placed on marbling deposition. Premium brands depend on adequate marbling deposition to ensure tenderness, juiciness, and flavor with proper

Table 1. Paths to branded beef.

Trait	Quality	Quantity
Market	Premium	Commodity
Beef	Upscale	Enhanced
Key Ingredient(s)	Marbling Based	Marinated, Water Added
Food Safety	+++	+++
Injection Sites	+++	+++
Animal Age	+++	+
Control Weight	++	++
Muscling (Ribeye Size)	++	++
Yield Grade	++	+++
Marbling	+++	o
Implant Program	Controlled	Aggressive
Producer Involvement	Critical	Unnecessary
Production Costs	+++	o

\+ emphasis placed on a particular trait.

aging. With enhanced beef, the quality is pumped in via postmortem technology.

Qualitative Approach

Producer involvement is critically important to select proper genetics and management strategies to produce quality products with acceptable red meat yield at a youthful age. Vertical coordination is necessary to meet expectations for time-on-feed, diet energy concentration, anabolic implant administration, and slaughter endpoint optimization. Value-based procurement programs have been developed to insure that consistent supplies of high quality beef are harvested to meet customer demands on a weekly basis. High quality products produced in this system must be marketed at a premium because production efficiency is seldom maximized. Postmortem technology may be used on carcasses with "small" and "slight" amounts of marbling to further improve the uniformity and consistency of tenderness for these natural (minimally processed) fresh beef products.

Quantitative Approach

Enhanced beef much like enhanced pork involves pumping muscles with a combination of water (8 to 12%), salt, phosphate, and natural flavorings. Therefore, enhanced beef is considered non-intact as the surface of muscles is penetrated to inject the solution. The enhancement process has a pronounced effect on the tenderness, juiciness and flavor of beef, especially at advanced degrees of doneness (medium well and well done). Leanness is key to maximize yields along with added water; marbling deposition is not necessary.

Production efficiency can be maximized and procurement needs may be satisfied in the open commodity market. Only time and additional research will reveal the extent to which enhancement technology expands in the beef marketplace. I personally feel that enhanced beef has a place for beef carcasses or cuts in need of palatability improvement (low quality grades and less tender locomotive muscles); however, additional consumer research is needed to better understand the level of acceptance by various consumer groups and industry segments.

Beef Improvement Federation Implications

The battle of branded beef strategies will influence the decision-making process for genetics, management, marketing, research, and education as we move to the future. I expect both brand strategies to survive, but only one will expand as the primary path for the beef industry to meet consumer expectations. If history holds true, then those of you designing programs to optimize production efficiency, product quality, and red meat yield should have the flexibility to participate in either brand strategy. If enhanced beef becomes the norm, then U.S. beef producers will have to redesign beef production more in line with models used currently in Europe and South America for beef and in the United States for pork.

Laura's Lean Beef

John Tobe, Chairman of the Board

Laura's Lean Beef Company helps grocery retailers achieve incremental sales of red meat by offering a healthy beef alternative to consumers who have cut back on red meat consumption. Laura's Lean Beef offers two major attributes that appeal to health-conscious consumers:

* Raised without antibiotics or growth hormones, Laura's Lean Beef appeals to consumers interested in natural foods.
* With 13 items certified by the American Heart Association, Laura's attracts consumers looking for low-fat, heart-healthy foods, including individuals on weight loss diets, those with high cholesterol or heart disease, and individuals who are generally interested in wellness.

Laura's Lean Beef is available in more than 1,000 grocery stores in 39 states.

Creekstone Farms

Joe Bill Meng – Director of Genetics and Supply Development

Creekstone Farms Premium Black Angus Beef is a unique program relative to other niche market programs. John Stewart, founder and president of Creekstone Farms has over thirty years experience in the meats business. Mr. Stewart identified the opportunity for this market and began developing the concept in the mid 90's. Following the identification of the market, the systems to create the product for this market were developed.

The concept was built around a goat of supplying food service, retail and export markets with a consistent, high quality Angus based product. The foundation for the program began with the development of superior genetics in the Creekstone Angus herd and the identification of existing genetics from other like-minded programs. These genetics were to be complimented with a uniform management system designed to maximize the health and performance of the animal. Protocol at every stage of the animal's life is based on the soundest and best scientific knowledge available. The intent is to identify producers, both purebred and commercial, feedyards and processors who are willing to adopt this protocol and partner with them. In many cases, partners were available that were already utilizing the practices we wished to incorporate. Animal welfare, bio-security and food safety all receive major emphasis.

The centerpiece for Creekstone Farms is 1200 acres of rolling grassland located in Henry Co., Kentucky. The farms is used to develop and market genetics, develop live animal protocol and expose our retail and food service customers to the live animal piece of the operation. Operations for Creekstone are located in Thornton, CO.

Before the first animal was harvested in April, 2001, markets had been identified and developed that would utilize the entire carcass and provide the opportunity to add value to each cut, rather than expecting the middle meats to carry the burden of offsetting the added costs involved with an integrated program. We understood that all phases of the production process had to function properly in order to achieve the desired end product; however, the size of our program made it difficult to have the leverage we needed at the harvesting and fabrication level. When we began working with Future Beef we knew that we had found a partner that appreciated our goals, and the Arkansas City, KS state-of-the-art facility was able to give our raw product the attention it needed in terms of processing, food safety and packaging, to enable us to deliver the product to our customer we had envisioned.

The misfortunes of Future Beef have been well documented, but Creekstone appreciated the cooperation and talent they provided when we were harvesting cattle in their facility. As fate would have it, we were successful in acquiring their Arkansas city facility and now are faced with an expanded set of opportunities and challenges.

At Creekstone, we feel more confident than ever that our direction is correct and we are realistically optimistic about the future of the beef industry. We look forward to working with the progressive programs and people in all phases of this industry and have faith in their support organizations and their leadership. We feel, that with all segments of the industry will work together in a spirit of cooperation and unity, there is opportunity to grow beef's market share and enhance profit opportunities at all levels.

Tools for Making Genetic Change

Tom Field, PhD, Colorado State University

Introduction

Imagine a carpenter who determines which tools to use before actually deciding what is to be built. Such a person would not likely find much success. Not every job requires a hammer, a saw, or a drill. So it is with the beef industry – lots of tools are available but not all are appropriate for the multitude of production scenarios. Thus a discussion of which genetic tools are most useful must be preceded by a determination of which goals ought to be pursued.

As a sidebar, it is probably useful to examine the use of the term "genetic change". A more appropriate term might be "genetic correction" or "genetic modification" implying that change directed towards a useful purpose is much more valuable in the long term than is the process of generating change for its own sake.

A reasonable goal for the beef industry is to "produce low-cost, high-profit cattle that yield competitively priced, highly palatable, lean products; while conserving and improving the resources utilized" (Field and Taylor, 2002). Yet the achievement of such a broadly stated objective should be examined in light of the very real conditions of the U.S. beef industry.

The implementation of genetic tools and strategies falls to the cow-calf producer who is challenged by the responsibility of maintaining a cow herd well suited to the conditions of a particular ranch as well as the production of feeder cattle that meet the goals and criteria of the other links of the beef production chain. Thus the goals of individual cow-calf enterprises must take into account trends in the consumer marketplace as well as dealing with the realities of the production environment.

The consumer

In regards to the consumer market there are four primary trends of interest.

1. Nearly 80 percent of the more than 7 billion servings of beef in the foodservice sector are delivered in the form of hamburgers or some other ground beef entrée (NCBA, 2000).
2. Consolidation in the grocery business is such that the top 5 grocery chains control more than 50% of retail sales (Supermarket News, 2003) with Wal-Mart as the driving competitive force.
3. Case-ready beef is another trend that will impact market specifications and thus the decisions of cow-calf producers.
4. The growth in the branded beef market has created more demand for cattle that meet specific criteria particularly in regards to palatability. Properly developed branded product strategies offer opportunities to sell more beef at higher prices. New beef product offerings have totaled more than 1,500 over the past five years.

The collective pressure from these trends has changed the way cattle are marketed in the United States with greater than 50% of cattle sales occurring on a forward priced or grid-based system. These trends equate to more attention on retail product yield (increased muscularity and reduced fat). Those programs that emphasize marbling will continue to have an impact on the industry but given the level of ground beef consumption in the U.S., demand growth for highly marbled, whole muscle cuts is somewhat limited.

Structural challenges

The differing needs of the various segments of the beef industry must also be noted. The magnitude of the industry makes coordination of genetic decisions problematic. Table 1 outlines the participants and products generated by each segment.

The typical beef producer

It is important to be realistic about the average cow-calf enterprise – not everyone is willing or able to adopt the potential technologies, management protocols, or tools avail-

Table 1. Overview of the U.S. Beef Industry

Segment	Participants	Inventory/Products
Seedstock	120,000 breeders plus a handful of AI studs	Approx. 80 breeds with 10 breeds most critical and 5 providing about 60% of the genetics, yearling bulls, semen, some females.
Cow-calf	814,000 beef herds 97,500 dairy herds 90% of beef cow herds with < 100 head but controlling only 50% of inventory	33.1 million beef cows 9.1 million dairy cows 29 million feeder calves
Feedlot	1,800 feeding companies with >1000 hd capacity	14 million head bunk capacity 23 million fed cattle marketings
Packer	795 plants harvest steers and heifers 97% of production is boxed beef, 81% of harvest by top 4 firms, and almost 50% of purchases on a carcass basis	34.8 million head harvested 27.1 billion pounds of beef 758 lb average carcass weight

Source: Field and Taylor, 2002

able to them (Table 2). As the NAHMS (1997, 1998) data points out, about two-thirds of cow-calf enterprises are secondary income sources. As such these typically smaller production units may have dramatically different needs than the professional cattle producer who derives the vast majority of their revenue from beef production.

Table 2. Characteristics of U.S. beef cattle enterprises

- 69% of cow-calf enterprises are in place as secondary income sources.
- 49.1% of individual beef cattle enterprises utilize individual calf identification (64.7% of the calves).
- 53.2% of enterprises record individual cow identification (69.8% of the cows).
- No form of identification is applied to 35% and 30% of the total calves and cows respectively.
- 34% of beef cattle herds are routinely pregnancy checked.
- 23% of beef cattle managers observe and record body condition scores.
- Approximately 1/5 of the cowherd is straight bred, 45% are F1s, and about a third result from a three-breed cross.
- Just over 10% of beef cattle enterprises utilize artificial insemination on any part of their herd.
- Only about one-half of producers report establishing a breeding season of specific duration.
- Nearly 80 percent of cattle enterprises rely on handwritten record keeping systems.

Source: NAHMS, 1997 and 1998

Table 2 points out that beef producers do not uniformly adopt even the most rudimentary technologies and best management practices. The reasons for non-adoption range from cost to lack of knowledge to tradition. Nonetheless, any discussion of genetic tools must be assessed with an awareness of the resistance to adoption that will likely be encountered.

The keys to widespread adoption of new technologies are two-fold:

1. They must be **cost effective** by returning clearly identified benefits beyond direct and indirect costs.
2. The technology **must** be user friendly.

Cost effectiveness

At last year's BIF conference, Barry Dunn (2002) made a strong case for evaluating profitability as a series of relationships that include productivity levels, market value of production, annual costs associated with production, and the investment required to maintain productive capacity. Most, if not all, of these relationships are either directly or indirectly affected by genetic influence. Yet, almost none of the current genetic tools available in the industry are reported in terms directly related to profitability.

For example, the use of ultrasound or genetic markers as selection tools for changing carcass traits are in vogue. However, it is extremely difficult to determine how much selection differential is required in intramuscular fat EPDs to actually change the profitability of a cattle cow-calf enterprise. This is particularly worrisome given the high cost of technologies used to estimate carcass traits in live animals – approximately $15 per head for ultrasound and $80 for a two-marker test. Don't assume that I am suggesting that there is no value in these technologies but that there is considerable confusion about how to use the results to improve return on assets.

Simplicity has a high value on most cow-calf enterprises. Any technology that betrays the premise of simplicity must have an easily recognizable high net value to the enterprise if it is to be integrated into the business. Given this fact, most genetic technologies will have to be initiated by the seedstock sector and the benefits then transferred to the commercial cow-calf sector via bull transactions. However, the real benefit of these technologies must translate into value for the commercial cow-calf enterprise if demand is to be sustained.

Genetic tools

In essence there are by my estimation three primary genetic tools available to the cow-calf producer – **selection pressure, breed differences, and mating systems**. This should come as no surprise to serious cattle breeders.

Don Scheifelbein (2003) advances the idea of "five undeniable truths of the beef business" and these principles make a good foundation for a discussion about genetic tools:

1. The success of commercial cow-calf producers is the foundation of any breed's longevity.
2. One breed cannot do it all.
3. Crossbred cows are essential for maximum financial success (longevity alone is worth the effort of creating them).
4. Uniformity and consistency drives producer success (manage breed composition to achieve this goal).
5. Simplicity is the key to success.

Dunn's argument for measuring return on assets as a function of the interaction of several factors leads to the notion that genetic influences should be evaluated in terms of how much is produced, what it costs to produce it, and the market value of what is produced. The major factors affecting the volume of production is weight per animal and total number of animals. The traits of interest then would most likely be as follows:

Volume of production (per animal):

Market weight (offspring plus culled breeding animals)

Units of production (per enterprise):

Reproductive rate
Calf survival
Cow survival

The driving force continues to be weight. For example, take a look at changes in the trigger point for incurring discounts for heavy weight carcasses. Many packers are accepting carcass weights up to 1,000 pounds without discount. While the advent of grid pricing has been a useful way of communicating desired carcass trait specifications throughout the industry, weight still drives the gross value of a carcass. Table 3 illustrates that heavy carcasses receiving lower prices can still generate more gross revenue than a higher-priced, but lighter, carcass.

The market signal that has favored weight was clearly interpreted by the industry. Research results from MARC point out in most cases the average birth weight and growth breed performance has increased while differences between breeds have declined (Table 4).

The traits that impact cost of production include maintenance costs (mature weight, milk production), cow longevity, calving difficulty, fleshing ability, feed efficiency, and the convenience traits such as disposition, pigmentation, and horned vs. polled.

The traits that impact the market value of production include retail yield, marbling, and conformance to specifications such as carcass weight (avoidance of outliers).

A cow-calf producer must evaluate how production, market value, and cost of production interact within their own system to determine which traits directly or indirectly impact profitability (Table 5). Some traits will respond to selection pressure while others will be more responsive as a result of generating heterosis via planned mating systems.

Two of the challenges facing producers include 1) measuring directly for the economically relevant trait versus having to rely on indicator traits and, 2) antagonisms between traits. Many of the traits of particular interest cannot be directly selected for due to problems with ease of measurement or the lack of availability of selection tools for specific traits. Cow-calf producers are further challenged by the problems encountered when selection for changes in one trait has favorable impacts on productivity but unfavorable effects on cost of production. For example, increased levels of mature weight favorably impact the volume of product sold from the cull cow but may unfavorably impact the feed costs associated with maintaining the female during her productive life on the ranch.

Producers have at their disposal a partially complete set of tools to assist them in making effective within breed selection decisions. While the current list of EPD provide a basis for making selection decisions, too many of the traits are indicators of economically important traits as opposed to being direct measures. For example, scrotal circumference is an indicator of age of puberty. Furthermore, EPD are lacking for many of these important traits such as feed efficiency.

Ultimately, selection must be based on a multiple trait strategy (Tess, 2002). As more cow-calf producers choose to retain ownership of their cattle beyond weaning or decide to participate in integrated beef production arrangements, there is a growing need for more effective multiple trait selection strategies that encompass lifetime productivity. Balancing selection for traits important at the ranch, the feedlot, and the packing plant is crucial.

While within breed selection is a useful tool, maximum genetic benefit is typically obtained via the exploitation of breed differences and the creation of heterosis as a result of planned crossbreeding systems. While the convenience of a straight breeding system is attractive, such an approach prevents the use of hybrid vigor and breed complementarity. While these topics have been thoroughly dealt with in the historical literature, the following summary points are useful reminders.

- No one breed does all things well and no one breed is without weaknesses.
- Careful matching of breed strengths and weaknesses can yield optimal trait combinations.
- Hybrid vigor (heterosis) provides a buffer against environmental stress that allows crossbred animals to be more productive in some traits than the average of the parental breeds that originated the cross.
- The advantage of heterosis is greatest in reproductive performance, calf survival, and cow longevity. The advantage increases as the environmental conditions become harsher.
- Implementing an effective crossbreeding system requires thoughtful planning, may increase the intensity of management, and must account for the resource limitations of a particular farm or ranch.
- Crossbreeding is not a silver bullet and a poorly designed program may yield less than desirable results.

Table 3. Gross revenue for various carcass weights at differing prices.

	$106/ cwt	$104/ cwt	$102/ cwt	$100/ cwt	$98/ cwt	$96/ cwt
650 lb	$689	$676	$663	$650	$637	$624
700 lb	$742	$728	$714	$700	$686	$672
750 lb	$795	$780	$765	$750	$735	$720
800 lb	$848	$832	$816	$800	$784	$768
850 lb	$901	$884	$867	$850	$833	$816
900 lb	$954	$936	$918	$900	$882	$864

Table 4. Average birth weight and finished weight of breeds – 1970s vs. 1990s.

	Birth weight	Birth weight	Finished weight	Finished weight
Breed	1970s	1990s	1970s	1990s
Hereford	79	90	1046	1363
Angus	79	84	1046	1375
Simmental	89	92	1141	1390
Gelbvieh	91	89	1115	1348
Limousin	92	89	1035	1308
Charolais	86	94	1143	1370

Source: MARC

Table 5. Heritability and heterosis of various traits and their impact on the components of cow-calf profitability.

Traits/trait classes	Heritability	Heterosis	Increases impact on cost	Increases impact on production	Increases impact on mkt. value
Market weight – offspring	40%	Moderate	Variable	Positive	Neutral
Market weight – culled breeders (mature size)	50%	Moderate	Variable	Positive	Neutral
Reproductive rate	<20%	High	Variable	Positive	Neutral
Survival rate - offspring	20%	High	Favorable	Positive	Neutral
Survival rate – parents	20%	High	Favorable	Positive	Neutral
Milk production	20%	Moderate	Variable	Positive	Neutral
Calving difficulty	15%	Moderate	Unfavorable	Negative	Neutral
Fleshing ability	40%	Moderate	Favorable	Variable	Variable
Feed efficiency	45%	Moderate	Favorable	Positive	Neutral
Convenience traits	Variable	Variable	Variable	Variable	Variable
Marbling	35%	Low	Neutral	Neutral	Positive
Retail yield	25%	Low	Neutral	Variable	Positive
Degree of conformance to specifications	Variable	Variable	Neutral	Neutral	Positive

Adapted from Field and Taylor, 2002

Why might a crossbreeding system fail? The late Bob DeBaca suggested four primary reasons:

1. Over-use of individual cattle breeds that have too much in them – too much milk, mature size, growth, or birth weight.
2. The mating system was too complicated or wasn't implemented in a systematic manner.
3. Seedstock providers failed to develop the expertise and service orientation to assist their clients in the development of effective crossing systems.
4. The use of poor quality bulls in a crossing system will not yield desirable results. The use of objective selection criteria is critical to the success of the mating system.

The choice of a mating system depends on a careful assessment of the environmental and market constraints associated with a particular ranch. Environmental considerations include forage availability, regularity of precipitation, feed costs, and the design of a grazing system that best utilizes and conserves the forage resources. The performance of progeny from the mating system should be appropriate for the desired market outlet. In a retained ownership setting a producer may want to emphasize cutability, marbling, and growth rate.

The logistics, benefits, and drawbacks associated with several crossbreeding systems are outlined in Table 6. The key summary points are that rotational crossing systems are excellent approaches to acquiring high levels of heterosis for pounds of calf weaned per cow exposed but they require multiple breeding pastures which may conflict with the grazing plan. Steer progeny from these systems may also tend to be more moderate in growth rate and retail yield. Thus, the flexibility of marketing may be reduced. Terminal crossing systems offer producers more options in the market place but they do intensify management requirements. Composite breeding systems produce less heterosis but may be more easily integrated into a grazing system. Numerous studies (Lamb and Tess, 1989, Lamb et al 1992 a and b, Tess and Kolstad, 2000) point out that crossbreeding systems improve net income from 11 to 19 percent as compared to straightbred systems.

The general targets in regards to carcass traits are 70% or better Choice, 70% Yield Grade 1 and 2, and 0% discounts for outliers. Table 7 illustrates the rationale for this recommendation. For most commercial cattle producers, the use of multiple breeds in a planned crossing system will be required to hit these targets. Cattle that are 50% British and 50% Continental breed influence are typically recommended as being best able to provide optimal levels of marbling and retail yield. In some instances, 75% British and 25% Continental may be most desirable when the target is weighted towards rewarding higher levels of marbling. It is important to remember the huge impact of weight on gross revenue and as such the use of Continental breed cattle should be seriously considered. For those environments where bos indicus cattle are required, the terminal sire may be a British breed bull.

The use of selection, breed differences and mating systems are of benefit to managers of commercial cow-calf enterprises. Deciding not to use one of these tools should be undertaken only with a detailed assessment of the value of lost opportunities. New approaches will surely be developed that enhance our ability to utilize these three tools. However, they will only be implemented if they are cost effective and user friendly.

Table 6. The Benefits and Drawbacks Associated With a Variety of Crossing Systems.

Mating Systems	Benefits	Requirements/Drawbacks
2-Breed Rotational	Weaning wt./cow exposed 16%	Minimum of 2 breeding pastures. Herd size of 50 or greater. Replacement heifers identified by sire breed. Generation-to-generation variation may be large. Management intensity—moderate.
3-Breed Rotational	Weaning wt./cow exposed 20%.	Minimum of 3 breeding pastures. Herd size of 75 or greater. Replacement heifers identified by sire breed. Generation-to-generation variation may be larger. Management intensity—high.
Rotation Terminal Sire (2-breed)	Weaning wt./cow exposed 21%. Target specific marketing goals.	Minimum of 3 breeding pastures. Herd size of 100 or greater. Replacement heifers identified by sire bred and year of birth. Management intensity—high.
Terminal SireX Purchased F1 Females	Weaning wt./cow exposed 21%. Average herd size. Target specific marketing goals.	Purchased females. Replacement heifers identified by source. Increased risk of disease. Management intensity—moderate.
4-Breed Composite	Weaning wt./cow exposed 17.5%. Minimum of 1 breeding pasture. Any herd size. Reduce inter-generational variation.	Availability may be limited. Genetic information (EPD) may be limited or lower in accuracy than from traditional bulls due to population size. Management intensity—low (after composite formation).
Composite-Terminal Sire	Weaning wt./cow exposed 21.0%. Minimum of 1 breeding pasture. Any herd size.	Availability of composite may be limited. Management intensity—moderate.

Table 7. Conformance of Various Breed Crosses and Composites to Yield and Quality Grade Targets in Steers Produced at the U.S. Meat Animal Research Center.

	MARC I[a]	MARC II[b]	British	Continental	MARC III[c]
= 70% Yield Grade (YG) 1 & 2	83.1	56.1	37.6	89.3	52.5
= 70% Quality Grade (QG) Ch & up	43.1	54.7	69.6	30.4	66.0
% Non-conform YG	16.9	33.9	62.4	10.7	47.5
% Non-conform QG	56.9	45.3	30.4	69.6	34.0
Deviation from acceptance Non-conform (30%)					
YG	0	3.9	32.4	0	17.5
QG	26.9	15.3	0.4	39.6	4.9
Total	**26.9**	**19.2**	**32.8**	**39.6**	**21.5**

a MARC I = ¼ Charolais, ¼ Limousin, ¼ Braunvieh, ⅛ Angus, ⅛ Hereford.

b MARC II = ¼ Gelbvieh, ¼ Simmental, ¼ Hereford, ¼ Angus.

c MARC III = ¼ Pinzgauer, ¼ Red Poll, ¼ Hereford, ¼ Angus.

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How Best to Achieve Genetic Change?

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Introduction

Genetic *change* is easy to achieve through selection. Selection typically leads to simultaneous change in a number of traits with not all traits changing in a favorable direction. Genetic *improvement* is much harder to achieve than genetic change. It requires the aggregate economic value of positive and negative changes in individual traits to be favorable, and greater than the costs of recording and evaluating animals.

Genetic improvement doesn't come about by chance. It doesn't come about from the act of pedigree and performance recording. It doesn't come about simply from the creation and distribution of sire summaries. Genetic improvement at an *enterprise* level comes about when those in a position to undertake selection have clear *goals* and access to relevant *tools*. Genetic improvement at *industry* level depends upon improvement at the *enterprise* level and relies further on *market signals* being transmitted along the lengthy and circuitous chain from the consumer through the packer, feedlot operator, backgrounder, cow-calf producer to the seedstock breeder.

It is easy to demonstrate genetic *change* has occurred in the beef cattle industry in recent years. Many sire summaries include graphs of genetic trends in individual traits such as weights at various age, scrotal circumference and calving ease. It is apparent there has been considerable emphasis on liveweight. Selection for liveweight has tended to: increase growth rates and weight at almost any age, including birth weight (with increased calving difficulty) and mature cow size (with increased maintenance feed costs) while reproductive performance has decreased. Unlike some other livestock industries the impact of these changes on profit is not immediately apparent, nor has it been repeatedly quantified and communicated. What has been the aggregate value of these changes on the cow-calf and other sectors? How does the value of these changes compare to the costs that were incurred in obtaining it? Who paid the costs and who were the greatest beneficiaries of these changes? A leading edge industry should know the answer to these questions.

Where have we gone wrong ?

One explanation for our current circumstances is that we have developed tools such as EPDs without an agreed *vision* for the nature, scope and responsibility for delivery in the *long term*. We have delivered EPDs in a knee-jerk fashion – first for weaning and yearling weight because data were easily collected. Later we added birth weight and then calving ease because selection for growth led to an increase in the incidence of difficult births. Then we added scrotal circumference to try (but fail) to arrest the decline in reproductive performance. Along the way we added other traits such as temperament, carcass and various ultrasonic measurements. We developed these evaluations because we knew how to do them, had the data and we failed to see the unintended consequences of selection on some of these characteristics because we did not have the time or the money to research them properly before their delivery to industry. The industry became the guinea pig and suffered some of the consequences of premature adoption. We concentrated on statistical problems in evaluation and in computational procedures for setting up and solving equations and did little to assist breeders and producers in quantifying the ramifications of using our evaluations in their selection. If we had our time over again, we would probably all make the same mistakes. But at CSU we have a vision to change some of this in the future. We will be heavily reliant on Federal funding support from the National Beef Cattle Evaluation Consortium. The degree to which the industry is ready to get behind and contribute to these efforts is also yet to be tested but we are motivated to try.

Current use of EPDs

Many producers have admitted using EPD systems to ensure that they do not unintentionally change various attributes of their animals while selecting for one or more traits they recognize as having particular importance. Pedigree and performance recording is a costly enterprise, and is largely a wasted investment if its main use is to avoid selection. No doubt, producers have been burnt in the past when selection for certain attributes has led to unintentional deterioration in other attributes.

What can we do better ?

Developing selection objectives. First, we need to remind ourselves that EPDs are a means to an end and not an end in themselves. A logical approach to animal improvement must begin with the goal, then the development of a breeding objective that reflects the list of traits that influence the goal and thereby identifies the characteristics which we need to measure on our animals. We don't want to think in the other direction (as we have in the past), starting with some characteristics we can measure, generating an EPD and then hoping its addition will make our toolkit more valuable. We want to design the tools we need for the job, rather than limit our job to the tools that happen to be available today.

There are few tools in existence that can assist a producer with a defined goal to identify their breeding objective. There are no such tools readily available for use in the US beef industry. Despite the existence of considerable knowledge of the economics of cow-calf operations, backgrounding systems, feedlot finishing and packing plants, none of this information is readily available in a format that will assist a producer in identifying the list of traits and/or their relative emphasis for use in a breeding program. We would like to change this. We have started this work in relation to researching some prototype "days to finish" EPDs. These EPDs reflect the fact that finishing costs are most closely related to the number of days an animal spends on feed, to reach some desired weight, fat or marbling endpoint. It appears that the value of particular weight, fat and marbling EPDs can vary notably depending upon the management of the cattle with respect to the finish endpoint.

Predict phenotypes rather than progeny differences (PDs). Consumers gain satisfaction from phenotypes, not EPDs. Decision makers are usually more comfortable interpreting phenotypic performance than interpreting EPDs. When we analyze pedigree and performance records, we obtain estimates of various effects, including effects of age, contemporary group and genetic effects. We have grown accustomed to using estimates of only two of these effects, namely direct and maternal breeding values, expressed as EPDs to communicate the results of our endeavors. The invention of EPDs was a clever discovery to communicate, for a particular trait, the effects of a sire in respect to the performance of his offspring. This works very well for the direct effect of a trait such as weaning or yearling weight but is more difficult to interpret for maternal characteristics or for some of the more recently developed "rate" traits such a heifer pregnancy or stayability. What would be more helpful, would be to use the knowledge of the effects from the mixed model analyses along with any other available knowledge to predict the phenotypic performance that will likely result from the use of particular sires in your herd with your production and management circumstances. Then this information will allow the ramifications and economic implications of the use of particular sires to be more readily assessed and taken into account by the breeding decision makers.

For example, suppose we select for a weight trait such as yearling weight. This is likely to result in a correlated increase in mature cow weight and in cow maintenance requirements. If we keep the size of our breeding cow herd constant, we have increased our total feed requirements. In a grazing scenario, if we had surplus feed available to support these larger cows we must have previously overlooked a management opportunity to increase cow numbers. Selection is a slow and inefficient method to make changes that could more quickly be achieved by changing management. If our stocking rate or carrying capacity was previously optimized, then it will be necessary to reduce cow numbers or introduce more supplementary feeds into the system in order to properly feed our improved herd without compromising the environment. Most breeders and producers are not in a position to readily determine the correlated response in mature weight following selection on yearling weight, nor can they easily determine the implications to annual or seasonal feed requirements. We should be taking advantage of the knowledge of other animal scientists, such as nutritionists, and incorporating their models in concert with our evaluation systems. Such plans are behind our drive for a maintenance EPD and the construction of days to finish EPDs.

As another example, consider the interpretation of stayability EPDs. Stayability relates to the proportion of first-calf heifers that are still present in the herd at age six. An average stayability is about 50%. A positive EPD for stayability reflects the presence of genes for an increased ability to repeatedly avoid voluntary and involuntary culling. A bull with an EPD for stayability of 5% is expected to have, on average, 5% more of his daughters still present in the herd at age six. Clearly a positive EPD is favorable and stayability is likely to have a significant impact on herd profit. But what are the actual ramifications of using a bull with a 5% EPD in your herd? What does such a "rate" EPD mean in terms of income and costs. If this question cannot be readily answered, how can one expect to rank animals for the combined effect of stayability and some other trait, such as liveweight or calving ease? Realistically, the interpretation of stayability relies on knowledge of the current herd age structure in order to determine the age structure at various times in the future as a result of using bulls with better or worse stayability EPD. The age structure will influence the average sale weight of the calf crop as cow age has a significant influence on weaning weight. The age structure will influence the annual requirement for replacements and the number of cull cows. The sensible approach to assessing the impact of stayability is achieved through the use of a computer-based decision support tool that allows the user to view the age structure of their herd and the likely (phenotypic) inputs (eg feed requirements) and outputs (eg sale animals) that are expected on an annual basis. Such a decision support tool should preferably be delivered via the world-wide web.

Web delivery. Web delivery of decision support tools will enable transparent on-line access to sire summaries and customization of the information that is displayed from those summaries. With an ever-increasing list of EPDs, it makes no sense to overwhelm the bull breeder or bull buyer with this information. The information age should make bull selection easier, not more difficult. A tiered system of information delivery should allow the user to focus on the traits of most interest to them, but still allow access to any other supporting information available on an individual.

Web delivery facilitates the prototyping of new EPDs and can speed up the rate at which these are rolled out to the industry. Some of the new EPDs can be presented in many different ways and it requires some degree of trial and error to identify the approach that make the most sense to users. Some producers may find value in calculating functions of EPDs, for example, calculating a postweaning gain EPD from the difference between the yearling weight and the weaning weight EPD. A maintenance energy EPD could be calculated as a function of various weight and condition score EPDs. An economic index of two or more EPDs can be obtained by multiplying each EPD by its relative economic value. All of these operations are difficult to achieve using paper-based sire summaries, but are straight forward on a web-based delivery system.

Web delivery allows graphical methods of displaying EPD information. It is very difficult to rapidly inspect a variety of numerical values from a published table but the same information displayed in bars or some other graphical form can be quickly interpreted.

One of the recently popularized approaches for analyzing longitudinal data such as weights taken at various stages of life is by random regression. This procedure has the advantage that weights from any age can be included in analyses and improve the accuracy of predicting weights at other ages. Furthermore, the solutions can be used to predict the weight of an animal at any arbitrary age, or the model can be fit in a manner that enables prediction of the number of days an animal will take to reach a particular finish endpoint. This approach might generate far too many EPDs to be published in printed form, but would provide ready customization for different users via an online web-based delivery system.

Most sire summaries and animal breeding courses go into some detail to discuss the interpretation of EPD accuracies. The calculations and formal interpretation of accuracy are not straightforward for the average user. Web delivery of EPDs allows visualization of EPD accuracy, for specific traits and/or specific bulls.

Account for breed and crossbred effects. Every animal breeding undergraduate class has been taught for many years that the performance of outcrosses between animals of different breeds will be influenced by heterotic effects as well as by the proportion of genes represented from each of the breeds. Numerous studies have been undertaken in recent decades to determine breed and heterosis effects, for example the successive phases of the MARC germplasm evaluations. In order to predict the future performance of any such crosses, it is necessary to add the breed effects, heterosis and relevant EPDs for each trait of interest. Notwithstanding the difficulties of breed by environment interaction in extrapolating results to your own herd, there are currently no readily available decision support tools that combine the available information on selection and crossbreeding in a way that aids objective decision making.

Summary

Over the last three decades, breeders have been provided with better tools to describe the likely performance of offspring with respect to some attributes of their cattle. However, the scope of available tools is far short of existing scientific knowledge. An opportunity exists to capture current knowledge and make it more accessible to decision makers in the context of selection. This includes knowledge relating to feed requirements, finishing characteristics, heterosis and breed effects (among others) in a production systems setting. Web delivery is critical to making such new tools available to bull breeders and bull buyers in a cost-effective manner. Colorado State University, along with some of its Center for Genetic Evaluation of Livestock (CGEL) clients and the National Beef Cattle Evaluation Consortium, has begun developing and implementing such a vision.

Emerging Technology

Craig Huffhines, Chair

Mapping the Bovine Genome; NAS and Department of Energy redirect funding from Human Genome Project to Bovine Genome.

Dr. Ronnie Green, National Program Leader-Food Animal Production USDA-ARS

What will mapping the genome mean to the industry.

Dr. Clare Gill Assistant Professor of Animal Genomic, Texas A&M University

Selection Decisions

Bob Weaber, Chair

Observed Response to Selection for Dickerson's Index of Yearling Weight and Birth Weight
Dr. Michael MacNeil, Research Geneticist, USDA Agricultural Research Service Fort Keogh Livestock & Range Research Lab, Miles City, Montana.

Genetic Evaluation of Carcass Data at Different Endpoints
Dr. Janice Rumph, Assistant Professor, Montana State University, Bozeman, Montana.

Breed Selection

Live Animal, Carcass, and Endpoint

Robert Williams, Chair

BIF Standardized Nomenclature
Lauren Hyde

Technology to streamline on farm data collection
Owen Boyes

Residual Feed Intake: Challenges and Opportunities
Denny Crews

Research on Days to Finish
Dorian Garrick

Genetic Prediction Committee

Larry Cundiff, Chair

Developing EPDs for Days to Finish
Mark Enns and Dorian Garrick, Colorado State University

Survey of World Wide Breed Evaluations
Hans Schild, ICAR

Across Breed EPDs
L. D. Van Vleck and L. V. Cundiff, USDA-MARC

Exploring Use of Dominance Effects in Genetic Prediction
Kath Donoghue, University of Georgia

Update on Carcass Merit Project
John Pollak, Cornell University

Across-breed EPD Tables for the Year 2003 Adjusted to Breed Differences for Birth Year Of 2001

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Introduction

This report is the year 2003 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 2001 base using EPDs from the most recent national cattle evaluations. Factors to adjust EPD of 17 breeds to a common birth year of 2001 were calculated and reported in Tables 1-3 for birth weight, weaning weight, and yearling weight and in Table 4 for 15 breeds for the MILK component of maternal weaning weight.

Changes from the 2002 update (Van Vleck and Cundiff, 2002) are as follows:

1. Records were added for the first time for 21 Brangus sires with 215 calves and for 20 Beefmaster sires with 205 calves at USMARC. Maternal information will not be available for two more years.
2. Braunvieh was added last year but two more (total of seven) sires with 52 calves (total now 188) were included this year. Those two sires also added about 50% more maternal records for the MILK analysis.
3. The EPDs of seven Hereford sires used in Cycles I and II of GPE which had not been reported last year were reported this year which added several hundred Hereford calves to the total compared with the year 2002 analyses.
4. Maternal data for Red Angus tripled from last year when maternal granddaughter performance first became available.
5. New data on maternal performance of females with Hereford, Angus, Simmental, Limousin, Charolais, and Gelbvieh sires added about 80 records of grandprogeny for each breed.

The across-breed table adjustments apply **only** to EPDs for most recent (in most cases; spring, 2003) 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 direct and maternal heterozygosity for MILK analysis and 100% of direct heterozygosity for 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 heterozygosity for the maternal analysis is required. Two approaches for accounting for differences in breed heterozygosity were tried which resulted in similar final table adjustments. One approach is to include level of heterozygosity in the statistical models which essentially adjusts to a basis of no heterozygosity. The other approach is 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 (1/4 each, Pinzgauer, Red Poll, Hereford, and Angus). 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 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 H-A cows from the diallel for estimates of direct heterosis from 1) and then estimate maternal heterosis effects from 3,116 weaning weight records of 750 daughters representing 166 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 1), and

4. Adjust all records used for analysis of MWWT for lack of both direct and maternal heterozygosity using estimates from 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 30.54 lb for BWT, WWT and YWT, respectively. The estimate of maternal heterosis was 23.44 lb for MWWT. As an example of step 3), birth weight of an H by H 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) (23.44) 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, 1998, 1999, 2000, 2001, 2002). All calculations were done with programs written in Fortran language with estimates of variance components, regression coefficients, and breed effects obtained with the MTDFREML package (Boldman et al., 1995). All breed solutions are reported as differences from Angus. The table values to add to within-breed EPDs are relative to Angus.

For completeness, the basic steps in the calculations will be repeated.

Models for Analysis of MARC Records

Fixed effects in the models for birth weight, weaning weight (205-d) and yearling weight (365-d) were: breed of sire (17), dam line (Hereford, Angus, MARC III composite) by sex (female, male) by age of dam (2, 3, 4, 5-9, $\geq$10 yr) combination (49), year of birth (21) of dam (1970-76, 86-90, 92-94 and 97-99, 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 have been used in 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, 4,248 for YWT). For estimation of variance components and to estimate breed of sire effects, sire of calf was also used as a random effect (591).

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 variance 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 analyses of maternal effects included breed of maternal grandsire (15), maternal granddam line (Hereford, Angus, MARC III), breed of natural service mating sire (16), sex of calf (2), birth year-GPE cycle-age of dam subclass (75), and mating sire breed by GPE cycle by age of dam subclass (40) with a covariate for day of year of birth. The subclasses are used to account for confounding of years, mating sire breeds, and ages of dams. Ages of dams were (2, 3, 4, 5-9, $\geq$10 yr). For estimation of variance components and estimation of breed of maternal grandsire effects, random effects were maternal grandsire (556) and dam (2,892 daughters of the maternal grandsires). 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 EPDs. The records from MARC are not included in calculation of within-breed EPD.

The basic calculations for BWT, WWT, and YWT are as follows:

MARC breed of sire solution 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 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 = 2001 for 2003 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 2003: 1.05, 0.83, 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 (milk) effect of the breed.

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

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

MARC breed of maternal grandsire solution 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 2003: 0.57 and 1.19),

$M(i) = M_i$ 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 2001 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 2001. These pairs of differences minus the corresponding differences in average EPD for animals born in 2001 result in the last column of the tables to be used as adjustments for pairs of within-breed EPD.

Birth Weight

The range in estimated breed of sire difference for BWT relative to Angus is large: from 1.5 lb for Red Angus to 9.5 lb for Charolais and 12.3 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. The trend seen in past years of the differences from Angus becoming smaller seems to have stopped. Differences from Angus were only slightly changed from the 2002 update but most of the changes were to slightly larger differences from Angus. The adjustments for heterosis were slightly smaller than last year for straightbred Angus calves and Angus sired calves from MARC III cows. Adjusted breed of sire effects for Brangus and Beefmaster were similar to the averages for their founder breeds and were intermediate between Angus and Brahman.

Suppose the EPD for birth weight for a Charolais bull is +2.0 (which is above the year 2001 average of 1.5 for Charolais) and for a Hereford bull is also +2.0 (which is below the year 2001 average of 3.8 for Herefords). Then the adjusted EPD for the Charolais bull is 10.5 + 2.0 = 12.5 and for the Hereford bull is 3.3 + 2.0 = 5.3. The expected birth weight difference when both are mated to another breed of cow, e.g., Angus, would be 12.5 - 5.3 = 7.2 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 2002 and 2003 updates were about 2 lb or less except for Hereford (+3.0 partly due to the seven bulls not reported in 2002) and Braunvieh (+4.2) due to the weaning weights of the two 2new2 Braunvieh sires when compared with Angus sired calves. Brangus and Beefmaster sire breed effects adjusted to a 2001 base were almost exactly the weighted averages of their founder breeds. All except three sire breed means for WWT adjusted to year of birth of 2001 are within about 10 lb of the Angus mean.

Yearling Weight

Changes in adjusted differences from Angus from the 2002 update were relatively small. The major exception was for Braunvieh. Progeny of two 2new2 Braunvieh sires closed the difference from Angus from -56.5 to -42.5. The difference between Hereford and Angus was also smaller, probably due to including again this year the seven sires missing last year. These seven sires were reference sires that produced a relatively larger number of progeny in cycles I (1970-1972), II (1973-1974), III (1975-1976), and cycle IV (1986-1990) of the Germplasm Evaluation Program at MARC. Changes from last year of 4 to 5 lb for Pinzgauer and Tarentaise seem due primarily to the head-to-head comparison with Angus at MARC. Brangus and Beefmaster adjusted means for YWT, as with BWT and WWT, are close to the weighted average for their

Table 1. Breed of sire solutions from MARC, mean breed and MARC EPDs used to adjust for genetic trend to 2001 base and factors to adjust within breed EPDs to Angus equivalent - BIRTH WEIGHT (lb)

	Number		Raw MARC Mean	Ave. Base EPD		Breed Soln at MARC		Adjust to 2001 Base		Factor to adjust EPD to Angus
				Breed 2001	MARC Bulls	+ Ang	vs Ang	+ Ang	vs Ang	
	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hereford	113	1817	87	3.8	2.5	88	3.6	89	4.5	3.3
Angus	105	1421	84	2.6	2.2	84	0.0	84	0.0	0.0
Shorthorn	25	181	87	1.8	0.9	90	6.4	91	7.0	7.8
South Devon	15	153	80	0.0	-0.2	88	4.3	89	4.1	6.7
Brahman	40	589	98	1.9	0.7	96	11.6	97	12.3	13.0
Simmental	48	623	87	3.1	2.8	91	7.0	91	6.9	6.4
Limousin	40	589	83	1.3	-0.5	87	3.0	89	4.5	5.8
Charolais	75	675	89	1.5	0.5	93	8.8	94	9.4	10.5
Maine-Anjou	18	218	94	3.2	6.0	95	10.6	92	7.2	6.6
Gelbvieh	48	595	89	1.4	1.0	88	4.2	89	4.1	5.3
Pinzgauer	16	435	84	-0.1	-0.4	89	5.2	89	5.0	7.7
Tarentaise	7	199	80	2.2	1.8	87	3.2	88	3.2	3.6
Salers	27	189	85	1.3	1.5	88	4.4	88	3.8	5.1
Red Angus	21	206	85	0.5	-0.7	85	0.6	86	1.5	3.6
Braunvieh	7	188	88	1.1	0.7	89	5.2	90	5.1	6.6
Brangus	21	215	91	2.0	2.4	90	5.9	90	5.1	5.7
Beefmaster	20	205	96	0.5	0.8	93	8.5	92	7.8	9.9

Calculations:
(4) = (5) + (1, Angus)
(6) = (4) + b[(2) - (3)] with b = 1.05
(7) = (6) - (6, Angus)
(8) = (7) - (7, Angus) - [(2) - (2, Angus)]

Table 2. Breed of sire solutions from MARC, mean breed and MARC EPDs used to adjust for genetic trend to 2001 base and factors to adjust within breed EPDs to Angus equivalent - WEANING WEIGHT (lb)

	Number		Raw MARC Mean	Ave. Base EPD		Breed Soln at MARC		Adjust to 2001 Base		Factor to adjust EPD to Angus
				Breed 2001	MARC Bulls	+ Ang	vs Ang	+ Ang	vs Ang	
Breed	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hereford	112	1712	503	34.0	22.8	501	-2.7	511	-2.4	-2.4
Angus	106	1315	504	34.0	23.2	504	0.0	513	0.0	0.0
Shorthorn	25	170	521	13.1	6.9	518	14.1	523	10.3	31.2
South Devon	15	134	443	16.2	0.2	503	-0.6	517	3.7	21.5
Brahman	40	509	532	15.1	4.7	520	16.1	529	15.8	34.7
Simmental	47	564	505	35.1	23.9	526	22.4	536	22.7	21.6
Limousin	40	533	477	12.4	-1.6	503	-0.8	515	1.9	23.5
Charolais	74	600	514	14.6	5.7	527	23.3	535	21.7	41.1
Maine-Anjou	18	197	459	16.2	23.4	519	15.1	513	0.1	17.9
Gelbvieh	48	559	507	36.0	30.5	518	14.3	523	9.9	7.9
Pinzgauer	16	415	478	0.6	-4.1	504	-0.1	508	-5.2	28.2
Tarentaise	7	191	476	12.0	-4.8	507	2.7	521	7.8	29.8
Salers	27	176	525	13.2	7.4	516	11.7	521	7.6	28.4
Red Angus	21	199	535	27.0	27.2	505	1.0	505	-8.2	-1.2
Braunvieh	7	183	451	6.3	6.7	516	12.0	516	2.6	30.3
Brangus	21	208	550	20.9	26.1	524	20.3	520	7.0	20.1
Beefmaster	22	215	563	6.1	14.2	530	26.3	524	10.6	38.5

Calculations:
(4) = (5) + (1, Angus)
(6) = (4) + b[(2) - (3)] with b = 0.83
(7) = (6) - (6, Angus)
(8) = (7) - (7, Angus) - [(2) - (2, Angus)]

Table 3. Breed of sire solutions from MARC, mean breed and MARC EPDs used to adjust for genetic trend to 2001 base and factors to adjust within breed EPDs to Angus equivalent--YEARLING WEIGHT (lb)

	Number		Raw MARC Mean	Ave. Base EPD		Breed Soln at MARC		Adjust to 2001 Base		Factor to adjust EPD to Angus
				Breed 2001	MARC Bulls	+ Ang	vs Ang	+ Ang	vs Ang	
Breed	Sires	Progeny	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hereford	112	1627	851	58.0	38.9	851	-20.8	873	-20.1	-15.1
Angus	106	1259	872	63.0	44.5	872	0.0	893	0.0	0.0
Shorthorn	25	168	918	20.5	13.4	887	14.8	895	2.0	44.5
South Devon	15	134	744	22.5	0.2	868	-4.3	893	0.0	40.5
Brahman	40	438	838	25.1	8.5	831	-41.3	849	-43.4	-5.5
Simmental	47	528	852	58.4	39.3	888	15.9	909	16.5	21.1
Limousin	40	527	797	23.4	0.4	848	-24.2	874	-19.1	20.5
Charolais	74	566	882	24.8	10.7	897	24.5	912	19.6	57.8
Maine-Anjou	18	196	787	31.3	46.2	884	11.7	867	-25.9	5.8
Gelbvieh	48	555	849	66.0	55.1	863	-8.7	876	-17.3	-20.3
Pinzgauer	16	347	838	0.7	-8.0	846	-26.3	855	-37.4	24.9
Tarentaise	7	189	807	23.0	-3.4	836	-36.1	866	-27.2	12.8
Salers	27	173	899	21.1	10.5	880	7.6	892	-1.3	40.6
Red Angus	21	194	916	46.0	47.0	877	4.8	876	-17.1	-0.1
Braunvieh	7	182	737	7.0	10.9	855	-17.2	850	-42.5	13.5
Brangus	21	155	957	33.5	44.0	886	14.2	874	-18.4	11.1
Beefmaster	22	159	972	11.1	24.6	886	13.9	871	-22.2	29.7

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 EPDs used to adjust for genetic trend to 2001 base and factors to adjust within-breed EPDs to Angus equivalent - MILK (lb)

	Number			Raw MARC Mean	Mean EPD				Breed Soln at MARC MWWT		Adjust to 2001 Base MWWT			Factor to Adjust MILK EPD to Angus
					Breed		MARC							
					WWT	MILK	WWT	MILK	+ Ang	vs Ang	+ Ang	vs Ang	MILK	
Breed	Sr	Gpr	Daughters	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Hereford	96	2400	621	472	34.0	12.0	18.5	5.6	472	-16.9	488	-22.4	-17.9	-16.2
Angus	92	1669	446	489	34.0	17.0	16.4	7.0	489	0.0	511	0.0	3.3	0.0
Shorthorn	22	251	69	527	13.1	2.3	6.9	6.8	515	26.2	513	2.4	0.6	12.0
South Devon	14	347	69	488	16.2	6.3	0.1	5.6	494	5.1	504	-6.8	-5.4	2.1
Brahman	40	880	216	522	15.1	7.7	4.8	2.7	524	34.8	536	24.7	20.1	26.1
Simmental	47	909	233	509	35.1	7.6	19.0	8.3	514	24.5	522	11.0	2.9	9.0
Limousin	40	879	233	474	12.4	5.1	-7.9	0.0	482	-6.5	500	-10.7	-8.4	0.2
Charolais	68	820	224	498	14.6	9.0	1.6	3.7	502	13.1	516	4.9	-2.7	2.0
Maine-Anjou	17	485	86	533	16.2	4.0	22.8	4.8	511	21.6	506	-5.0	-1.7	8.0
Gelbvieh	46	765	222	528	36.0	18.0	29.6	17.6	516	27.5	521	9.7	8.1	3.8
Pinzgauer	15	545	133	504	0.6	-1.0	-1.7	6.4	504	14.8	496	-14.6	-8.7	6.0
Tarentaise	6	341	78	513	12.0	1.5	-6.0	4.7	511	21.8	517	6.2	5.6	17.8
Salers	25	351	87	534	13.2	8.0	5.8	9.7	515	25.8	517	6.1	5.6	11.3
Red Angus	21	112	83	450	27.0	14.0	26.7	14.7	494	4.8	493	-17.8	-10.4	-10.7
Braunvieh	7	502	92	542	6.3	-0.3	7.3	-1.1	518	28.6	518	7.1	9.1	23.1

Calculations:

(6) = (7) + (1, Angus)

(8) = (6) + b_{WWT} [(2) - (4)] + b_{MLK} [(3) - (5)] with b_{WWT} = 0.57 and b_{MLK} = 1.19

(9) = (8) - (8, Angus)

(10) = [(9) - Average (9)] - 0.5[(7, Table 2) - Average (7, Table 2)]

(11) = [(10) - (10, Angus)] - [(3) - (3, Angus)]

founder breeds and reflect the adverse effect of cold weather on postweaning growth rate of progeny with Brahman sires. Adjusted to a base year of 2001, Angus have heavier yearling weights than 10 breeds (1.3 to 43.4 lb) and lighter yearling weights than 3 breeds (2.0 to 19.6 lb).

MILK

As with previous updates, changes relative to Angus are somewhat volatile. Most of the larger changes from the 2002 update seem associated with more maternal records. Gelbvieh decreased relative to Angus but both had more maternal performance records. The largest change was for Red Angus but nearly three times more Red Angus grandprogeny had records in the 2003 analysis than in the 2002 analysis. The change for Red Angus is due almost entirely to the change in breed of sire solution for Red Angus vs Angus with the added grandprogeny at MARC. The large change for Salers is due to the inexplicable change in MILK EPD of bulls which produced calves at MARC. The average MILK EPD for the MARC bulls increased from 4.4 to 9.7. The same bulls were included in both the 2002 and 2003 analyses. The breed average for EPD for MILK, however, was 8.0 lb for both the 2000 and 2001 years of birth.

Table 5 summarizes the average 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 2002 report.

Table 7 updates the coefficients of regression of records of MARC progeny on sire EPD 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 1.05 for BWT, 0.83 for WWT, and 1.13 for YWT were used to adjust breed of sire solutions to the base year of 2001. These regression coefficients are reasonably close to expected values of 1.0. Deviations from 1.0 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 17 breeds.

The regression coefficient for female progeny on sire EPD was 0.97 compared to 1.26 for steers. These differences are probably expected since postweaning average daily gains for heifers have been significantly less than those for steers. The females 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 five years the pattern has been fairly consistent (female estimates have ranged from .94 to 1.02; while male estimates have ranged from 1.26 to 1.32).

The coefficients of regression of records of grandprogeny on MGS EPD 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

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	0.56	0.53	0.48	0.48	0.46
Angus	0.88	0.87	0.84	0.83	0.81
Shorthorn	0.81	0.80	0.74	0.81	0.78
South Devon	0.37	0.39	0.37	0.41	0.42
Brahman	0.50	0.54	0.37	0.55	0.41
Simmental	0.94	0.93	0.92	0.95	0.94
Limousin	0.95	0.93	0.89	0.94	0.90
Charolais	0.81	0.79	0.69	0.77	0.68
Maine-Anjou	0.72	0.71	0.71	0.71	0.71
Gelbvieh	0.72	0.65	0.51	0.67	0.55
Pinzgauer	0.85	0.68	0.62	0.70	0.64
Tarentaise	0.95	0.95	0.94	0.95	0.95
Salers	0.81	0.81	0.75	0.80	0.81
Red Angus	0.87	0.84	0.83	0.83	0.79
Braunvieh	0.77	0.70	0.69	0.70	0.48
Brangus	0.76	0.75	0.61	–	–
Beefmaster	0.57	0.66	0.47	–	–

[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	639	
Dams (4395) within breed (3)	26.8	876	1231	
Residual	68.0	1535	4125	
Maternal				
MGS (556) within MGS breed (15)				185
Daughters within MGS (2892)				899
Residual				1272

[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	1.05 ± 0.05	0.83 ± 0.05	1.13 ± 0.05
Sire breed			
Hereford	1.17 ± 0.08	0.76 ± 0.07	1.11 ± 0.07
Angus	1.01 ± 0.11	0.79 ± 0.10	1.18 ± 0.08
Shorthorn	0.63 ± 0.47	0.72 ± 0.41	1.11 ± 0.34
South Devon	0.88 ± 0.58	-0.18 ± 0.37	-0.09 ± 0.42
Brahman	1.80 ± 0.26	1.11 ± 0.27	0.69 ± 0.24
Simmental	1.04 ± 0.22	1.20 ± 0.17	1.25 ± 0.15
Limousin	0.66 ± 0.16	0.49 ± 0.15	1.07 ± 0.14
Charolais	0.99 ± 0.14	0.95 ± 0.14	0.99 ± 0.13
Maine-Anjou	1.11 ± 0.38	0.59 ± 0.48	0.26 ± 0.49
Gelbvieh	1.01 ± 0.16	1.24 ± 0.27	1.34 ± 0.23
Pinzgauer	1.26 ± 0.17	1.49 ± 0.21	1.66 ± 0.16
Tarentaise	0.67 ± 0.89	0.76 ± 0.55	1.38 ± 0.61
Salers	1.26 ± 0.40	0.68 ± 0.38	0.68 ± 0.41
Red Angus	0.55 ± 0.19	0.53 ± 0.33	0.75 ± 0.30
Braunvieh	0.46 ± 0.36	0.78 ± 0.79	1.95 ± 0.54
Brangus	1.25 ± 0.32	0.81 ± 0.46	0.17 ± 0.41
Beefmaster	1.95 ± 0.69	1.46 ± 0.37	1.68 ± 0.43
Dam breed			
Hereford	0.98 ± 0.08	0.73 ± 0.08	0.99 ± 0.07
Angus	1.11 ± 0.06	0.84 ± 0.06	1.17 ± 0.06
MARC III	1.00 ± 0.08	0.92 ± 0.09	1.20 ± 0.08
Sex of calf			
Heifers	1.03 ± 0.06	0.94 ± 0.06	0.97 ± 0.06
Steers	1.06 ± 0.06	0.73 ± 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	0.57 ± 0.04	1.19 ± 0.07
Breed of maternal grandsire		
Hereford	0.58 ± 0.06	1.17 ± 0.12
Angus	0.57 ± 0.09	1.03 ± 0.14
Shorthorn	0.30 ± 0.35	0.83 ± 0.49
South Devon	0.32 ± 0.24	-1.21 ± 0.81
Brahman	0.42 ± 0.21	0.66 ± 0.35
Simmental	0.67 ± 0.19	1.21 ± 0.48
Limousin	0.74 ± 0.14	2.19 ± 0.26
Charolais	0.36 ± 0.14	1.33 ± 0.20
Maine-Anjou	0.09 ± 0.33	0.43 ± 0.37
Gelbvieh	0.98 ± 0.26	1.80 ± 0.35
Pinzgauer	0.70 ± 0.19	0.31 ± 0.58
Tarentaise	0.20 ± 0.66	0.77 ± 0.80
Salers	0.94 ± 0.26	2.35 ± 0.34
Red Angus	0.40 ± 0.43	1.14 ± 0.52
Braunvieh	0.00 ± -	2.76 ± 0.65
Breed of maternal grandam		
Hereford	0.52 ± 0.06	1.51 ± 0.11
Angus	0.63 ± 0.05	1.18 ± 0.10
MARC III	0.46 ± 0.09	0.80 ± 0.13
Sex of calf		
Heifers	0.57± 0.05	1.18 ±_0.09
Steers	0.57± 0.05	1.21 ±_0.09

overlap for milk EPD. Again, the pooled regression coefficients of 0.57 for MWWT and 1.19 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. How to use these 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 and a Hereford bull has an EPD of 30.0 with PEV of 50. The difference in predicted progeny performance is (Salers adjustment + Salers bull's EPD) - (Hereford adjustment + Hereford bull's EPD):

$$(28.4 + 15.0) - (-2.4 + 30.0) = 43.4 - 27.6 = 15.8.$$

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, $\sqrt{143} = 12$.

If the difference between the Salers and Hereford breeds in the year 2001 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:

$\sqrt{0 + 75 + 50} = 11.2$ which is only slightly smaller than 12.0.

which is only slightly smaller than 12.0.

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 EPDs for bulls of two different breeds[a]. Birth weight above diagonal and yearling weight below diagonal

Breed	HE	AN	SH	SD	BR	SI	LI	CH	MA	GE	PI	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	0.8	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	0.9	2.6	0.8	0.8	1.2	0.9	1.0
SH	54	55	0.0	2.0	1.2	1.1	1.2	1.0	1.6	1.0	1.3	3.1	1.1	1.4	1.8	1.7	1.8
SD	84	84	124	0.0	1.7	1.3	1.4	1.3	2.1	1.6	2.0	3.7	1.9	1.8	2.3	2.2	2.3
BR	37	37	80	112	0.0	0.9	0.9	0.7	1.3	0.8	0.9	2.6	1.1	1.2	1.5	1.3	1.5
SI	29	29	71	81	57	0.0	0.5	0.5	1.3	0.6	1.1	2.8	1.1	0.8	1.5	1.3	1.4
LI	31	31	73	84	59	31	0.0	0.5	1.3	0.6	1.1	2.9	1.1	0.8	1.5	1.3	1.4
CJ	24	25	61	82	52	28	31	0.0	1.2	0.5	1.0	2.7	0.9	0.8	1.4	1.2	1.3
MA	63	65	99	130	87	77	79	72	0.0	1.0	1.5	3.2	1.5	1.6	1.1	1.9	2.0
GE	28	30	65	97	55	38	40	34	64	0.0	1.0	2.8	0.9	0.8	1.2	1.2	1.4
PI	54	56	87	125	66	70	73	64	96	65	0.0	2.6	1.3	1.4	1.7	1.7	1.8
TA	153	156	191	223	160	170	172	165	194	166	158	0.0	3.1	3.2	3.4	3.4	3.5
SA	50	51	72	121	76	67	69	57	95	61	84	187	0.0	1.4	1.7	1.6	1.8
RA	47	47	90	113	76	50	51	48	97	53	91	191	86	0.0	1.8	1.5	1.6
BV	76	78	113	143	100	90	92	85	75	77	109	207	109	110	0.0	2.1	2.2
BS	66	66	115	144	98	87	89	83	124	87	116	215	112	102	138	0.0	1.0
BM	70	70	119	148	101	91	93	87	128	91	119	219	116	106	142	82	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 di fference in EPDs for the two bulls is 54 + 300 + 200 = 554 with SEP = the square root of 554 = 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 diagonal and MILK below the diagonal

Breed	HE	AN	SH	SD	BR	SI	LI	CH	MA	GE	PI	TA	SA	RA	BV	BS	BM
HE	0	4	19	28	11	9	10	8	22	9	15	42	18	17	25	20	20
AN	15	0	20	28	11	10	10	8	23	9	16	43	18	17	26	20	20
SH	49	52	0	43	27	25	26	22	36	23	29	56	27	33	40	38	38
SD	57	59	96	0	36	27	28	27	45	32	40	66	42	39	48	46	46
BR	25	27	65	73	0	18	18	16	29	17	18	43	26	26	32	29	29
SI	27	29	66	60	43	0	10	9	27	12	21	48	24	18	30	27	27
LI	29	31	68	62	45	33	0	10	28	13	22	48	25	18	31	28	28
CJ	22	24	58	59	38	29	31	0	26	11	19	46	21	17	29	26	26
MA	54	57	90	99	69	69	71	64	0	22	31	58	35	35	26	41	41
GE	24	27	59	68	40	37	38	31	58	0	19	46	21	19	25	27	27
PI	50	53	84	96	57	66	68	60	81	61	0	41	27	29	35	34	34
TA	121	124	158	167	125	138	140	132	151	121	132	0	55	56	61	61	61
SA	41	44	68	87	56	57	59	50	81	50	69	146	0	31	38	37	37
RA	52	54	91	93	68	59	60	55	100	66	95	149	88	0	38	34	34
BV	78	80	114	122	92	93	95	87	94	80	111	182	96	116	0	44	44
BS	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	22
BM	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0

Implications

Bulls of different breeds can be compared on a common EPD scale by adding the appropriate table factor to expected progeny differences (EPDs) produced in the most recent genetic evaluations for each of the 17 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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Mean EPDs Reported By Different Breeds

Larry V. Cundiff

The mean non-parent EPDs are shown for growth traits in Table 1 for seventeen different breeds. The mean EPDs for certain carcass traits are shown in Table 2 for ten breeds. Mean non-parent EPDs are useful only for making comparison within breeds. They can not be used to compare different breeds because EPDs are estimated from separate analyses for each breed. These estimates are from the most current genetic evaluation conducted by each breed. They are presented here primarily to show the traits included in genetic evaluations of these breeds.

Table 1. 2001 non Parent Average Epds of Seventeen Different Breeds

Breed	Birth wt.	Weaning wt.	Yearling wt.	Milk
Angus	2.6	34	63	17
Hereford	3.8	34	58	12
Red Angus	0.5	27.0	46.0	14.0
Shorthorn	1.8	13.1	20.5	2.3
S. Devon	0.0	16.2	22.5	6.3
Brahman	1.94	15.1	25.1	7.7
Limousin	1.32	12.35	23.45	5.11
Simmental	3.1	35.1	58.4	7.6
Charolais	1.5	14.6	24.8	9.0
Gelbvieh	1.4	36	66	18
Maine Anjou	3.16	16.23	31.32	3.95
Salers	1.3	13.2	21.1	8.0
Tarentaise	2.2	12.0	23.0	1.5
Pinzgauer	-.1	0.6	0.7	-1.0
Braunvieh	1.057	6.26	7.04	-.28
Beefmaster	.5	6.1	11.1	2.8
Brangus	1.99	20.94	33.54	9.01

Table 2. 2001 non Parent Average Epds for Carcass Traits of Different Breeds to Estimate Ab-epd Factors

Breed	Carcass wt	BF thick.	REA	Marbling	IMF %	% Retail Prod.	Shear
Angus		.002	.07		+.03	.02	
Hereford		0.00	0.04		0.00		
Red Angus		0.00	-.05	0.05			
Shorthorn	-2.45	0.00	-0.03	-0.04		0.00	-0.02
Limousin	10.3	0.00	0.11	0.01			
Simmental	0.2			0.03		0.03	
Charolais	0.20	0.00	0.06	0.00			
Gelbvieh	0.55	0.00	0.01	-0.01			
Salers	16	.00	.02	.02	.1		
Brangus		0.001	0.261		.001		

Producer Applications

Sally Dolezal, Chair

Using Beef Cattle Identification: Pathway to Genetic Progress

Putting Individual ID to Work: Benefits of "Knowing What Your Cattle Will Do"

- John Johns—Extension Professor, University of Kentucky, Department of Animal Sciences
- Producer Perspective: Nelson Curry—Paris, Kentucky
- David Demarcus—Lexington, Kentucky

Can Producers Utilize an ID Program For Profit?

- Matt Perrier—Director, Commercial Programs, American Angus Association

Five State Beef Initiative Display

Frank Baker Biography

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 the 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.

Marker Assisted Selection for Beef Palatability Characteristics

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Introduction

Future success of the beef industry hinges on the ability to regain market share, and sustain demand from competing protein sources. Because of the 2000 National Beef Quality Audit (NBQA), aggregate concerns of several beef marketing segments (beef processors, purveyors, restaurateurs, and retailers) were made aware to the beef industry. The top three producer issues in the NBQA were low overall uniformity and consistency, inadequate tenderness, and low overall palatability (McKenna et al., 2002).

Many researchers have documented the importance of tenderness on beef palatability. Smith et al. (1987), Savell et al. (1989), and Miller et al. (1995) determined tenderness to be the most important palatability attribute of beef. While tenderness has, and will continue to be, one of the focal points for future beef research, many questions still surround the variation in beef tenderness (Wheeler et al., 1994).

Marbling score has been used in the U.S. beef industry as the primary predictor of beef palatability among carcasses with similar maturity characteristics (USDA, 2001a). Intramuscular fat has been shown to have a small, positive relationship with beef palatability, along with a small inverse relationship with Warner-Bratzler shear force (WBS; Wheeler et al., 1994). Interestingly, Boleman et al. (1997) revealed the willingness of consumers (78%) to purchase a product labeled "guaranteed tender" at a higher price.

Clearly, the value of tenderness cannot be disputed with regards to consumer perception of beef. Likewise, it is apparent that many different factors contribute to beef tenderness. Therefore, genetic evaluation of tenderness among different seedstock breeds has become a "top-of-mind" issue. Current research has begun to focus on specific genes that are highly associated with increased beef tenderness and palatability characteristics. Likewise, marker assisted selection (MAS) should be utilized in beef herds, along with economically important phenotypic traits, for genetic progress to be made with respect to improving the uniformity and consistency of beef. The following will detail the significance of marbling and tenderness to overall beef palatability, as well as detail the use of objective genetic mapping for tenderness evaluation and subsequent implications for genetic selection.

Review of Literature

Overview

Palatability is defined as being "pleasant to the taste" (Webster's New Collegiate Dictionary, 824). Meat palatability is generally referred to as tenderness, juiciness and flavor of a cooked product. These three cooked meat characteristics are what consumers desire and what the beef industry is trying to supply on a consistent and uniform basis. Of these three palatability attributes, tenderness is the most influential to consumer preference (Savell et al., 1989). Miller et al. (1995) found that consumers preferred meat that offered increased tenderness and flavor. Variation in meat tenderness can be explained by examining multiple animal and/or carcass factors (marbling, physiological maturity, and breed/genetic effects).

Marbling: A Palatability Attribute

Interfascicular or intramuscular adipose tissue is a unique fat depot. This tissue can be distinguished from other fat reservoirs by its location within perimysial connective tissue located alongside myofibers. Postnatal growth of intramuscular fat involves substantial hypertrophy of the adipocytes and also appears to include a period of apparent hyperplasia of preadipocytes (Smith et al., 2000).

The "jury" is still out concerning the role marbling plays in the formulation of beef tenderness. Romans et al. (1965) documented that only 5% of the variation in beef tenderness is accounted for by differences in marbling, whereas Campion et al. (1975) determined that marbling explained 10% of the variation of cooked beef. Likewise, Armbruster et al. (1983) found that marbling explained 1% of the variation in tenderness after accounting for other sources of variation and only 1.2% when other sources of variation were ignored. Smith et al. (1984) noted that marbling accounted for more desirable panel scores and lower shear force ratings when wide ranges of marbling scores were present. However, within a tighter range of marbling scores (i.e., Small to Moderately Abundant), marbling had little or no effect on sensory panel ratings and shear force values (Smith et al., 1984). Conversely, McBee and Wiles (1967) found that shear force, sensory panel tenderness, juiciness and flavor improved as marbling increased. Dolezal et al. (1982a) found that steaks with a Modest or higher degree of marbling had increased overall palatability ratings in relation to steaks from carcasses with Slight degree of marbling. Smith and Carpenter (1974) noted that the perceived value of a fattened animal dates back to Biblical times. In the early 20th century, researchers seemed to further echo these findings. Hall (1910) postulated that an increase in tenderness is the direct result of decreased elasticity of connective tissue due to the deposition of fat therein. Nelson et al. (1930) documented an 18 to 30% decrease in shear force values for samples from fat animals in relation to the force required to shear samples from thin animals. Research has also shown that deposition of intramuscular fat leads to decreased rigidity of connective tissue due to adipose accretion within (Nishimura et al., 2000). In a study to determine the effect of differing physiological maturity (i.e., potential differences in connective tissue) across similar marbling scores, McPeake et al. (2001) reported a more favorable trend for various palatability characteristics when steaks were from carcasses with increased marbling levels (Table 1).

Theories

Carpenter and Smith (1974) detailed several theories relating marbling and tenderness. The **bite theory** hypothesizes that within a certain bite-size portion of cooked meat, marbling reduces the overall mass per unit of volume, which in turn lowers bulk density. Bulk density is the amount, distribution, and chemical or physical state of intramuscular fat and moisture. The **strain theory** suggests that as intramuscular fat is being formed, a portion is deposited within the perimysium or endomysium thereby decreasing the strength of connective tissue fibers. Increased accumulation of marbling causes the actual rigidity of the connective tissue to be weakened resulting in increased tenderness. This proposed theory can be affirmed by a recent study done by Nishimura et al. (1999) which found the development of adipose tissue in *longissimus dorsi* muscle appears to disorganize the structure of the intramuscular connective tissue and contributes to the tenderization of highly marbled beef from Wagyu cattle. Increased tenderness is the result of connective tissue that is more heat susceptible; the direct result of structural changes causing more efficient collagen solubilization. The **lubrication theory** states that as heat is applied to meat, intramuscular fat dissolves. The cooked fat and meat juices combine and serve as lubrication during the chewing process. Pearson (1966) found sustained juiciness (the sensation of juiciness perceived during continued chewing) to be related to intramuscular fat content. The **Insurance theory** suggests that increased amounts of intramuscular fat allow different preparation opportunities to be utilized that could affect degree of doneness. Marbling would provide some insurance that meat cooked too extensively or too rapidly would still be relatively palatable.

Breed Differences: Brahman and Brahman-crossbred cattle, in relation to other breeds, have been shown to have lower marbling scores and tenderness ratings. Sherbeck et al. (1995) showed that carcasses from Hereford steers had higher marbling scores in relation to carcasses of 25 or 50% Brahman descent. Hereford carcasses had an increased proportion of USDA Choice than did carcasses from Brahman decent (44 versus 19 and 14%, respectively) and a smaller percentage of USDA Standard grade carcasses than Brahman-crossbred carcasses (0 versus 19 and 18%, respectively). Nevertheless, Wheeler et al. (1994) documented that carcasses originating from *Bos taurus* and *Bos indicus* steers experienced a small, positive relationship between marbling score and palatability. It can be disputed how much appreciable difference between *Bos indicus* and *Bos taurus* breeds for marbling deposition actually exist. Nonetheless, sensory panel tenderness differences do exist between these two diverse biological types of cattle due to biochemical differences in Zebu breeds (Koch et al., 1988). Zebu breeds have increased calpastatin activity, the endogenous inhibitor of calpain, when compared to cattle of British decent (Wheeler et al., 1994). While proteolysis will be discussed later, it has been documented that the calpain proteases (m- and m-calpain) play an important role in beef tenderness as a result of postmortem aging.

Environmental Factors Effecting Palatability

Time-on-Feed: Traditionally, to increase marbling deposition, feedlot managers tend to increase the amount of time that animals are fed a high-concentrate finishing ration. Increased time-on-feed increases the probability that animals will produce carcasses with a more desirable quality grade (Zinn et al., 1970; Tatum et al., 1980; May et al., 1992).

The interaction between quality grade and palatability, as well as marbling and carcass value, has led researchers to hypothesize exactly how many days on feed are actually necessary for cattle to be acceptable in terms of palatability. Dolezal (1982b) suggested that feeding a high-grain ration for

Table 1. Least squares means and pooled standard errors for palatability attributes stratified by quality grade category[h]

	Quality grade category[a]								
Trait[b]	HSMA	HSMB	LSMA	LSMB	HSEA	HSEB	LSEA	LSEB	SE
Tenderness	6.14[de]	5.43[ef]	5.52[ef]	5.43[ef]	5.44[ef]	5.43[ef]	5.17[f]	5.04[f]	0.26
Juiciness	5.76[d]	5.68[d]	5.82[d]	5.53[d]	5.61[d]	5.66[d]	5.56[d]	5.68[d]	0.21
Connective tissue	6.33[cde]	5.66[f]	5.83[ef]	5.78[ef]	5.88[def]	5.69[f]	5.61[f]	5.57[f]	0.26
Flavor intensity	5.90[de]	5.72[ef]	5.78[ef]	5.50[f]	5.63[ef]	5.80[ef]	5.63[ef]	5.62[ef]	0.16
Beef fat flavor	1.53[cd]	1.48[cd]	1.47[cd]	1.55[cd]	1.44[d]	1.45[d]	1.43[d]	1.46[cd]	0.15
Overall Acceptability	5.44[def]	5.04[efg]	5.01[fg]	4.92[fg]	4.87[fg]	4.99[fg]	4.63[g]	4.51[g]	0.22

a Quality grade categories defined as High Small, A maturity; High Small, B maturity; Low Small, A maturity, Low Small, B maturity; High Select, A maturity; High Select, B maturity; Low Select, A maturity; Low Select, B maturity (HSMA, HSMB, LSMA, LSMB, HSEA, HSEB, LSEA, and LSEB, respectively).

b Tenderness: 1=extremely tough, 8=extremely tender; Juiciness: 1=extremely dry, 8=extremely juicy; Connective tissue: 1=abundant, 8=none; Flavor intensity: 1=extremely bland, 8=extremely intense; Beef fat flavor: 1=none detectable, 3=very strong; Overall acceptability: 1=extremely undesirable, 7=extremely desirable

cdefg Means within a row with different superscripts differ ($P < 0.05$).

h Adapted from McPeake et al. (2001).

at least 90 d was necessary for acceptable palatability. May et al. (1992) and Van Koevering et al. (1995) suggest feeding animals for 84 and 119 d for palatability to be acceptable. Duckett et al. (1993) found that marbling levels doubled between 84 and 112 days on feed, but did not differ from day 0 to 84 or from day 112 to 196. Nash et al. (1999) utilized ultrasound technology to monitor changes in marbling deposition and predicted USDA Quality Grade in feedlot heifers relative to days on feed. The percent grading Choice increased from 20% at d 84 to 80% at d 100 and 120, with little change occurring there after.

Implants: Beef industry segmentation is a major problem surrounding the problems with consistency and uniformity. Time-on-feed and breed differences have already been discussed, however, management regimes which utilize different implant protocols are undoubtedly a "hot topic" when considering the potential impact implants have on carcass quality. Anabolic implants are used routinely during the feedlot phase in order to promote increased gain and feed efficiency. Duckett's (1997) review of 36 research trials determined implants caused a mean reduction of 24% in marbling and a 14.5% reduction in the number of carcasses grading Choice. Roeber et al. (2000) revealed that different implant strategies resulted in increased hot carcass weights and larger *longissimus dorsi* area while decreasing marbling scores and consumer preference of steaks. Duckett et al. (1999) found a reduction in marbling score when comparing implanted cattle with non-implanted controls. Research also exists that portrays the fact that certain implant regimes differ in their effect on carcass quality. Gerken et al. (1995) found that use of single implants containing 140 mg trenbolone acetate or the combination of 24 mg 17-β estradiol and 120 mg trenbolone acetate had little appreciable effect on marbling or beef tenderness in genetically identical steers. Within this same trial, carcasses from cattle implanted with a single estrogenic implant containing 20 mg estradiol benzoate and 200 mg progesterone had significantly reduced marbling scores and decreased tenderness of top sirloin steaks when compared to the previously mentioned implant treatments.

Marker Assisted Selection

Genetic improvement of livestock primarily focuses on selection for quantitative traits, since most traits of economic importance including beef palatability are quantitative traits (i.e., controlled by many genes). In the past, most genetic improvement has been achieved through selection using estimated breeding values based on the phenotype of the individual and/or its relatives (Dekkers, 1999). The availability of molecular genetic tools has equated into increased genetic progress achieved via the ability to select on specific DNA markers for quantitative trait loci (QTL). Markers arise from research where a candidate gene of known effect is shown to influence a certain phenotypic attribute or where a specific genomic region is determined to significantly influence a particular trait. Meuwissen and Goddard (1996) documented several factors that affect the response to MAS: size of QTL variance, heritability of trait, and selection for phenotypic traits that are difficult to measure (i.e., carcass and sex-limited traits). In terms of carcass traits (heritability approximately 0.27), when displayed in terms of the percentage extra response from MAS, the maximum response was found during the first generation and declined substantially by generation five (64% vs. 39%, respectively). Strictly using MAS for breeding decisions is not advisable due to the inability to predict what is happening with other background genes (i.e., population differences) that may affect other traits. Accordingly, Dekkers and van Arendonk (1998) developed methods to optimize selection on a known QTL, leading to a greater response in both the short and long term when selection on the QTL is balanced with selection based on phenotypic information. This is further enhanced when QTL exhibit dominance.

Very few cattle breed associations have EPDs for WBS or sensory evaluated tenderness. Furthermore, little economic incentive has existed in the past for beef producers to select for tenderness. Therefore, selection for tenderness has not been practiced. The economic incentive to select for tenderness now exists due to the formation of various beef alliances and branded beef programs that could use this as marketing leverage. There are, however, substantial difficulties associated with the mass collection of WBS data. Therefore, research has focused on identifying gene markers that are highly associated with different palatability characteristics. Currently, the thyroglobulin, leptin, and calpastatin genes have been identified due to their strong relationship with marbling deposition and tenderness.

Thyroglobulin

Thyroglobulin is a glycoprotein hormone that is synthesized from the thyroid follicular cell and iodinated upon release. Thyroglobulin is the carrier for triiodothyronine (T3) and thyroxin (T4) and is stored in the lumen. When either of these hormones is needed, thyroglobulin is transported across the apical membrane where these hormones are cleaved and released into the blood. These hormones have been shown to affect both in vitro and in vivo adipocyte growth and differentiation (Ailhaud et al., 1992). Likewise, T3 and T4 have also been associated with marbling deposition in Wagyu cattle (Mears et al., 2001).

The TG5 polymorphism occurs in the 5' leader sequence of the thyroglobulin gene and has been highly associated with intramuscular fat deposition in long-fed cattle (Barendse, 2001). Cattle that are heterozygous or homozygous for the delta T allele (e.g., CT or TT) have higher marbling scores than cattle that are homozygous for the delta C allele (e.g., CC), with the delta locations defined as the beginning of the start of the first exon (Barendse, 1997). Additionally, steers exhibiting the delta T allele had increased growth performance and marbling deposition. Interestingly, no association was found for rump fat thickness or hot carcass weight. These results imply that selecting cattle based on this DNA marker should not result in subcutaneous fat thickness changes, a major factor affecting USDA yield grades for beef carcasses.

Leptin

Leptin is a protein hormone that has been implicated in the control of food intake and body composition in mammals (Geary et al., 2003). Leptin is produced primarily by white adipose tissue and, to a lesser extent, in the placenta, skeletal muscle, and stomach fundus in rats in response to fattening (Margetic et al., 2002). In skeletal muscle, leptin plays an important role in glycogen synthesis, glucose transport, and lipid partitioning (Margetic et al., 2002). As adipocytes become larger, more leptin mRNA is present (Auwerx and Staels, 1998; Masuzaki et al., 1995) and peripheral leptin concentrations increase (Ahima and Flier, 2000). Mice that are homozygous for an obesity condition (ob/ob) are the prototypical experimental subjects that set the stage for the discovery of leptin. These mice lack the leptin gene and are overweight. Both leptin deficiency (Tartaglia et al. 1995) and resistance (in *db/db* mice having a defective leptin receptor; Lee et al., 1996) are characterized by hyperphagia and reduced energy expenditure.

Studies have also been conducted to determine the significance of circulating leptin concentration on carcass characteristics of feedlot cattle. Serum leptin is positively correlated with ($P < 0.001$) ribeye fat thickness ($r = 0.32$), KPH ($r = 0.18$), marbling score ($r = 0.18$), and yield grade ($r = 0.28$; Minton et al., 1998). Geary et al. (2003) also found that serum concentrations of leptin were significantly associated with carcass composition and quality grade; these researchers concluded that leptin may be beneficial as an additional indicator of fat content in feedlot cattle. Currently, however, there is no commercially available application that utilizes serum leptin concentration as a predictor of beef quality grade or palatability.

DNA analysis for the leptin gene has also received research attention. Fitzsimmons et al. (1998) reported that alleles of the BM1500 microsatellite were associated with carcass fat measures in a population of 154 unrelated beef bulls. Likewise, Buchanan et al. (2002) determined that a cytosine (C) to thymine (T) transition that encoded an amino acid change of an arginine to a cysteine was identified in exon 2 of the leptin gene. Further results from this trial indicated that the T allele is associated with fatter carcasses (whole body fat) and the C allele with leaner carcasses. Not suprisingly, British breeds (i.e., Angus and Hereford) had a higher frequency of the T allele (0.59 and 0.57, respectively) whereas continental breeds (i.e., Charolais and Simmental) had a higher occurrence of the C allele (0.54 and 0.58, respectively).

Calpastatin

Postmortem management of beef plays a particularly important role in helping to reduce the variation in beef tenderness at the consumer level (Koohmaraie, 1996). Increased tenderness in meat is caused by endogenous enzymatic activity in the form of the calpains (m- and μ-calpain), which occur naturally in the muscle. The calpain proteases are different in the amount of calcium required for activation; μ-calpain requires micromolar concentrations of calcium (200-300 μM) and m-calpain requires millimolar calcium concentrations (~10mM) for activation to occur. Calpastatin is an endogenous substrate that inhibits the calpain proteases. According to Koohmaraie (1992), when normal postmortem conditions are realized, m-calpain is very stable in the body due to insufficient calcium present for its' activation. Furthermore, a gradual decline in activity occurs with μ-calpain as calcium in the body is depleted and calpastatin loses activity very rapidly. Calpastatin is hydrolyzed by calpain proteases when greater quantities of protease are present in relation to inhibitor (Shannon and Goll, 1985). Prediction equations show 24-h calpastatin activity and 0-h μ-calpain activity account for 41% of the variation in WBS in beef aged 14 d (Shackelford et al., 1991). Likewise, research conducted by Johnson et al. (1990) and Calkins et al. (1988) found WBS values to be correlated with both calpastatin ($r = 0.41$) and μ-calpain activity ($r = -0.71$), respectively.

A DNA marker for the calpastatin gene has now been developed. Researchers with Australia's Commonwealth Scientific and Industrial Research Organization (Bindon, 2002) reported two variants of the calpastatin gene, one associated with tenderness and the other with increased toughness. While both alleles have been found in all breeds tested, there appear to be clear differences in genotype frequency within breeds; Zebu breeds have a greater frequency of the genotype associated with toughness (i.e., '11') relative to British, Belmont Red, and Santa Gertrudis cattle (i.e., '22'). In this trial, the estimated difference between the '11' and the '22' genotype for WBS was 1.34 kg (Bindon, 2002). However, this value represents the extremes of the distribution tested and not a random population sample. Likewise, Chung et al. (2001) found genetic polymorphisms among individuals for two different domains of the Calpastatin locus (domain I = CAST67 and domain IV = CAST28). Results from this trial also indicate that use of calpastatin genotypes in MAS programs can improve carcass traits and calpastatin activity.

Conclusions and Implications to Genetic Improvement of Beef Cattle

It is quite evident that reproduction and growth traits are still major factors in maintaining profitable beef production. However, only around 10% of fed cattle processed in the United States meet the requirements for upper 2/3 USDA Choice or Prime grade carcasses (McKenna et al., 2002). Several breed associations are now compiling ultrasound information for development of EPDs for marbling, ribeye area, and fat thickness. Likewise, DNA markers now exist that determine if certain animals express certain genes that are highly associated with beef palatability. Pricing grids now exist that reward higher levels of marbling; therefore, the economic incentive for increased marbling will continue to be important in the future. One should note that genetic selection for marbling will not always yield a tender product (i.e., the phenotypic relationship between marbling and tenderness is not especially high.) Consequently, some cattle with relatively high marbling will produce meat that is unacceptable in tenderness, and some cattle with low levels of marbling will produce meat that is very desirable in tenderness. Many researchers continually point out the fact that marbling accounts for little of the variation in beef tenderness. However, taste panel ratings indicate that with increased marbling score, the chance for an undesirable eating experience is reduced (McPeake et al., 2001). Therefore, genetic selection based on both marbling and tenderness traits should be conducted in the future to help insure a highly palatable beef product for the consumer.

While the entire captive supply should not be comprised of Choice or Prime carcasses, by emphasizing carcass traits during genetic selection producers can have the ability to address these areas of concern. One should note, however, that MAS alone is not the beef industry's "silver bullet" for solving the beef quality and tenderness equation. Marker assisted selection translates into one of the many ingredients involved in the recipe for genetic selection. Beef producers should utilize this tool, along with phenotypic records for quantitative traits, to insure both short and long term genetic progress.

The importance of expected progeny differences (EPD) as a tool for genetic selection cannot be questioned. In yesteryears, beef producers would evaluate "traditional" EPDs for birth weight, weaning weight, yearling weight, milk, and scrotal circumference in order to increase genetic progress for reproduction, maternal, and growth traits within the herd. However, the beef industry has undergone a fundamental shift in beef marketing from a commodity based, low-cost system that offers little incentive for a quality product, to a value-based marketing system where dollars are passed along the production chain based on product quality and value. This shift has now forced beef producers to be information gatherers: from collection and analysis of carcass data, to incorporation of carcass EPDs in selection decisions. While MAS requires more sophisticated sampling and decision making, it also adds to conventional selection and allows for exploitation of specific genetic effects.

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The Value of Hierarchical Bayes Models on Genetic Evaluation of Multiple-breed Beef Cattle Populations

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Introduction

Crossbreeding is an important tool to increase the efficiency of beef production through heterosis and complementarity between breeds (Gregory, 1999). This is one of the reasons that has led to an increasing proportion of the beef cattle populations being composed of crossbred animals. Crossbreeding and selection are synergic key factors to improve production in the long-term. The response to selection is proportional to the accuracy on predictions of genetic merit (Falconer and Mackay, 1996). These predictions of genetic merit on crossbred animals depend on reliable estimates of breed-composition specific means, individual deviations from these means, and covariances between related animals (Fernando, 1999); however, genetic evaluations of multiple-breed populations are complicated by the different genetic backgrounds and degrees of crossing present in these populations.

The complexity of the biological and environmental issues involved makes the task challenging and demands the effort of several research groups. Bayesian statistics, in this context, provide a set of flexible tools and a general framework to tackle this task (Sorensen and Gianola, 2002). Hierarchical Bayes models (HBMs) can handle virtually any level of complexity that is present in the population of interest and are particularly useful when records are correlated (Hobert, 2000), as typical of related animals. Moreover, HBMs allow for optimal combination of information present in the data with previous inferences from the literature to estimate the parameters of interest (e.g. genotypic means). The current "state of art" multiple-breed genetic evaluation model for beef cattle in the United States uses a HBM to incorporate prior knowledge on heterosis (Klei et al., 1996).

The objectives of this paper were to review the current state of knowledge on major issues involved on the prediction of performance and genetic merit of multiple-breed beef cattle populations; and to describe how HBMs and Bayesian inference can by employed to tackle these issues.

Review of literature

Genotypic means. Several approaches have been considered to estimate means of genotypes or breed-composition groups in multiple-breed populations. The simplest strategy involves including breed-composition in the definition of the contemporary group (CG) and estimating heterotic effects jointly with the CG effects. However, this method reduces the number of possible direct comparisons and connectedness in the population, since animals with different compositions are considered different contemporary groups even when they are raised together under the same management and environmental conditions (Klei et al., 1996). More parsimonious models are obtained by estimating breed-composition means as a function of additive (breed proportion) and non-additive (degree of allelic and non-allelic interaction) genetic coefficients. If heterosis is primarily due to dominance (allelic interaction) with no epistasis, then it is proportional to heterozygosity (proportion of heterozygotes at individual loci) (Gregory, 1999). Dickerson (1969; 1973), however, introduced the concept of "recombination loss" to explain deviations from the heterozygosity found in crossbred individuals. The recombination loss is equal to "the average fraction of independently segregating pairs of loci in the gametes from both parents which are expected to be non-parental combinations" (Dickerson, 1969). The effect of recombination loss is attributable to the loss of favorable epistatic combinations present in the gametes from purebreds as a result of long-term selection. Kinghorn (1987) proposed several hypotheses and models to account for "epistatic loss" in crossbred populations, and Wolf et al. (1995) proposed a general model based on the two-loci theory to account for dominance and epistatic effects.

Confoundedness and multicollinearity between the coefficients for genetic effects complicates the estimation of dominance effects separately from epistatic effects such that most of the models proposed for multiple breed evaluations are only based on dominance effects (Cunningham, 1987; Klei et al., 1996; Miller and Wilton, 1999; Sullivan et al., 1999).

Accounting for additive and heterotic mean effects on genetic evaluations can be accomplished by using information in the literature to pre-adjust records (Roso and Fries, 1998; Sullivan et al., 1999), provided that the published estimates are reliable and applicable to the population being evaluated; by estimating these mean effects solely from the data of the population under investigation (Arnold et al., 1992; Miller and Wilton, 1999), or by simultaneously using information from the literature combined with data information, as in the benchmark model used currently in the U.S. beef industry (Klei et al., 1996; Quaas and Pollak, 1999).

Let g be a genotype (breed-composition) composed of B breeds; let α_b be the proportion of genes from the b^{th} source; let $\delta_{bb'}$ and δ_{bb} be the probability that at a randomly chosen locus from an individual in g, one allele is from the b^{th} source and the other allele, respectively, from b'^{th} and b^{th} source population. A general model assumed for the mean of g (μ_g) based on the two-loci theory and absence of inbreeding is as follows (Wolf et al., 1995):

$$\begin{aligned}\mu_g = {} & \mu + \sum_{b=1}^{B}\alpha_b A_b + \sum_{b=1}^{B}\sum_{b'=b}^{B}\delta_{bb'}D_{bb'} + \sum_{b=1}^{B}\alpha_b^2 AA_{bb} + 2\sum_{b=1}^{B-1}\sum_{b'=b+1}^{B}\alpha_b\alpha_{b'}AA_{bb'} \\ & + \sum_{b=1}^{B}\sum_{b'=1}^{B}\sum_{b''=b'}^{B}\alpha_b\delta_{b'b''}AD_{b(b'b'')} + \sum_{b=1}^{B}\sum_{b'=b}^{B}\delta_{bb'}^2 DD_{(bb')(bb')} + \sum_{b=1}^{B}\sum_{b'=b}^{B}\sum_{b''=1}^{B}\sum_{\substack{b'''=b'' \\ (b\neq b'' \text{ or } b'\neq b''')}}^{B}\delta_{bb'}\delta_{b''b'''}DD_{(bb')(b''b''')}\end{aligned} \quad [1]$$

where μ is the overall mean, A_b is the additive effect, $D_{bb'}$ is the dominance effect, $AA_{bb'}$ is the additive $\times$ additive effect, $AD_{b(b'b'')}$ is the additive $\times$ dominance effect and $DD_{(bb')(b''b''')}$ is the dominance $\times$ dominance effect. The indices refer to the source populations. The extension of [1] to other effects is naturally done by adding analogous terms referring to the extra effects; e.g A_b^M would be the additive maternal effect. The coefficients in [1] can be obtained from the parental generation as follows: $\alpha_b = 0.5\left(\alpha_b^P + \alpha_b^M\right)$, $\delta_{bb} = \alpha_b^P\alpha_b^M$, $\delta_{bb'} = \alpha_b^P\alpha_{b'}^M + \alpha_{b'}^P\alpha_b^M$, for b=1,..., B; b'=1,..., B; and $b < b'$. Here P and M denote paternal and maternal groups, respectively.

Equation [1] is clearly overparameterized; thus some restriction on the parameters must be applied in order to make them estimable. These restrictions are based on the relationship between the coefficients, namely $\sum_{b=1}^{B}\alpha_b = 1$, $\sum_{b\leq b'}\delta_{bb'} = 1$ and $\alpha_b = \delta_{bb} + 0.5\sum_{b'}\delta_{bb'}$. For example, in a two population scenario, a restricted model would be given by:

$$\mu_g = \mu + \alpha_1 A_1 + \delta_{12}D_{12} + 2\alpha_1\alpha_2 AA_{12} + \alpha_1\delta_{12}AD_{1(12)} + \delta_{12}^2 DD_{(12)(12)}, \quad [2]$$

which has 6 parameters and requires at least six genotypic groups to be estimable. This model is equivalent to (or a reparameterization of) the models proposed by Mather and Jinks (1971) and Hill (1982).

Another important aspect to consider in a crossbred population is that the relationship between performance and contribution of each breed may not be linear in all ranges of compositions and can also be environmentally dependent (Arthur et al., 1999; Long, 1980). As an example, the combination of *Bos Indicus* (for fitness) and *Bos Taurus* (for production) that optimizes performance will vary according to the quality of the environment in terms of management and climate. Larger percentages of *Bos Taurus* will be more suitable to temperate environments while animals with larger proportion of *Bos Indicus* blood are expected to perform better in tropical environments. If we partition the different environments into R regions, the mean of a breed-composition group raised in the r^{th} region can be written as:

$$\mu_{g,r} = \mu + \alpha_1 A_1 + \delta_{12} D_{12} + 2\alpha_1 \alpha_2 AA_{12} + \alpha_1 \delta_{12} AD_{1(12)} + \delta_{12}^2 DD_{(12)(12)} + \text{Region}_r + \alpha_1 A_1 \text{Region}_r \quad r = 1, \ldots, R. \qquad [3]$$

Here Region$_r$ represents the effect of the r^{th} class of region. Conceivably higher order genetic effects could also interact with region effects (Arthur et al., 1999), yielding a straightforward extension of [3]. On the other hand, simpler models can be obtained by setting some of the effects of the general model in [1] equal to zero. For instance, a model including solely additive and dominance effects is obtained when we let all $AA_{bb'}$, $AD_{b(b'b'')}$, and $DD_{(bb')(b''b''')}$ effects be equal to zero. The models of Dickerson (1973) and Kinghorn (1980) based on the concept of recombination loss are also simpler versions of [1]. Their models are equivalent in a two-breed population (Wolf et al., 1995) but Kinghorn's parameterization has a better biological interpretation. Kinghorn's hypothesis X for recombination loss assumes that each locus codes for a different component of a dimorphic enzyme and epistatic loss is proportional to the probability that choosing one allele from each locus comes from a different breed. This is equivalent to assuming that recombination loss is due to between breed additive × additive effects and the model can be written as:

$$\mu_g = \mu + \alpha_1 A_1 + \delta_{12} D_{12} + 2\alpha_1 \alpha_2 AA_{12}. \qquad [4]$$

Animal additive genetic effects. The genetic value of an animal can be determined by the mean of its breed-composition or genotypic group plus an individual deviation from its group (Arnold et al., 1992; Elzo, 1994; Klei et al., 1996; Sullivan et al., 1999). Deviations are due to additive and non-additive genetic effects. Additive effects or breeding values indicate the deviance from the population means expected in the offspring of an individual when it is mated at random to another individual in the population, while non-additive effects are useful to determine specific combining abilities between individuals (Falconer and Mackay, 1996). These deviations are determined by the performance of an individual and its relatives; therefore, it is important to properly account for covariances between relatives when predicting genetic value of crossbred animals.

Theory to estimate the covariance between crossbred animals was presented by Lo et al. (1993) for an additive model and by Lo et al. (1995) for an additive and dominance model. Under the additive model, (co)variances are modeled as a function of breed specific additive variances and variances due to the segregation between breeds. These segregation variances represent the additional variance observed in F_2 individuals compared to the F_1's (Lo et al., 1993). These methods derive genetic means and covariances between crossbred and purebred individuals from "identity modes" and based upon the probability that related individuals share alleles that are identical-by-descent (IBD). The additive and dominance model is derived for a two-breed and their crosses scenario (Lo et al., 1995). This model has an exact theoretical derivation and can accommodate the presence of inbreeding, but requires a relatively larger number of variance components to be estimated (up to 25 in the former when inbreeding is present). Simplifications arise when the population is composed only by the two pure breeds and F_1's (Lo et al., 1997), and this model has been applied to swine data (Lutaaya et al., 2001).

For more general crossbreeding schemes, the dominance model (Lo et al., 1995) can be cumbersome due to the large number of dispersion parameters to be estimated, while the additive model (Lo et al., 1993) can be implemented without great difficulty. An alternative formulation of the additive model with a regression approach to account for non-additive effects and a sire-maternal grandsire model implementation was proposed by Elzo (1994) and applied to multiple-breed data (Elzo et al., 1998; Elzo and Wakeman, 1998). Recently, Birchmeier et al. (2002) proposed a REML algorithm to estimate additive breed and segregation variances under a typical animal model and general pedigree structure. Yet, several recently proposed models (Klei et al., 1996; Miller and Wilton, 1999; Quaas and Pollak, 1999; Roso and Fries, 1998; Sullivan et al., 1999) assume that all breeds have the same additive genetic variance and there is no variance due to segregation between breeds in advanced crosses. A model including additive and non-additive breed-composition means and additive individual deviations may offer a parsimonious model for genetic evaluation of multiple-breed populations.

Bayesian Inference and hierarchical models on multiple-breed genetic evaluations. The milestone paper that introduces Bayesian inferences to animal breeding research is credited to Gianola and Fernando (1986). The most striking, and perhaps controversial, difference between Bayesian and classical (or frequentist) inference is that the former allows the incorporation of prior knowledge (Blasco, 2001). From the practical point of view, if significant prior information is available, ignoring it seems poor advised, especially when the complexity of the problem is high and data information limited.

Hierarchical or multistage models are used in Bayesian inference to functionally describe complex problems through a series of nested levels or sub-models (Sorensen and Gianola, 2002). Distributional assumptions and parameter values associated with these distributions (hyperparameters in Bayesian terminology) are used to integrate prior knowledge in the analyses. The Henderson's mixed model equation (Henderson, 1973) widely used in animal breeding are an example of a two stage model as seen below in the illustration of a hierarchical multiple-breed animal model (HMBAM). The first stage of this model is the distribution of $\mathbf{y}$, a vector of n phenotypic records, presented as follows:

$$\mathbf{y} \mid \boldsymbol{\beta}, \mathbf{g}, \mathbf{a}, \sigma_e^2 \sim N\left(\mathbf{X}_1\boldsymbol{\beta} + \mathbf{X}_2\mathbf{g} + \mathbf{Z}\mathbf{a}, \mathbf{I}\sigma_e^2\right) \qquad [5]$$

where $\boldsymbol{\beta}$ is a vector of non-genetic "fixed" effects (e.g. gender, age of dam, contemporary groups, etc.); $\mathbf{g}$ is a vector of "fixed" genetic effects (as in [1] to [4]); and $\mathbf{a}$ is a vector of q animal additive genetic effects; $\mathbf{X}_1$, $\mathbf{X}_2$, and $\mathbf{Z}$ are known incidence matrices. The elements of $\mathbf{X}_2$ are determined by the coefficients of genetic effects specified above (α's and δs). Finally σ_e^2, represents the residual variance, assumed to be homogeneous across breed groups.

The second stage of the model states the prior knowledge on all parameters in $\boldsymbol{\beta}$, $\mathbf{g}$ and $\mathbf{a}$ contributing to the mean (location) of the normal distribution assumed on $\mathbf{y}$ [5], and is represented by:

$$\boldsymbol{\beta} \mid \boldsymbol{\beta}_o, \mathbf{V}_\beta \sim N\left(\boldsymbol{\beta}_o, \mathbf{V}_\beta\right), \qquad [6]$$

$$\mathbf{g} \mid \mathbf{g}_o, \mathbf{V}_g \sim N\left(\mathbf{g}_o, \mathbf{V}_g\right), \qquad [7]$$

and

$$\mathbf{a} \mid \mathbf{G}_a \sim N\left(\mathbf{0}, \mathbf{G}_a\right), \qquad [8]$$

where β_o and $\mathbf{g}_o$ are prior means and $\mathbf{V}_\beta, \mathbf{V}_g$ and $\mathbf{G}_a$ are prior variance matrices. The values of β_o and $\mathbf{g}_o$ can be elicited from the literature, and would be particularly relevant when the data does not have a suitable structure to adequately estimate the effects for all levels or combination of levels, as in the cases of unbalanced distributions of records in the subclasses and multicollinearity, which are often the case for $\mathbf{g}_o$. These "fixed" genetic effects determining the genotypic means are generally difficult to estimate solely from the data due to confounding and multicollinearity (Birchmeier et al., 2002; Klei et al., 1996), but reliable estimates may be available from the literature (Gregory, 1999). The use of informative priors reduces confounding among correlated effects (Quaas and Pollak, 1999). The variance specification $\mathbf{V}_\beta$ and $\mathbf{V}_g$, typically diagonal, are used to state the uncertainty about β_o and $\mathbf{g}_o$. If these variances are set to very large values, there would be little confidence on prior means and the inference will be basically driven by the data; on the other hand, if the elements of $\mathbf{V}_\beta$ and $\mathbf{V}_g$ are set to very small values then the impact of the prior means on the yielded estimates will be large. This is the specification adopted by the benchmark model used in today's Simmental genetic evaluation (Quaas and Pollak, 1999). The prior assignment on **a** is based on the additive genetic variance-covariance between animals represented by $\mathbf{G}_a$. The matrix $\mathbf{G}_a$ contains elements as defined by Lo et al. (1993). These elements can be computed by the tabular method provided that the variance of crossbred individuals is computed as:

$$\mathrm{Var}\left(a_j\right) = \sum_{b=1}^{B} \alpha_b^j \sigma_{(a)b}^2 + \sum_{b=1}^{B-1} \sum_{b'>b}^{B} 2\left(\alpha_b^s \alpha_{b'}^s + \alpha_b^d \alpha_{b'}^d\right) \sigma_{(a)bb'}^2 + 0.5 \mathrm{cov}\left(a_j^s, a_j^d\right), \qquad [9]$$

where a_j^s and a_j^d represent, respectively, the additive genetic effect of the sire and the dam of j; $\sigma_{(a)b}^2$ is the additive variance of breed b; and $\sigma_{(a)bb'}^2$ is the variance due to the segregation between breed b and b'. Here, this proposition differs from that of Klei et al. (1996), in which all breeds are assumed to have the same genetic variance and there is no variance due to segregation between breeds.

Following Quaas (1988), Lo et al. (1993) showed that the inverse of the additive covariance matrix $\mathbf{G}_a^{-1}$ can be computed as:

$$\mathbf{G}_a^{-1} = \left(\mathbf{I} - \mathbf{P}\right)' \mathbf{\Omega}_a^{-1} \left(\mathbf{I} - \mathbf{P}\right),$$

where $\mathbf{\Omega}_a^{-1}$ is a diagonal matrix with the jth diagonal element is defined as:

$$\omega_{(a)j} = \mathrm{Var}\left(a_j\right) - .25\left(\mathrm{Var}\left(a_j^s\right) + \mathrm{Var}\left(a_j^d\right)\right) - .5\mathrm{cov}\left(a_j^s, a_j^d\right), \quad [10]$$

which is a linear function of breed additive variances ($\sigma^2_{(a)b}$'s), and segregation variances ($\sigma^2_{(a)bb'}$'s).

The third stage of the model corresponds to prior information on variance components. This information is introduced via scaled inverted chi-square prior distributions, defined as follows:

$$p\left(\sigma_e^2 \middle| \nu_e, s_e^2\right) \propto \left(\sigma_e^2\right)^{-\left(\frac{\nu_e+2}{2}\right)} \exp\left(-\frac{\nu_e s_e^2}{2\sigma_e^2}\right) \quad [11]$$

$$p\left(\sigma^2_{(a)b} \middle| \nu_{(a)b}, s^2_{(a)b}\right) \propto \left(\sigma^2_{(a)b}\right)^{-\left(\frac{\nu_{(a)b}+2}{2}\right)} \exp\left(-\frac{\nu_{(a)b} s^2_{(a)b}}{2\sigma^2_{(a)b}}\right), \ b=1,\dots, B; \quad [12]$$

$$p\left(\sigma^2_{(a)bb'} \middle| \nu_{(a)bb'}, s^2_{(a)bb'}\right) \propto \left(\sigma^2_{(a)bb'}\right)^{-\left(\frac{\nu_{(a)bb'}+2}{2}\right)} \exp\left(-\frac{\nu_{(a)bb'} s^2_{(a)bb'}}{2\sigma^2_{(a)bb'}}\right), \ b=1,\dots, B;$$

$$b'=b+1,\dots, B. \quad [13]$$

Here, the s_e^2, $s^2_{(a)b}$ and $s^2_{(a)bb'}$ hyperparameters represent prior values, respectively for $\sigma_e^2, \sigma^2_{(a)b}$ and $\sigma^2_{(a)bb'}$; and the ν_e, $\nu_{(a)b}$ and $\nu_{(a)bb'}$ hyperparameters state the prior degrees of belief or certainty about s_e^2, $s^2_{(a)b}$ and $s^2_{(a)bb'}$, respectively. Although prior information for segregation variances is limited (Birchmeier et al., 2002; Elzo and Wakeman, 1998), there is extensive information available on breed specific variances (Koots et al., 1994; Meyer, 1992) that could be incorporated in the analysis through [12].

The product of [5], [6], [7], [8], [11], [12] and [13] yields the joint posterior density, which is a function of all unknowns in the model given the data **y** and all hyperparameters, represented as follows:

$$
\begin{aligned}
&p\left(\boldsymbol{\beta},\mathbf{g},\mathbf{a},\sigma^2_{(a)b},\sigma^2_{(a)bb'},\sigma^2_e \mid \boldsymbol{\beta}_o,\mathbf{V}_\beta,\mathbf{g}_o,\mathbf{V}_g,\nu_e,\nu_{(a)b},\nu_{(a)bb'},s^2_e,s^2_{(a)b},s^2_{(a)bb'},\mathbf{y}\right)\\
&\propto\left(\sigma^2_e\right)^{-n/2}\exp\left(-\frac{1}{2\sigma^2_e}\left(\mathbf{y}-\mathbf{X}_1\boldsymbol{\beta}-\mathbf{X}_2\mathbf{g}-\mathbf{Z}\mathbf{a}\right)'\left(\mathbf{y}-\mathbf{X}_1\boldsymbol{\beta}-\mathbf{X}_2\mathbf{g}-\mathbf{Z}\mathbf{a}\right)\right)\\
&\times\exp\left(-.5\left(\boldsymbol{\beta}-\boldsymbol{\beta}_o\right)'\mathbf{V}_\beta^{-1}\left(\boldsymbol{\beta}-\boldsymbol{\beta}_o\right)\right)\exp\left(-.5\left(\mathbf{g}-\mathbf{g}_o\right)'\mathbf{V}_g^{-1}\left(\mathbf{g}-\mathbf{g}_o\right)\right)\left|\mathbf{G}_a\right|^{-1/2}\exp\left(-.5\mathbf{a}'\mathbf{G}_a^{-1}\mathbf{a}\right)\quad[14]\\
&\times\left(\sigma^2_e\right)^{-\left(\frac{\nu_e+2}{2}\right)}\exp\left(-\frac{\nu_e s^2_e}{2\sigma^2_e}\right)\prod_{b=1}^{B}\left(\sigma^2_{(a)b}\right)^{-\left(\frac{\nu_{(a)b}+2}{2}\right)}\exp\left(-\frac{\nu_{(a)b}s^2_{(a)b}}{2\sigma^2_{(a)b}}\right)\\
&\times\prod_{b=1}^{B-1}\prod_{b'>b}^{B}\left(\sigma^2_{(a)bb'}\right)^{-\left(\frac{\nu_{(a)bb'}+2}{2}\right)}\exp\left(-\frac{\nu_{(a)bb'}s^2_{(a)bb'}}{2\sigma^2_{(a)bb'}}\right)
\end{aligned}
$$

Inferences (e.g. estimation of genotypic means or prediction of breeding values) are derived from this joint posterior density [14]. There are two main venues to obtain the estimates: 1) an empirical Bayes approach, in which the modes of all parameters are obtained by iterative methods, such as the Expectation-Maximization (EM) algorithm (Dempster et al., 1977) and approximate "large sample" standard error derived from the information matrix; 2) a fully Bayes approach, in this case Monte Carlo Markov Chain (MCMC), a simulation-intensive algorithm is used to derive marginal densities obtaining "exact" small sample inference of any parameter (Gilks, 1996). The Metropolis-Hasting algorithm (Hasting, 1970; Metropolis, 1953) and the Gibbs sampler (Gelfand and Smith, 1990; Geman and Geman, 1984) are the most common MCMC strategies used in animal breeding. A large number of cycles are generated and samples are saved. Eventually, the Gibbs sampler converges to the joint posterior distribution. Values drawn after convergence are considered random samples from the joint posterior distribution and used to draw inference (e.g. calculate means, modes, medians, standard errors, credibility sets, etc) (Sorensen and Gianola, 2002).

Fully Bayesian methods have been used in the last decade for inference in animal breeding problems in several applications, including variance component estimation (Jensen et al., 1994; Wang et al., 1994b), predictions of selection response (Sorensen et al., 1994; Wang et al., 1994a) and in threshold models for categorical data (Sorensen et al., 1995; Wang et al., 1997). The possibility of combining prior and data information, and the ability to provide exact small sample inference, make Bayesian methods attractive for animal breeding and genetics problems, especially when the number of parameters exceeds the number of observations.

Using either an empirical or fully Bayes approach, inference on location parameters ($\boldsymbol{\beta}$, $\mathbf{g}$ and $\mathbf{a}$) of the hierarchical model described above is derived from the following mixed model equations:

$$\begin{bmatrix} \mathbf{X}_1'\mathbf{X}_1 + \mathbf{V}_\beta^{-1}\sigma_e^2 & \mathbf{X}_1'\mathbf{X}_2 & \mathbf{X}_1'\mathbf{Z} \\ \mathbf{X}_2'\mathbf{X}_1 & \mathbf{X}_2'\mathbf{X}_2 + \mathbf{V}_g^{-1}\sigma_e^2 & \mathbf{X}_2'\mathbf{Z} \\ \mathbf{Z}'\mathbf{X}_1 & \mathbf{Z}'\mathbf{X}_2 & \mathbf{Z}'\mathbf{Z} + \mathbf{G}_a^{-1}\sigma_e^2 \end{bmatrix} \begin{bmatrix} \hat{\boldsymbol{\beta}} \\ \hat{\mathbf{g}} \\ \hat{\mathbf{a}} \end{bmatrix} = \begin{bmatrix} \mathbf{X}_1'\mathbf{y} + \mathbf{V}_\beta^{-1}\boldsymbol{\beta}_o\sigma_e^2 \\ \mathbf{X}_2'\mathbf{y} + \mathbf{V}_g^{-1}\mathbf{g}_o\sigma_e^2 \\ \mathbf{Z}'\mathbf{y} \end{bmatrix} \quad [15]$$

Note that if $\mathbf{G}_a^{-1}$ based on Lo et al. (1993) is replaced by the classical $\frac{\mathbf{A}^{-1}}{\sigma_a^2}$, with $\mathbf{A}$ being a numerator relationship matrix, equations on [15] become equivalent to the ones proposed by Klei et al. (1996). Additionally, if $\mathbf{V}_\beta^{-1} \to \mathbf{0}$, then [15] equates to Henderson' mixed model equations (Henderson, 1973).

The HMBAM was applied to analyze 22,717 post-weaning gain (PWG) records of a beef cattle population under genetic evaluation in Brazil, consisting of Herefords and crosses Hereford × Nelore (Cardoso and Tempelman, 2003). Including base animals, 40,082 animals were in the pedigree, pertaining to 15 different herds. Results were compared to those from a standard animal model (AM) that assumes equal breed variances and no variance due to segregation. MCMC was the estimation method used for both models. Posterior means (± standard deviation) in kg for fixed genetic effects on $\mathbf{g}$ were obtained by HMBAM, using Kinghorn's parameterization [4] (Kinghorn, 1980) and non-informative priors, were -29.3 ± 10.1 for the additive (A) effect (representing the proportion of Nelore genes); 36.7 ± 5.0 for dominance (D) and -30.8 ± 9.0 for A × A interaction effects. As expected, D favorably affected PWG while A × A interaction had an adverse effect. The authors however failed to fit the two-loci model (Hill, 1982; Wolf et al., 1995) due to extremely high correlations between coefficients of genetic effects: ranging from 0.92 between A × A and D × D to a maximum of 0.99 between D and A × D. A similar situation was observed by Birchmeier et al. (2002), who used a model with only A and D as fixed genetic effects and no epistatic effects. Certainly, incorporation of prior information available from the literature on fixed genetic effects in the analyses of poorly structured datasets, as those above, will be helpful on accurately predicting performance on these populations. The models based on recombination loss (Dickerson, 1973; Kinghorn, 1980; Kinghorn, 1987) present an interesting compromise between the two-loci model (Hill, 1982;

Wolf et al., 1995) and the purely dominance models, allowing for epistatic effects with fewer parameters (only one in two breed scenario); however, availability of reliable estimates of epistatic effects is still limited (Arthur et al., 1999; Koch et al., 1985).

Nelore and Hereford additive genetic variances of PWG in kg^2 obtained by Cardoso and Tempelman (2003) using HMBAM differed substantially. Herefords had a posterior mean genetic variance of 93.1 with a 95% posterior probability interval (PPI) of [70.1, 118.0] whereas the corresponding values for the Nelore were 33.8 and [20.6, 52.5]. The AM estimate of a common genetic variance had an intermediate value of 60.4 between the Nelore and Hereford variances and PPI of [44.4, 77.5]. The posterior mean variance due to the segregation between these breeds was 15.1 with a 95% PPI of [5.0, 33.8], having a magnitude of about 45% of the Nelore genetic variance, but represented only 16% of Hereford genetic variance. These percentages are reasonably larger than those found for birth and weaning weight of crosses of Angus and Brahman in Florida, ranging from 1.4 to 3.1% (Elzo and Wakeman, 1998). The magnitude of the segregation variance relative to the Hereford genetic variance (16%) found by Cardoso and Tempelman (2003) was, however, similar in magnitude to the results obtained for birth weight of Hereford-Nelore crosses in Argentina (16.5%) (Birchmeier et al., 2002). In this data set, the Nelore genetic variance was 73.5% of the magnitude of the Hereford genetic variance in birth, while in Cardoso and Tempelman (2003) Nelores had a genetic variance for PWG that was only 36.2% that of Herefords. The advantage of HMBAM is the flexibility on modeling the genetic variability of the different breed composition groups of crossbred populations. With HMBAM the genetic variance of each genotypic group is a function of breed specific variances and the segregation variance; for example, the genetic variance of the F_2 groups is obtained by $0.5\sigma^2_{a1} + 0.5\sigma^2_{a2} + \sigma^2_{a12}$ (Lo et al., 1993); whereas, a common genetic variance is attribute to all compositions in AM. This will affect the dispersion of the genetic values and the accuracy of predictions, as it is clear by the different heritabilities obtained by Cardoso and Tempelman (unpublished data) for the different genotypes (Table 1). The benefits of HMBAM over AM are, however, dependent on the magnitude of difference among breed specific genetic variances and of the segregation variance.

Expected progeny differences (EPD) in a multiple-breed scenario are a function of fixed and random additive genetic effects (Arnold et al., 1992; Elzo, 1994; Klei et al., 1996; Sullivan et al., 1999). The coefficient for the fixed effect (A, D, A $\times$ A, etc.) will depend on the mate's genotype and therefore, comparison between candidates for selection should be made for specific breed compositions of the mates. The additive genetic effect corresponds to the general combining ability of the individual and does not depend on the genotype of the mates. The determination of specific combining abilities requires the estimation of non-additive genetic variances. Even though theory for an additive and dominance two-breed genetic model is available (Lo et al., 1995), this model requires a larger number of variance components to be estimated and may be cumbersome for practical applications. A simplified formulation for general crossbreeding scenarios including additive effects and regression approach to account for non-additive effects (sire × dam genotype interaction) is also available (Elzo, 1994).

Conclusions and implications to genetic improvement of beef cattle

The accurate prediction of performance of crossbred animals is one of the most important factors ultimately determining the success of breeding programs in the industry today, since a substantial portion of the beef is produced from crossbred animals. These predictions require reliable estimates of genotypic means and breeding values for complex multiple-breed populations. Bayesian inference provides a general framework for optimal merging of information derived from data with prior knowledge to achieve this task.

Hierarchical Bayes models are extremely powerful, yet flexible, tools available to the breeders for better describing the biological and environmental complexities behind the performance of beef crosses. The implementation of a more realistic modeling of the additive genetic variability and correlation between relatives on crossbred populations (Lo et al., 1993) will help to improve accuracy of genetic predictions and, consequently, selection response (Falconer and Mackay, 1996). Increased genetic progress is a key factor helping producers to achieve efficiency in their systems.

Finally, beef cattle performance is, in general, measured across diverse production systems and environments, with data quality often compromised by the occurrence of recording error, preferential treatment and/or the effect of injury or disease. Hierarchical models present a general framework to tackle problems arising from the nature of field data structure; a variety of multistage propositions have been advocated to handle issues such as heterogeneity of variance (Foulley et al., 1992; Foulley and Quaas, 1995; Gianola et al., 1992; SanCristobal et al., 1993), outlying observations (Rosa, 1999; Stranden and Gianola, 1998, 1999), and uncertain paternity as typical of multiple-sire mating (Cardoso and Tempelman, ; Foulley et al., 1987; Henderson, 1988), for instance. These situations can be addressed individually, but there is no conceptual difficulty in handling them jointly. These critical issues arising from field data could be naturally incorporated into HMBAM by adding levels of complexity to its hierarchy.

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Table 1. Posterior mean, standard deviation (std), and 2.5% and 97.5% percentiles of direct additive heritability of post-weaning gain (PWG) for different genotypes, obtained by hierarchical multiple-breed animal model (HMBAM) and animal model (AM).

Model	Genotype	Mean	Std	2.5%	97.5%
AM	*Overall*	0.15	0.02	0.11	0.19
HMBAM	*Nelore*	0.09	0.02	0.06	0.14
	Hereford	0.22	0.03	0.17	0.27
	F_1	0.16	0.02	0.12	0.20
	F_2	0.19	0.03	0.15	0.25
	BC_1	0.14	0.02	0.11	0.19
	BC_2	0.21	0.02	0.16	0.25
	Adv38[a]	0.20	0.03	0.16	0.26

[a] Advanced generation of 3/8 Nelore and 5/8 Hereford composition.

Seedstock Producer Honor Roll of Excellence

John Crowe	CA	1972
Dale H. Davis	MT	1972
Elliot Humphrey	AZ	1972
Jerry Moore	OH	1972
James D. Bennett	VA	1972
Harold A. Demorest	OH	1972
Marshall A. Mohler	IN	1972
Billy L. Easley	KY	1972
Messersmith Herefords	NE	1973
Robert Miller	MN	1973
James D. Hemmingsen	IA	1973
Clyde Barks	ND	1973
C. Scott Holden	MT	1973
William F. Borror	CA	1973
Raymond Meyer	SD	1973
Heathman Herefords	WA	1973
Albert West III	TX	1973
Mrs. R. W. Jones, Jr.	GA	1973
Carlton Corbin	OK	1973
Wilfred Dugan	MO	1974
Bert Sackman	ND	1974
Dover Sindelar	MT	1974
Jorgensen Brothers	SD	1974
J. David Nichols	IA	1974
Bobby Lawrence	GA	1974
Marvin Bohmont	NE	1974
Charles Descheemacker	MT	1974
Bert Crame	CA	1974
Burwell M. Bates	OK	1974
Maurice Mitchell	MN	1974
Robert Arbuthnots	KS	1975
Glenn Burrows	NM	1975
Louis Chestnut	WA	1975
George Chiga	OK	1975
Howard Collins	MO	1975
Jack Cooper	MT	1975
Joseph P. Dittmer	IA	1975
Dale Engler	KS	1975
Leslie J. Holden	MT	1975
Robert D. Keefer	MT	1975
Frank Kubik, Jr.	ND	1975
Licking Angus Ranch	NE	1975
Walter S. Markham	CA	1975
Gerhard Mittnes	KS	1976
Ancel Armstrong	VA	1976
Jackie Davis	CA	1976
Sam Friend	MO	1976
Healey Brothers	OK	1976
Stan Lund	MT	1976
Jay Pearson	ID	1976
L. Dale Porter	IA	1976
Robert Sallstrom	MN	1976
M.D. Shepherd	ND	1976
Lowellyn Tewksbury	ND	1976
Robert Brown	TX	1977
Glen Burrows	NM	1977
Henry, Jeanette Chitty	NM	1977
Tom Dashiell	WA	1977
Lloyd DeBruycker	MT	1977
Wayne Eshelman	WA	1977
Hubert R. Freise	ND	1977
Floyd Hawkins	MO	1977
Marshall A. Mohler	IN	1977
Clair Percel	KS	1977
Frank Ramackers, Jr.	NE	1977
Loren Schlipf	IL	1977
Tom & Mary Shaw	ID	1977
Bob Sitz	MT	1977
Bill Wolfe	OR	1977
James Volz	MN	1977
A. L. Frau		1978
George Becker	ND	1978
Jack Delaney	MN	1978
L. C. Chestnut	WA	1978
James D. Bennett	VA	1978
Healey Brothers	OK	1978
Frank Harpster	MO	1978
Bill Womack, Jr.	AL	1978
Larry Berg	IA	1978
Buddy Cobb	MT	1978
Bill Wolfe	OR	1978
Roy Hunt	PA	1978
Harold Anderson	SD	1977
William Borror	CA	1977
Del Krumwied	ND	1979
Jim Wolf	NE	1979
Rex & Joann James	IA	1979
Leo Schuster Family	MN	1979
Bill Wolfe	OR	1979
Jack Ragsdale	KY	1979
Floyd Mette	MO	1979
Glenn & David Gibb	IL	1979
Peg Allen	MT	1979
Frank & Jim Wilson	SD	1979
Donald Barton	UT	1980
Frank Felton	MO	1980
Frank Hay	CAN	1980
Mark Keffeler	SD	1980
Bob Laflin	KS	1980
Paul Mydland	MT	1980
Richard Tokach	ND	1980
Roy & Don Udelhoven	WI	1980
Bill Wolfe	OR	1980
John Masters	KY	1980
Floyd Dominy	VA	1980
James Bryany	MN	1980
Charlie Richards	IA	1980
Blythe Gardner	UT	1980
Richard McLaughlin	IL	1980
Bob Dickinson	KS	1981
Clarence Burch	OK	1981
Lynn Frey	ND	1981
Harold Thompson	WA	1981
James Leachman	MT	1981
J. Morgan Donelson	MO	1981
Clayton Canning	CAN	1981
Russ Denowh	MT	1981
Dwight Houff	VA	1981
C. W. Cronwell	IA	1981
Bob & Gloria Thomas	OR	1981
Roy Beeby	OK	1981
Herman Schaefer	IL	1981
Myron Aultfathr	MN	1981
Jack Ragsdale	KY	1981
W. B. Williams	IL	1982
Garold Parks	IA	1982
David A. Breiner	KS	1982
Joseph S. Bray	KY	1982
Clare Geddes	CAN	1982
Howard Krog	MN	1982
Harlin Hecht	MN	1982
William Kottwitz	MO	1982
Larry Leonhardt	MT	1982
Frankie Flint	MN	1982
Gary & Gerald Carlson	NS	1982
Bob Thomas	OR	1982
Orville Stangl	SD	1982
C. Ancel Armstrong	KS	1983
Bill Borror	CA	1983
Charles E. Boyd	KY	1983
John Bruner	SD	1983
Leness Hall	WA	1983
Ric Hoyt	OR	1983
E. A. Keithley	MO	1983
J. Earl Kindig	MO	1983
Jake Larson	ND	1983
Harvey Lemmon	GA	1983
Frank Myatt	IA	1983
Stanley Nesemeier	IL	1983
Russ Pepper	MT	1983
Robert H. Schafer	MN	1983
Alex Stauffer	WI	1983
D. John & Lebert Shultz	MO	1983
Phillip A. Abrahamson	MN	1984
Ron Beiber	SD	1984
Jerry Chappel	VA	1984
Charles W. Druin	KY	1984
Jack Farmer	CA	1984
John B. Green	LA	1984
Ric Hoyt	OR	1984
Fred H. Johnson	OH	1984
Earl Kindig	VA	1984
Glen Klippenstein	MO	1984
A. Harvey Lemmon	GA	1984
Lawrence Meyer	IL	1984
Donn & Sylvia Mitchell	CAN	1984
Lee Nichols	IA	1984
Clair K. Parcel	KS	1984
Joe C. Powell	NC	1984
Floyd Richard	ND	1984
Robert L. Sitz	MT	1984
Ric Hoyt	OR	1984
J. Newbill Miller	VA	1985
George B. Halterman	WV	1985
David McGehee	KY	1985
Glenn L. Brinkman	TX	1985
Gordon Booth	WY	1985
Earl Schafer	MN	1985
Marvin Knowles	CA	1985
Fred Killam	IL	1985

Tom Perrier .... KS 1985
Don W. Schoene .... MO 1985
Everett & Ron Batho .... CAN ... 1985
Bernard F. Pedretti .... WI 1985
Arnold Wienk .... SD 1985
R. C. Price .... AL 1985
Clifford & Bruce Betzold .... IL 1986
Gerald Hoffman .... SD 1986
Delton W. Hubert .... KS 1986
Dick & Ellie Larson .... WI 1986
Leonard Lodden .... ND 1986
Ralph McDanolds .... VA 1986
W.D. Morris/James Pipkin .... MO 1986
Roy D. McPhee .... CA 1986
Clarence VanDyke .... MT 1986
John H. Wood .... SC 1986
Evin & Verne Dunn .... CAN ... 1986
Glenn L. Brinkman .... TX 1986
Jack & Gini Chase .... WY 1986
Henry & Jeanette Chitty .... FL 1986
Lawrence H. Graham .... KY 1986
A. Loyd Grau .... NM 1986
Matthew Warren Hall .... AL 1986
Richard J. Putnam .... NC 1986
R.J. Steward/P.C. Morrissey .... PA 1986
Leonard Wulf .... MN 1986
Charles & Wynder Smith .... GA 1987
Lyall Edgerton .... CAN ... 1987
Tommy Branderberger .... TX 1987
Henry Gardiner .... KS 1987
Gary Klein .... ND 1987
Ivan & Frank Rincker .... IL 1987
Larry D. Leonhardt .... WY 1987
Harold E. Pate .... IL 1987
Forrest Byergo .... MO 1987
Clayton Canning .... CAN ... 1987
James Bush .... SD 1987
R.J. Steward/P.C. Morrissey ...... MN 1987
Eldon & Richard Wiese .... MN 1987
Douglas D. Bennett .... TX 1988
Don & Diane Guilford &
David & Carol Guilford ...... CAN ... 1988
Kenneth Gillig .... MO 1988
Bill Bennett .... WA 1988
Hansell Pile .... KY 1988
Gino Pedretti .... CA 1988
Leonard Lorenzen .... OR 1988
George Schlickau .... KS 1988
Hans Ulrich .... CAN ... 1988
Donn & Sylvia Mitchell .... CAN ... 1988
Darold Bauman .... WY 1988
Glynn Debter .... AL 1988
William Glanz .... WY 1988
Jay P. Book .... IL 1988
David Luhman .... MN 1988
Scott Burtner .... VA 1988
Robert E. Walton .... WA 1988
Harry Airey .... CAN ... 1989
Ed Albaugh .... CA 1989
Jack & Nancy Baker .... MO 1989
Ron Bowman .... ND 1989
Jerry Allen Burner .... VA 1989
Glynn Debter .... AL 1989
Sherm & Charlie Ewing .... CAN ... 1989
Donald Fawcett .... SD 1989
Orrin Hart .... CAN ... 1989
Leonard A. Lorenzen .... OR 1989
Kenneth D. Lowe .... KY 1989
Tom Mercer .... WY 1989
Lynn Pelton .... KS 1989
Lester H. Schafer .... MN 1989
Bob R. Whitmire .... GA 1989
Dr. Burleigh Anderson .... PA 1990
Boyd Broyles .... KY 1990
Larry Earnhart .... WY 1990
Steven Forrester .... Mis 1990
Doug Fraser .... CAN ... 1990
Gerhard Gueggenberger .... CA 1990
Douglas & Molly Hoff .... SD 1990
Richard Janssen .... KS 1990
Paul E. Keffaber .... IN 1990
John & Chris Oltman .... WI 1990
John Ragsdale .... KY 1990
Otto & Otis Rincker .... IL 1990
Charles & Rudy Simpson .... CAN ... 1990
T.D. & Roger Steele .... VA 1990
Bob Thomas Family .... OR 1990
Ann Upchurch .... AL 1991
N. Wehrmann/R. McClung .... VA 1991
John Bruner .... SD 1991
Ralph Bridges .... GA 1991
Dave & Carol Guilford .... CAN ... 1991
Richard/Sharon Beitelspacher ... SD 1991
Tom Sonderup .... NE 1991
Steve & Bill Florshcuetz .... IL 1991
R. A. Brown .... TX 1991
Jim Taylor .... KS 1991
R.M. Felts & Son Farm .... TN 1991
Jack Cowley .... CA 1991
Rob & Gloria Thomas .... OR 1991
James Burns & Sons .... WI 1991
Jack & Gini Chase .... WY 1991
Summitcrest Farms .... OH 1991
Larry Wakefield .... MN 1991
James R. O'Neill .... IA 1991
Francis & Karol Bormann .... IA 1992
Glenn Brinkman .... TX 1992
Bob Buchanan Family .... OR 1992
Tom & Ruth Clark .... VA 1992
A. W. Compton, Jr. .... AL 1992
Harold Dickson .... MO 1992
Tom Drake .... OK 1992
Robert Elliott & Sons .... TN 1992
Dennis, David, Danny Geffert .. WI 1992
Eugene B. Hook .... MN 1992
Dick Montague .... CA 1992
Bill Rea .... PA 1992
Calvin & Gary Sandmeier .... SD 1992
Leonard Wulf & Sons .... MN 1992
R. A. Brown .... TX 1993
Norman Bruce .... IL 1993
Wes & Fran Cook .... NC 1993
Clarence/Elaine/Adam Dean ..... SC 1993
D. Eldridge & Y. Adcock .... OK 1993
Joseph Freund .... CO 1993
R. B. Jarrell .... TN 1993
Rueben, Leroy, Bob Littau .... SD 1993
J. Newbill Miller .... VA 1993
J. David Nichols .... IA 1993
Miles P. "Buck" Pangburn .... IA 1993
Lynn Pelton .... KS 1993
Ted Seely .... WY 1993
Collin Sander .... SD 1993
Harrell Watts .... AL 1993
Bob Zarn .... MN 1993
Ken & Bonnie Bieber .... SD 1994
John Blankers .... MN 1994
Jere Caldwell .... KY 1994
Mary Howe di'Zerega .... VA 1994
Ron & Wayne Hanson .... CAN ... 1994
Bobby F. Hayes .... AL 1994
Buell Jackson .... IA 1994
Richard Janssen .... KS 1994
Bruce Orvis .... CA 1994
John Pfeiffer Family .... OK 1994
Calvin & Gary Sandmeier .... SD 1994
Dave Taylor/Gary Parker .... WY 1994
Bobby Aldridge .... NC 1995
Gene Bedwell .... IA 1994
Gordon & Mary Ann Booth ..... WY 1995
Ward Burroughs .... CA 1995
Chris & John Christensen .... SD 1995
Mary Howe de'Zerega .... VA 1995
Maurice Grogan .... MN 1995
Donald J. Hargrave .... CAN ... 1995
Howard & JoAnne Hillman .... SD 1995
Mack, Billy, Tom Maples .... AL 1995
Mike and Carolyn McDowell .... VA 1995
Tom Perrier .... KS 1995
John Robbins .... MT 1995
Thomas Simmons .... VA 1995
D. Borgen & B. McCulloh .... WI 1996
Chris & John Christensen .... SD 1996
Frank Felton .... MO 1996
Galen & Lori Fink .... KS 1996
Cam, Spike, Sally Forbes .... WY 1996
Mose & Dave Hebbert .... NE 1996
C. Knight & B. Jacobs .... OK 1996
Robert C. Miller .... MN 1996
Gerald & Lois Neher .... IL 1996
C. W. Pratt .... VA 1996
Frank Schiefelbein .... MN 1996
Ingrid & Willy Volk .... NC 1996
William A. Womack, Jr. .... AL 1996
Alan Albers .... KS 1997
Gregg & Diane Butman .... MN 1997
Blaine & Pauline Canning .... CAN ... 1997
Jim & JoAnn Enos .... IL 1997
Harold Pate .... AL 1997
E. David Pease .... CAN ... 1997
Juan Reyes .... WY 1997
James I. Smith .... NC 1997
Darrel Spader .... SD 1997
Bob & Gloria Thomas .... OR 1997
Nicholas Wehrmann
& Steve Munger .... VA 1997
James D. Bennett Family .... VA 1998
Dick & Bonnie Helms .... NE 1998
Dallis & Tammy Basel .... SD 1998
Duane L. Kruse Family .... IL 1998
Abigail & Mark Nelson .... CA 1998
Airey Family .... MB 1998
Dave & Cindy Judd .... KS 1998
Earl & Nedra McKarns .... OH 1998
Tom Shaw .... ID 1998
Wilbur & Melva Stewart .... AB 1998
Adrian Weaver & Family .... CO 1998
Kelly & Lori Darr .... WY 1999

Kent Klineman
& Steve Munger .... SD 1999
John Kluge .... VA 1999
Kramer Farms .... IL 1999
Noller & Frank Charolais .... IA 1999
Lynn & Gary Pelton .... KS 1999
Rausch Herefords .... SD 1999
Duane Schieffer
& Terry O'Neill .... MT 1999
Tony Walden .... AL 1999
Ralph Blalock, Sr., Blalock, Jr.
& David Blalock .... NC 2000
Larry & Jean Croissant .... CO 2000
John C. Curtin .... IL 2000
Galen, Lori & Megan Fink .... KS 2000
Harlin & Susan Hecht .... MN 2000
Banks & Margo Herndon .... AL 2000
Ken Klineman
& Steve Munger .... SD 2000
Jim & Janet Listen .... WY 2000
Mike & T.K. McDowell .... VA 2000
Vaughn Meyer & Family .... SD 2000
Blane & Cindy Nagel .... SD 2000
John & Betty Rotert .... MO 2000
Alan & Deb Vedvei .... SD 2000
Bob & Nedra Funk .... OK 2001
Steve Hillman & Family .... IL 2001
Tom Lovell .... AL 2001
McAllen Ranch .... TX 2001
Kevin, Jessica, & Emily Moore .. TX 2001
Blane & Cindy Nagel .... SD 2001
Don & Priscilla Nielsen .... CO 2001
George W. Lemm, Marvin
& Katheryn Robertson .... VA 2001
Dale, Don & Mike Spencer .... NE 2001
Ken Stielow & Family .... KS 2001
Eddie L. Sydenstricker .... MO 2001
Dave Gust Family .... MO 2002
DeBruycker Charolais .... MT 2002
Ellis Farms .... IL 2002
Holly Hill Farm/Dwight Houff .. VA 2002
Isa Cattle Co., Inc./Lasater FamilyTX .. 2002
Lyons Ranch .... KS 2002
Noller & Frank Charolais .... IA 2002
Rishel Angus .... NE 2002
Running Creek Ranch/
Joseph D. Freund .... CO 2002
Shamrock Angus/
Parker Family .... WY 2002
Stewart Angus .... IN 2002
Triple "M" Farm/
Mayfield Family .... AL 2002

Seedstock Producer of the Year

John Crowe	CA	1972
Mrs. R. W. Jones	GA	1973
Carlton Corbin	OK	1974
Leslie J. Holden	MT	1975
Jack Cooper	MT	1975
Jorgensen Brothers	SD	1976
Glenn Burrows	NM	1977
James D. Bennett	VA	1978
Jim Wolfe	NE	1979
Bill Wolfe	OR	1980
Bob Dickinson	KS	1981
A.F. "Frankie" Flint	NM	1982
Bill Borror	CA	1983
Lee Nichols	IA	1984
Ric Hoyt	OR	1985
Leonard Lodoen	ND	1986
Henry Gardiner	KS	1987
W.T. "Bill" Bennett	WA	1988
Glynn Debter	AL	1989
Doug & Molly Hoff	SD	1990
Summitcrest Farms	OH	1991
Leonard Wulf & Sons	MN	1992
R. A. "Rob" Brown	TX	1993
J. David Nichols	IA	1993
Richard Janssen	KS	1994
Tom & Carolyn Perrier	KS	1995
Frank Felton	MO	1996
Bob & Gloria Thomas	OR	1997
Wehrmann Angus Ranch	VA	1997
Flying H Genetics	NE	1998
Knoll Crest Farms	VA	1998
Morven Farms	VA	1999
Fink Beef Genetics	KS	2000
Sydenstricker Angus Farms	MO	2001
Dave Gust Family	MO	2002

Circle A Ranch Receives the 2002 BIF Outstanding Seedstock Producer Award

Circle A Ranch was named the Beef Improvement Federation (BIF) Outstanding Seedstock Producer of the Year at the organization's 34th annual convention in Omaha, Neb., July 12, 2002.

Circle A Ranch is headquartered in Iberia, Mo., with satellite operations in Stockton and Huntsville, Mo., and Lineville, Iowa. The ranch headquarters was established 12 years ago and is home to 700 registered Angus and Red Angus females in addition to 1,800 commercial Angus cows. Circle A runs approximately 2,000 commercial Angus cows near Huntsville, Mo., and 2,200 commercial Angus cows at Stockton, Mo. Approximately 2,100 head of fall and spring replacement heifers are developed at Lineville, Iowa.

The Dave Gust family started Circle A with two main goals: 1) Produce the best possible genetics in the industry and 2) provide service to customers in the best way possible.

In their efforts to produce superior genetics, Circle A has

- contributed more than 4,000 carcass records to the Angus Herd Improvement Records (AHIR) program from their designed progeny-testing program;
- established the Angus Sire Alliance;
- implemented economic selection indexing into its breeding program;
- constructed a feed efficiency research center;
- established a DNA repository of approximately 3,500 steer samples;
- produced seven clone-mate families from proven sire and dam cell donors;
- constructed their own Internet-based data collection system that ties together all of the four ranches; and
- computed within-herd expected progeny differences (EPDs) twice each year for the commercial operations.

To better serve customers, Circle A has held seedstock female sales for eight years and bull sales for 10. The ranch annually hosts four feeder-calf sales that highlight genetics from their customers, and it employs a full-time staff member with commercial marketing responsibilities.

Circle A Ranch is owned by Dave Gust Sr. and Family and is managed by Mark Akin.

2003 BIF Seedstock Producer Award Nominees

Bedwell Charolais

Gene and Ruth Bedwell, Iowa

In 1965, we purchased 40 acres of rolling, green pasture and hay ground in south central Iowa (cow country). Ruth and I worked full time in Des Moines, but wanted to farm since we had both been raised on farms. In 1966, we bought our first cows, ten half-blood Charolais, then in 1969 we bought the 160 acres of crop and pasture ground adjoining our farm and in the following year, we purchased ten more half-blood, Charolais x Hereford cows plus a bull and started raising and keeping our own replacement heifers. From this start of twenty half-blood cows, we have bred up to a complete purebred, registered herd.

Ruth quit working in town when we began having our children, and I continued to work there until 1972, when we purchased more farm ground and pasture that adjoined ours. Today, we are still living in the same home that we moved into in 1965. Our farm has expanded to 640 acres, with a 100+ spring calving cowherd. In order to raise and support a family, we needed a product that we could promote and merchandize ourselves. The purebred livestock industry was our opportunity to do this as a family, without off-farm income.

When you approach our farm through the rolling green hills, dotted with white cattle, you instantly get the impression of an expertly maintained, no-nonsense cattle operation. Everywhere you look things are painted, mowed and in as close-to-perfect order as things can be on a working ranch without unnecessary frills.

Boyd Farm

L.A. (Lee) Boyd, IV and Harriet Boyd, Alabama

Boyd Farms is located in the heart of the Wiregrass region of Alabama. Established over 80 years ago, Boyd Farms breeds purebred Simmental genetics. With goals including structural correctness, muscling, easy fleshing, and high performance, Boyd Farms plans to consistently produce the type of genetics commercial and purebred cattle producers are looking for to improve their herds. The current cow herd consists of 125 females which are bred AI to bulls with balanced EPD trait values. Bulls are matched to individual cow groups to compliment cow genetics. Over 40 bulls are marketed each year primarily through private treaty and the Wiregrass BCIA Grazing Evaluation Sale. Heifers are also marketed through Alabama Simmental Association Sales, BCIA Heifer Sales and private treaty. In 2002, breeding stock was also marketed to Venezuela. Pastures are primarily bahia grass and coastal Bermuda. In the summer, sudan grass is planted to supplement grazing or for hay production. Pastures are overseeded for winter grazing and crabgrass is planted on idle peanut land. Last year, 240 acres was cross fenced and rotational grazing implemented. Financial information is analyzed through the Wiregrass Farm Analysis Program. This information is allowing Boyd Farms to continually reduce costs without sacrificing performance. Lee Boyd is active in his community and state organizations. He has been a regional vice president of the Alabama Cattlemen's Association and currently serves on the Board of Directors for the Alabama Simmental and Coffee County Cattlemen's Associations.

Camp Cooley Ranch

Mr. Klaus Birkel, owner; Mr. Mark Cowan, manager; Texas

Camp Cooley Ranch is a progressive beef operation located east of Franklin, TX. Set on gently rolling hills, the 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 2,000 registered females at the ranch and additional cattle at joint ventures in Mexico, Bolivia, Argentina and Brazil.

Camp Cooley Ranch has taken progressive measures, funding and participating in numerous research projects across the nation. With the development of programs such as the Producer Revenue Enhancement Program (P.R.E.P.), they continue to stay on the forefront of the industry with carcass research and the collection of data.

During the calendar year 2003, Camp Cooley Ranch will market over 700 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 staff at Camp Cooley Ranch strives to provide customer service that is second to none while providing performance backed seed stock.

Hilltop Ranch

Mr. and Mrs. Bill Carr, Texas

I have been raising cattle for a little over fifty years starting with a small interest in a family operation in the early 1950's in the brush country of Webb County, Texas. By 1988 and through various means, including the borrowing of money to buy other ranch lands and negotiating tax free exchanges of same with other family members, I acquired sole ownership of the original Webb County ranch. In 1994 we bought another ranch in the "Hill Country" of Kendall

County, North of San Antonio and South of Fredericksburg, Texas. It was a productive ranch for that scenic part of the country in that it had most of the cedar removed and a good turf of grass with miles of crystal clear spring-fed creeks that flow most of the year. In 1996 we bought another ranch in the very productive sandy loam portion of Wilson County, Texas, about 30 miles Southeast of San Antonio. With additional land clearing, fencing, water well drilling and center pivot system installation, I keep this place in Coastal Bermuda and oats. These ranches total about 14,000 acres. The Webb County Ranch is by far the biggest part of the operation and where we call home, but we get to each ranch all but two or three weeks of the year.

I've always considered ranching to be a two pronged effort. One being the transformation to and maintenance of productive range and pasture land and the other being the operation of an efficient, and hopefully profitable, cattle raising and marketing program.

What success I've had has probably been primarily attributable to having early in my endeavors worked out a uniquely efficient process of converting the mixed brush and prickly pear infested range lands of Webb County to relatively clean grass pastures and a strong emphasis on performance in our cattle operation.

Our breed is Beefmaster. Our capacity is about 1000 cows, but having been through numerous droughts over the years we will usually be stocked with 700 to 900 breeding age females. About half of these will be purebred Beefmaster females that we synchronize, heat detect and A.I. and then break into groups with one Beefmaster followup bull on each group for an additional approximately 60 days. The other half are commercial Braford cows that we synchronize and use for recipients for Beefmaster embryos. I put an English breed bull on these recipients right after they receive an embryo, or fail to qualify for same, to get a readily distinguishable and marketable commercial calf as soon as possible.

We calve in the spring, wean in the fall, grow our replacement heifers on irrigatible oats at the Wilson County ranch to approximately 14 months of age and breed them to calve as two year olds. We grow our sale and replacement bull calves in grass traps of 50 acres or more supplemented with a growing supplemental feed formulated for our grass by Texas A&M University staff. A sampling of our bull calves that are culled at weaning are knife cut, preconditioned and fed each year in a retained ownership program where I receive gains and carcass data.

We collect weaning weights, yearling weights and post weaning gains. As yearlings, we measure pelvics and have sonogram carcass evaluations made of all retained heifers and bulls and measure the scrotals of such bulls. We keep complete production records on our cows and they are culled on their calving frequency and overall calf quality.

Our cattle or genetics have been involved in a number of University sponsored research projects and have done well in same. Very recently, Texas A&M University concluded a three year project of producing and evaluating through slaughter, calves out of their Angus test herd and from the semen from 15 Beefmaster bulls. One of our bulls was involved and, while doing well in all traits measured, produced calves that were number one in yearling weight, ribeye size and tenderness substantiating their growth, muscularity and eating quality.

We advertise our cattle in cattle magazines, newspapers and other media and market them through occasional production sales, consignment sales and private treaty and most importantly stand behind them beyond the requirements of such sales.

Moser Ranch

Harry and Lisa Moser Family, Kansas

The spring of 1987 saw the Moser Ranch market four bulls as breeding stock to local cattlemen, and in their 11th annual sale on February 8, 2003, 118 head of Simmental, Angus and Red Angus bulls sold into seven states and one Canadian province. Harry, a native of North Dakota and graduate of North Dakota State University in Agriculture/Animal Science, and Lisa, a native Kansan with a degree in Agriculture/Animal Science from Kansas State University, have been in the cattle business all of their lives. Along with their children, Cameron (19), Kendra (16) and Kayla (11), the Mosers own and manage the Moser Ranch, located approximately 40 miles northeast of Manhattan in the northern Flint Hills of Kansas.

With the use of proven, predictable genetics, and extensive artificial insemination (AI) and embryo transfer (ET) program, utilizing every available economic and performance measurement as much as possible, the Mosers have built a very strong genetic base in their cowherd, while at the same time developing a strong customer service program. 150 spring and 20 fall-calving Simmental females, 40 spring and 10 fall-calving Angus, 25 Red Angus spring-calving females, and 50 fall-calving commercial Angus females make up the cowherd numbers on the Moser Ranch. Currently, seven producers are cooperator herds for the embryo transfer program, which began in 1991 and this enables the Mosers to produce approximately 150 additional calves per year. Bulls are sold primarily to commercial cattlemen in the annual bull sale, and females and embryos are sold private treaty.

The Mosers are very "hands-on" with respect to their entire operation. Whether it be day-to-day care of the cowherd, sire selection and mating decisions, all heat detection and AI work, weaning and development of bulls and replacements, putting up and grinding feed, all aspects of sale management and promotion, financial and breed association bookwork, computer time and web site updates, customer service and consultations or developing marketing options and feeding alliances, the family works together and utilizes the strengths each person brings to the operation.

In the past five years, the commitment to helping market customer calves through various avenues has been especially rewarding. Two alliances with which they are involved provide feedlot and carcass data on each individual animal that goes through each program. In addition, a Moser Influence Preconditioned Calf Sale held each fall gives still other customers a very lucrative option. Continued customer and consumer education is addressed regularly by holding seminars and hosting tours to enhance understanding of the beef industry.

Mystic Hill Farms

David and Charlotte Caldwell, Virginia

Mystic Hill Farms, established in 1988 by the Caldwells located in the Blue Ridge Mountain foothills of Culpeper County, is committed to the breeding of registered Angus seedstock to serve all phases of the beef industry. The primary objective is to address the needs of the commercial cow-calf producer with genetics developed in a practical environment. Mystic Hill runs 850 cattle on 1800 acres under conditions experienced by producers in the region. The farm was third, eighth and fourth in Angus registrations for 2000, 2001 and 2003 respectively in Virginia and had 7 bulls in 2002 Angus sire summary, one of which is leased to a major bull stud and 3 bulls in the Braunvieh sire summary.

Mystic Hill calves out 300 purebred Angus and 30 purebred Braunvieh cows mated to performance sires. resulting in functional and balanced offspring that avoid extremes. Calving seasons include both spring and fall to efficiently use facilities, labor and bull power. Heifers are synchronized for AI breeding followed by the adult cows; all females later sorted into breeding groups for natural service. Selected donors support the embryo transfer program with proven superior value to the program, expanding their influence on the herd. Commercial cows raise embryo calves or produce Braunvieh/Angus hybrid offspring that express heterosis, enhance end product value and offer alternative outcross genetics.

Bulls are co-mingled with cooperators' bulls then performance tested on the farm for 110 days, and marketed in two annual sales targeting local commercial producers. The feeding program expresses genetic differences for growth, ultrasound measurements are taken to determine carcass merit, reproductive evaluation including semen testing determines breeding soundness and visual evaluations are made for soundness and disposition. Bulls that fail go to slaughter.

Pingetzer's Six Iron Ranch

George and Robert Pingetzer, Wyoming

Six Iron Ranch, established in the late 1950s, is located eight miles south of Shoshoni in West Central Wyoming. We started raising registered Red Angus cattle in the early 1970s. Currently we have 200 head of registered Red Angus cows. In the last year we have also expanded to incorporate a small herd consisting of 25 head of registered Black Angus cows. We also run 600 head of commercial Red Angus cross cattle.

Our calving season begins in late January, with the first-calf heifers and registered cows. The commercial cows are bred to start March 1st. By April 1st, we are 85-90% calved out. Our registered herd receives no preferential treatment. They are expected to earn their keep just like the commercial herd.

Our operation also includes 1400 acres of irrigated farmland. We raise corn, oats, alfalfa, and mixed hays. We also feed the bulls for the annual Wyoming Beef Cattle Improvement Association (WBCIA) bull test and sale. The sale is held at our sale barn here at the test facility.

San Isabel Ranch, LLP

Elizabeth R. Kettle, Personal Representative for Benjamin W. Kettle, DVM, Colorado

San Isabel Ranch (SIR) is located in the Wet Mountain Valley, 3 ½ miles West of Westcliffe at 8,000 ft. The ranch has been in continuous operation by the Kettle family since 1872. The production of Registered Horned Herefords began in 1916.

The base of the cow herd is approximately 150 cows. All of the cows are home raised as are the herd bulls. The herd is intensely line-bred on the basis of performance records kept for over 50 years. Every five or six years SIR will purchase an outcross bull to ensure the progression of the genetic pool. Feedlot and carcass data is collected whenever possible. We plan our calving season to match the growing season within this high mountain valley. We begin calving early April and finish in about 75 days.

The cattle are maintained with no creep feeding. We provide a free choice, complete protein mineral supplement and free choice salt to all cattle on the ranch. Winter feed includes native and mixture grass hay produced at the ranch and, in times of hay shortage &/or when the ground is open, a small amount of protein/mineral fortified cake is fed for a short time in the Fall.

The sale cattle are offered private treaty or through video auction. Heifer replacements are bred as yearlings at a minimum weight of 650#. They are bred for their first calves to low birth-weight, registered Red Angus bulls to best utilize heterosis in those calves.

In typical moisture years, the ranch produces an excess of native (Timothy, Brome, small amounts of Alfalfa, and various clovers) hay for market. We include a custom haying enterprise at SIR to offset the expense of producing our own feed.

In addition, we have capacity to manage approximately 1,500 of stocker cattle for our custom grazing enterprise. We typically receive those cattle mid-May and ship late September.

San Isabel Ranch had the first herd in the country to conduct Brisket disease research in cooperation with Colorado State University to determine the genetic tendency to high-altitude disease. This results in the development of the PAP testing for genetic susceptibility.

Shamrock Vale Farms

Earl and Nedra McKarns, Ohio

Earl was raised on a dairy and beef farm in northeast Ohio. After high school and four years in the Navy, he started farming full-time on his 137 acre farm with 12 Holstein cows. Over the years he increased his farm to 600 acres, enlarged his dairy herd to 150 head and started a small registered Angus herd in the late 70s. He expanded his Angus herd by retaining his own replacement heifers. In 1991 the dairy cattle and 250 acres were dispersed.

Shamrock Vale Farms today is a registered Angus business with all 400 acres consisting of grass, also 150-175 mother cows plus calves and about 75 replacement heifers.

Forages on the farm consist of mostly orchard grass and clover mixed with some fescue. The farm is laid out in paddocks for rotational grazing. Cattle are moved every 12 hours during the growing season. A water system has been developed to supply water into most every paddock. Stockpiled grass and small round bales are used for winter grazing.

Heifers and cows are estrous synchronized and bred using artificial insemination to calve from January-March. The breeding program has been totally AI for the last six years. Sires are selected with balanced EPDs for both growth and carcass traits. Fleshing ability and a medium frame are also important.

Shamrock Vale Farms is a closed herd producing its own replacements. The herd is accredited and certified for Brucellosis and TB. Johne's Disease test negative for the past seven years and Bovine Leukosis Virus negative for the last six years.

All three-year-old cows are sold each fall after weaning their second calf and being pregnancy checked. Heifer calves are retained in the herd for replacements. About 40 bulls are marketed through Camp Cooley Ranch in Texas with whom we are a cooperator herd, and 15 to 20 are marketed from the farm.

Earl is a past president of the Ohio Cattlemen's Association, served nine years on the Ohio Beef Council and is active in his church and community.

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 Kilgore ... 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
Lloyd Mygard ... MD ... 1974
Dave Matti ... MT ... 1974
Eldon Wiese ... MN ... 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 D. 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. Station ... MT ... 1976
John Blankers ... MN ... 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 & Malcolm 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. Romersberger ... IL ... 1982
Milton Krueger ... MO ... 1982
Carl Odegard ... MT ... 1982
Marvin & Donald Stoker ... IA ... 1982
Sam Hands ... KS ... 1982
Larry Campbell ... KY ... 1982
Lloyd Atchison ... CAN ... 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 Freitag ... WI ... 1983
Eddie Hamilton ... KY ... 1983
Bill Jones ... MT ... 1983
Harry & Rick Kline ... IL ... 1983
Charlie Kopp ... OR ... 1983
Duwayne Olson ... SD ... 1983
Ralph Pederson ... SD ... 1983
Ernest & Helen Schaller ... MO ... 1983
Al Smith ... VA ... 1983
John Spencer ... CA ... 1983
Bud Wishard ... MN ... 1983
Bob & Sharon Beck ... OR ... 1984
Leonard Fawcett ... SD ... 1984
Fred & Lee Kummerfeld ... WY ... 1984
Norman 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 ... 1985
Bob & Sheri Schmidt ... MN ... 1985
Delmer & Joyce Nelson ... IL ... 1985
Harley Brockel ... SD ... 1985
Kent Brunner ... KS ... 1985
Glenn Harvey ... OR ... 1985
John Maino ... CA ... 1985
Ernie Reeves ... VA ... 1985
John R. Rouse ... WY ... 1985
George & Thelma Boucher ... CAN ... 1985
Kenneth Bentz ... OR ... 1986
Gary Johnson ... KS ... 1986
Ralph G. Lovelady ... AL ... 1986
Ramon H. Oliver ... KY ... 1986
Kay Richardson ... FL ... 1986
Mr. & Mrs. Clyde Watts ... NC ... 1986
David & Bev Lischka ... CAN ... 1986
Dennis & Nancy Daly ... WY ... 1986
Carl & Fran Dobitz ... SD ... 1986
Charles Fariss ... VA ... 1986
David J. Forster ... CA ... 1986
Danny Geersen ... SD ... 1986
Oscar Bradford ... AL ... 1987
R. J. Mawer ... CAN ... 1987
Rodney G. Oliphan ... KS ... 1987
David A. 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. & 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 A. Stegner ... ND ... 1988
Lee Eaton ... MT ... 1988
Larry D. Cundall ... WY ... 1988
Dicker & 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 McAvoy, 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 J. Chrisman .... WY 1990
Les Herbst .... KY 1990
Jon C. Ferguson .... KS 1990
Mike & Diana 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 & Wendy Sweetland .... CAN ... 1990
Swen R. Swenson Cattle .... TX 1990
Robert A. Nixon & Son .... VA 1991
Murray A. Greaves .... CAN ... 1991
James Hauff .... ND 1991
J. R. Anderson .... WI 1991
Ed & 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
Lloyd & 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 Beitelspacher .... SD 1993
Glenn Calbaugh .... WY 1993
Oscho Deal .... NC 1993
Jed Dillard .... FL 1993
Art Farley .... IL 1993
Jon Ferguson .... KS 1993
Walter Hunsuker .... CA 1993
Nola & Steve Kleiboeker .... MO 1993
Jim Maier .... SD 1993
Bill & Jim Martin .... WV 1993
Ian & Alan McKillop .... ON 1993
George & Robert Pingetzer ...... WY 1993
Timothy D. Sutphin .... 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
Clinton 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
Delbert Ohnemus .... IA 1995
Olafson Brothers .... ND 1995
Henry Stone .... CA 1995
Joe Thielen .... KS 1995
Jack Turnell .... WY 1995
Tom Woodard .... TX 1995
Jerry & Linda Bailey .... ND 1996
Kory M. Bierle .... SD 1996
Mavis Dummermuth .... IA 1996
Terry Stuart Forst .... OK 1996
Don W. Freeman .... AL 1996
Lois & Frank Herbst .... WY 1996
M/M 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 Petik .... SD 1996
Ken Risler .... WI 1996
Merlin Anderson .... KS 1997
Joe C. Bailey .... ND 1997
William R. "Bill" Brockett .... VA 1997
Arnie Hansen .... MT 1997
Howard McAdams, Sr
& Howard McAdams, Jr. .... NC 1997
Rob Orchard .... WY 1997
Bill Peters .... CA 1997
David Petty .... IA 1997
Rosemary Rounds &
Marc & Pam Scarborough .... SD 1997
Morey & Pat Van Hoecke .... MN 1997
Randy and Judy Mills .... KS 1998
Mike & Priscilla Kasten .... MO 1998
Amana Farms, Inc. .... IA 1998
Terry & Dianne Crisp .... AB 1998
Jim & 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
and Patricia R. Spearman ..... CO 1998
Glenn Baumann .... ND 1999
Bill Boston .... IL 1999
C-J-R Christensen Ranches .... WY 1999
Ken Fear, Jr. .... WY 1999
Giles Family .... KS 1999
Burt Guerrieri .... CO 1999
Karlen Family .... SD 1999
Deseret Ranches of Alberta ..... CAN ... 1999
Nick & Mary Klintworth .... NE 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 & Claudia Tucker .... VA 2000
Wayne & Chip Unsicker .... IL 2000
Billy H. Bolding .... AL 2001
Mike & Tom Endress .... IL 2001
Henry & Hank Maxey .... VA 2001
Paul McKie .... KS 2001
3R Ranch/Reeves
& Betsy Brown .... CO 2002
Okla. Dept. of Corrections .... OK 2002
Alpine Farms/Walter Nelson ..... VA 2002
Amana Farms, Inc. .... IA 2002
Griffith Seedstock/
Griffith Family .... KS 2002
Indian Knoll Cattle Co./
Bliler Family .... IL 2002
Miles Land & Livestock Co./
Price Family .... WY 2002
Shovel Dot Ranch
Buell Family .... NE 2002
Torbert Farms, Ltd. .... AL 2002
Craig & Margaret White .... IA 2002
Voyles Farms, Inc. .... IN 2002

Commercial Producer of the Year

Chan Cooper	MT	1972
Pat Wilson	FL	1973
Lloyd Nygard	ND	1974
Gene Gates	KS	1975
Ron Blake	OR	1976
Steve & Mary Garst	IA	1977
Mose Tucker	AL	1978
Bert Hawkins	OR	1979
Jess Kilgore	MT	1980
Henry Gardiner	KS	1981
Sam Hands	KS	1982
Al Smith	VA	1983
Bob & Sharon Beck	OR	1984
Glenn Harvey	OR	1985
Charles Fariss	VA	1986
Rodney G. Oliphant	KS	1987
Gary Johnson	KS	1988
Jerry Adamson	NE	1989
Mike & Diana Hopper	OR	1990
Dave & Sandy Umbarger	OR	1991
Kopp Family	OR	1992
Jon Ferguson	KS	1993
Fran & Beth Dobitz	SD	1994
Joe & Susan Thielen	KS	1995
Virgil & Mary Jo Huseman	KS	1996
Merlin & Bonnie Anderson	KS	1997
Randy & Judy Mills	KS	1998
Mike & Priscilla Kasten	MO	1998
Giles Ranch	KS	1999
Mossy Creek Farm	VA	1999
Bill Tucker	VA	2000
Maxey Farms	TX	2001
Griffith Seedstock	KS	2002

Griffith Seedstock Receives 2002 BIF Commercial Producer of the Year Award

Griffith Seedstock was named the Beef Improvement Federation (BIF) Outstanding Commercial Producer of the Year at the organization's 34th annual convention in Omaha, Neb., July 12, 2002.

John and Terry Griffith and John's mother, Connie, are owners of Griffith Seedstock, Wakeeney, Kan. The family has been raising beef cattle in northwest Kansas since 1878 and takes great pride in producing a quality product for today's consumers. The Griffiths place great emphasis on natural resource conservation and appreciate the unique ability of a cow to convert low-quality natural resources into a high-quality protein source for human consumption.

Located in an area with average moisture of 22 inches per year, the diversified operation is evenly split between dryland cultivation and native rangeland. The diversification allows the cow herd to dovetail with the farming operation. Crop residue and feedstuffs produced on the farm are used for maintaining the cow herd and backgrounding feeder calves. An extensive rotational grazing system, which incorporates alternative water sources, allows optimum use of the native grass.

The Griffiths annually calve about 250 Angus and high-percentage commercial Red Angus cows, with heifers calving in 30 days and cows in 45-50 days. Artificial insemination (AI) is used extensively on all cows and heifers. Replacement heifers are retained from the operation, and steers are backgrounded at the ranch, then fed to finish at commercial feedlots and sold on quality-based grids to capture premiums for improvements made in carcass quality.

Through detailed recordkeeping and stringent culling pressure, the Griffiths have developed an efficient, performance-based commercial cow herd. Several marketing options are implemented to maximize profit when selling cattle. Heifers not retained for the herd are sold as replacements to other commercial producers; cows not meeting retention criteria are sold as pairs at specific times of the year. A select group of performance bulls are sold annually.

In addition to their commitment to producing high-quality beef, the Griffiths are active in industry organizations, their community and church.

2003 BIF Commercial Producer Award Nominees

Clear Creek Cattle Company

Robert, Leslie, J.W. and Jarrod Hendry, Wyoming

William "Scotty" Hendry, who emigrated from Scotland in 1906, started the ranch in 1912. The ranch headquarters is 15 miles north and east of Lost Cabin, Wyoming, which is 75 miles west of Casper, Wyoming. Around 1946, James D. Hendry, youngest son of Scotty Hendry, assumed the management of the ranch. Together, they acquired land and changed from sheep to cattle. In the early 1980's Robert took over the day to day management of the ranch and he and his Father expanded the ranch and started changing the types of cattle. Today, the ranch covers over 150,000 acres of deeded, as well as BLM, State and private leases. The 2600 cows that are run today are Angus and Angus cross (black and black white face) bred to 100% Charolais bulls. We sell all the calves and buy replacement bred heifers each year. 424 bred heifers are calved day and night at the ranch and the running age cows are calved out in pastures of 2000 acres up to 9000 acres. The heifers start calving the first of February and the older cows begin around the first of March. We winter the cows on grass hay, some alfalfa and ear corn up and down Badwater Creek.

We maintain good records on all of our cattle. Every calf gets an identification number which allows us to zero in on which genetics work and which genetics don't, as we run just one bull per pasture. This allows us to precisely evaluate each bull on just about every economically important trait from birth weight, weaning weight, feedlot performance, health and carcass quality.

Crider Salers

Joe and Sharon, Mike and Donita Crider, North Dakota

We are a family operation located in north central North Dakota near the small town of Donnybrook. Joe and Sharon started farming and ranching in 1965. Mike, having grown up with the cattle, brought his wife, Donita, into the operation in 1990. Now both of their children, Clinton, 11, and Caleen, 8, are very interested in the cattle business. Clinton is starting his third year of showing calved in our local 4-H club and Caleen will be starting her first year.

We farm 2000 acres on which we grow wheat, barley, oats, canola and alfalfa. We have 3500 acres of native pasture on which we run approximately 300 Saler cross cows. We start calving around March 1st.

We purchased our first Saler bulls in 1982 and used them on Polled Hereford and Angus cows. We not only increased weaning weights but recognized immediately other economic advantages of Saler cattle. They calved with no trouble and the newborns got up off the frozen North Dakota ground long before our other calves did. The Saler female is what has really kept us in business. They milk good, they are excellent mothers, have more live calves and more pounds weaned per calf. Through the years we continued using registered Saler bulls and keeping replacement heifers based on the performance records of their mothers. Today the herd is completely Saler influenced.

Mike Goldwasser, Virginia

A cornerstone of our operation has been retained ownership of the calf crop through harvest. This practice has enabled our operation to realize the full benefits of superior management and genetics. The cow herd consists of Continental (Gelbvieh, Simmental, Charolais) x Angus cross cows. Sire selection places heavy emphasis on carcass merit. Mostly Angus bulls have been used in recent years, with all sires ranking in the top 1/3 of their breed for yearling growth and all have been positive for marbling and ribeye area. Selection pressure for yearling growth has equated to improved feed efficiency and fewer days on feed for the calf crop. The target performance is a calf crop that grade 80% Choice while maintaining or improving rate and efficiency of growth. Genetic progress has seen an increase in finished live weights by 100 pounds with less than a 2% increase in YG 4's. Close monitoring of genetic lines for carcass quality, and the use of systematic crossbreeding have been important aspects of achieving these goals.

Due to extensive history of carcass data and feedyard information, along with a desire to add further value to our cattle, I organized a partnership with four other like-minded cattlemen to create Blue Ridge Premium Beef. Blue Ridge Premium Beef, LLC markets a high quality, branded beef product and all cattle are bred, fed, and processed in Virginia. The branded beef product has been marketed direct and to retailers and restaurants since April, 2002. All cattle in the program are source-verified and fed without growth implants, carcasses tendercut and aged 21 days, and sold frozen in a cryovac package.

I have been practicing rotational and intensive grazing as well as positive conservation practices for more than 15 years. One of our greatest assets is the value of the superior forage available here in Southwest Virginia. Cool season grasses are utilized extensively in the rotation, along with stockpiling fescue. Carrying Capacity records along with the number of feeding vs. grazing days and records on grass yield and rest periods between grazing rotations are used to adjust and make improvements. Grazing management is a key component to the approximately 500 stocker calves developed each year. Multiple paddocks are valuable for herd health during times of purchasing stockers; as they allow smaller groups to be isolated and monitored.

Patterson Ranch

Bob Patterson, Colorado

Patterson Ranch is a cow/calf operation owned and operated by Bob Patterson and his wife, Bunny. They have three married children who were raised on the ranch and they now enjoy six grandchildren. Bob is a third generation rancher and has been involved in his career since the age of six. He began Patterson Ranch 35 years ago with 50 head of Angus cows. He now runs approximately 500 head of Angus-cross cattle on 13,000 acres on Mesa de Maya in Southeastern Colorado, which is 12 miles southwest of Kim.

Mesa de Maya is a unique blending of mountains and plains. It combines short prairie grass with high mesa landscapes. Bob uses a summer-winter rotational grazing plan and a spring calving season which allow for the best use of the high mesa pastures in the summer. The cattle are brought to lower pastures for care and feeding during the cold winter season. The ranch has excellent wildlife habitat and many species, including deer, elk, antelope, bear, and wild turkey share the resources.

Two of the Patterson children own adjoining ranches and all, including the children, work together to make it a family operation.

Bob is committed to the land and the cattle industry. He believes in producing quality cattle while maintaining the integrity of the land, water, and wildlife habitat for generations to come.

W.S. Roberts and Sons

Jerry, Randy and Rick Roberts, Indiana

The W.S. Roberts and Sons farming operation is located in Southeast Lawrence County (site of the family's home farm and has been in the operation for 67 years) and in Northwest Washington County (location of the Roberts' homes and has been in the operation for 48 years). The Roberts own 1544 acres and rent 600 acres, that are utilized to produce corn, soybeans, timber, and 600 acres of pasture and hay. There are 280 spring calving cows and 60 fall calving cows.

The cowherd consists of primarily Angus or Simmental based cows and crosses of those breeds. Performance tested Angus and Simmental bulls have been obtained directly from seedstock producers and bull test stations. Recently, composite bulls of those two breeds have been utilized to maintain breed composition.

In addition to the commercial cow-calf and grain operation (corn, soybeans and wheat), Jerry Roberts also is a seed dealer for Garst Seed Company. The family has been involved in seed production and sales since the early 1950's.

Shriver Farms

Wayne Shriver, Ohio

Wayne Shriver, his wife Krista, their two sons Ethan and Heath, along with Wayne's mother and father, Martha and Dean reside on their southeastern Ohio farm. Wayne and his family own and operate Shriver Farms where they raise 400 commercial beef cows and 400 commercial ewes.

Wayne is also the manager of the Eastern Ohio Resource and Development Center (EORDC) where he oversees the center's daily operations that includes 400 plus mature cows, two bull development facilities, heifer growing and development, and 100 ewes that are utilized in research conducted by The Ohio State University. Included on the 2,100 acres at EORDC is the Ohio Bull Test, where Shriver was the herdsman for six years prior to becoming the overall farm manager.

The home cowherd started from a Hereford base that has now been bred to Angus, both Black and Red, and a little bit of Simmental. An Estrous synchronization program is used prior to breeding and each animal is serviced at least one time artificially at the start of the breeding season. Bull selection is based upon EPDs with a focus on calving ease, birth weight, yearling weight, and carcass traits.

The cows are expected to transform the grasses and legumes on the farm into pounds of production. Cows live on grass and hay, and are provided a good supplemental mineral mix. Stock-piled fescue provides the winter-feed source.

Wayne has served on the Ohio Cattlemen's Association board of directors.

Stroud Farms

Wesley D. and Melba Stroud, Alabama

Nestled in the rolling hills of eastern Limestone County, Alabama, the Stroud operation consists of approximately 750 acres of owned and leased land where the family has been raising beef cattle for over 48 years. The operation currently supports about 200 brood cows and replacement heifers consisting of Black Angus, Red Angus and Saler genetics. The average cow at Stroud Farms is a 50% English, 50% continental cow produced in a back cross system with the black and red Angus bulls being used interchangeably in the system. Cows are maintained on several types of forages adapted to north Alabama. Cattle are rotated between pastures frequently to optimize forage use. Since 1993, the Stroud herd has continually expanded with weaning performance remaining steady to slightly increasing. Along with the cow/calf pairs and replacement heifers, Stroud Farms routinely backgrounds calves before they are sent to mid-Western feedlots. Stroud Farms retains ownership on all steer calves and non-replacement females. This has allowed Stroud Farms to realize a 50% increase in net price/calf over traditional markets. Replacement heifer demand and net price has also increased with the carcass data bank. There are many creek bottoms and natural riparian areas on Stroud Farms land. The land is managed to minimize erosion, maximize benefit to wildlife and ensure a stable consistent stand of forages on all areas of the farm. The Stroud operation is a family operation. The daily operation of the farm is done by Wesley Stroud, his wife Melba, his son Wes and his grandson, Samuel.

Tailgate Ranch Company

Paul McKie, Kansas

Tailgate Ranch is a commercial cow-calf operation consisting of about 1,500 acres of cool-season grass and legume pastures, 390 acres of brome hay meadows, and 60 acres of alfalfa. Tailgate was formed in 1962 by Paul McKie and grew into its present state. The ranch is located at Tonganoxie, KS. about 30 minutes west of Kansas City. We currently run about 280 females (including 80 replacement heifers) in our spring calving herd and 120 cows in the fall calving herd. Our main focus over the last seven years has been developing and breeding high quality replacement females following a strict culling regime in order to build a superior maternal cowherd. Feedlot and carcass data have been collected to help improve feed efficiency and product quality.

Bred heifers begin calving February 10. and are through in 45 days. Heifers are estrus synchronized and artificially inseminated (AI) one time, then cleaned up by proven, easy calving Angus/Red Angus bulls. Spring cows, consisting mostly of Red Angus or Angus crossbreds, begin calving March 1 and are through by April 15. Calves are pre-wean vaccinated, then weaned September 20 and put on growing ration and pasture until steers are either sold or sent to a feedlot. Heifers continue developing on pasture for the AI breeding program. Fall calving cows, mostly straight Angus, begin September 1 and finish by October 15. Fall calves are generally creep fed 60-80 days, weaned at 150 days of age, preconditioned and sold as grass cattle. Angus, Red Angus, and Red Angus x Simmental bulls are used on the spring herd with Angus, Red Angus and Braunvieh bulls used on fall cows.

Ambassador Award Recipients

Warren Kester	Beef Magazine	MN	1986
Chester Peterson	Simmental Shield	KS	1987
Fred Knop	Drovers Journal	KS	1988
Forrest Bassford	Western Livestock Journal	CO	1989
Robert C. DeBaca	The Ideal Beef Memo	IA	1990
Dick Crow	Western Livestock Journal	CO	1991
J. T. "Johnny" Jenkins	Livestock Breeder Journal	GA	1993
Hayes Walker, III	America's Beef Cattleman	KS	1994
Nita Effertz	Beef Today	ID	1995
Ed Bible	Hereford World	MO	1996
Bill Miller	Beef Today	KS	1997
Keith Evans	American Angus Association	MO	1998
Shauna Rose Hermel	Angus Journal & Beef Magazine	MO	1999
Wes Ishmael	Clear Point Communications	TX	2000
Greg Hendersen	Drovers	KS	2001
Joe Roybal	Beef Magazine	MN	2002

2002 BIF Beef Ambassador Award

Roybal Named BIF Ambassador

Joe Roybal, editor of BEEF magazine was named the 2002 Ambassador by the Beef Improvement Federation (BIF) July 12 in Omaha. The prestigious honor is given to a member of the media each year for their efforts in helping cattle producers understand cattle performance testing and genetic prediction tools.

Roybal, considered an "editor's editor" among his peers, is an award winning livestock writer and photographer who became the second editor BEEF magazine has ever had in 1993; he'd already been part of the magazine's editorial and management team since 1985. Prior to that the South Dakota Native was editor of Feedlot Magazine, managing editor of Dairy Herd Management, and a bureau news writer.

Along with his journalistic achievements, Roybal also has a long list of industry leadership under his belt. Currently, he serves as second vice-president of the Livestock Publications Council and is the incoming chairman of the Agricultural Publications Summit.

Pioneer Award Recipients

Jay L. Lush	IA	1973
John H. Knox	NM	1974
Ray Woodward	ABS	1974
Fred Wilson	MT	1974
Charles E. Bell, Jr.	USDA	1974
Reuben Albaugh	CA	1974
Paul Pattengale	CO	1974
Glenn Butts	PRT	1975
Keith Gregory	MARC	1975
Braford Knapp, Jr.	USDA	1975
Forrest Bassford	WLJ	1976
Doyle Chambers	LA	1976
Mrs. Waldo Emerson Forbes	WY	1976
C. Curtis Mast	VA	1976
Dr. H. H. Stonaker	CO	1977
Ralph Bogart	OR	1977
Henry Holsman	SD	1977
Marvin Koger	FL	1977
John Lasley	FL	1977
W. L. McCormick	GA	1977
Paul Orcutt	MT	1977
J. P. Smith	PRT	1977
James B. Lingle	WYE	1978
R. Henry Mathiessen	VA	1978
Bob Priode	VA	1978
Robert Koch	MARC	1979
Mr. & Mrs. Carl Roubicek	AZ	1979
Joseph J. Urick	USDA	1979
Bryon L. Southwell	GA	1980
Richard T. "Scotty" Clark	USDA	1980
F. R. "Ferry" Carpenter	CO	1981
Clyde Reed	OK	1981
Milton England	TX	1981
L. A. Moddox	TX	1981
Charles Pratt	OK	1981
Otha Grimes	OK	1981
Mr. & Mrs. Percy Powers	TX	1982
Gordon Dickerson	NE	1982
Jim Elings	CA	1983
Jim Sanders	NV	1983
Ben Kettle	CO	1983
Carroll O. Schoonover	WY	1983
W. Dean Frischknecht	OR	1983
Bill Graham	GA	1984
Max Hammond	FL	1984
Thomas J. Marlowe	VA	1984
Mick Crandell	SD	1985
Mel Kirkiede	ND	1985
Charles R. Henderson	NY	1986
Everett J. Warwick	USDA	1986
Glenn Burrows	NM	1987
Carlton Corbin	OK	1987
Murray Corbin	OK	1987
Max Deets	KS	1987
George F. & Mattie Ellis	NM	1988
A. F. "Frankie" Flint	NM	1988
Christian A. Dinkle	SD	1988
Roy Beeby	OK	1989
Will Butts	TN	1989
John W. Massey	MO	1989
Donn & Sylvia Mitchell	CAN	1990
Hoon Song	CAN	1990
Jim Wilton	CAN	1990
Bill Long	TX	1991
Bill Turner	TX	1991
Frank Baker	AR	1992
Ron Baker	OR	1992
Bill Borror	CA	1992
Walter Rowden	AR	1992
James W. "Pete" Patterson	ND	1993
Hayes Gregory	NC	1993
James D. Bennett	VA	1993
O'Dell G. Daniel	GA	1993
M. K. "Curly" Cook	GA	1993
Dixon Hubbard	USDA	1993
Richard Willham	IA	1993
Dr. Robert C. DeBaca	IA	1994
Tom Chrystal	IA	1994
Roy A. Wallace	OH	1994
James S. Brinks	CO	1995
Robert E. Taylor	CO	1995
A. L. "Ike" Eller	VA	1996
Glynn Debter	AL	1996
Larry V. Cundiff	NE	1997
Henry Gardiner	KS	1997
Jim Leachman	MT	1997
John Crouch	MO	1998
Bob Dickinson	KS	1998
Douglas MacKenzie Fraser	AB	1998
Joseph Graham	VA	1999
John Pollak	NY	1999
Richard Quaas	NY	1999
Robert R. Schalles	KS	2000
J. David Nichols	IA	2000
Harlan Ritchie	MI	2000
Larry Benyshek	GA	2001
Minnie Lou Bradley	TX	2001
Tom Cartwright	TX	2001
H.H. "Hop" Dickenson	MO	2002
Martin & Mary Jorgensen	SD	2002
L. Dale Van Vleck	NE	2002

2002 BIF Pioneer Awards

H.H. "Hop" Dickenson Receives BIF Pioneer Award

The Beef Improvement Federation (BIF) honored H.H. "Hop" Dickenson with the Pioneer Award at the the organization's 34th annual convention July 12, 2002, in Omaha, Neb. The award recognizes individuals who have made significant and lasting contributions to the genetic improvement of beef cattle.

Dickenson served 23 years (1974-1997) as executive vice president and secretary of the American Hereford Association (AHA). He first joined the AHA in 1960 and served as the southeast representative of the American Hereford Journal. His tenure at AHA has included several positions, including area representative of AHA (1963-1968), general manager of the American Hereford Journal (1968-1970), director of marketing development and general manager of the American Hereford Journal (1970-1974).

Prior to joining AHA, Hop served as an Extension specialist with Virginia Tech University's animal husbandry department from 1959 to 1962; in the U.S. Army from 1957 to 1958; as secretary of the North Carolina Hereford Association in 1956 and as a fieldman for the Virginia Hereford Association in 1955. Dickenson was born in Lebanon, Va., and earned a bachelor's degree in animal science from Virginia Tech in 1955.

Dickenson has served the beef industry in many capacities including: president, U.S. Beef Breeds Council; president, National Society of Livestock Record Associations; director , National Agriculture Hall of Fame; director, American Royal Livestock Show; director, Kansas City Agribusiness Council; director, National Livestock and Meat Board; member U.S. Agriculture Technical Advisory Committee; member, National Western Stock Show; and advisor, World Hereford Council.

Throughout his career, Dickenson demonstrated unusual vision and leadership in implementing, conducting and educating customers on use of beef cattle genetic improvement programs. He played a significant role in initiating the Culpeper Bull Testing program while serving as an Extension specialist at Virginia Tech. Many significant program changes and improvements were made in AHA's Total Performance Recording Program while Dickenson was at the helm. Under his leadership, TPR grew to become the focal point and basis of genetic improvement in the Hereford breed.

He was a strong supporter of BIF, attending, speaking and actively participating in many annual meetings and workshops. At the 1983 annual meeting he said, "I think Sire Evaluation is the most important development in the history of the beef cattle industry." Shortly after the first Genetic Prediction Workshop at Winrock International, in December 1983, AHA was one of the first organizations to shift to the use of reduced animal model methodology, a step that significantly increased accuracy of genetic prediction and effectiveness of selection in breed improvement programs.

Martin and Mary Jorgensen Receive Beef Improvement Federation Pioneer Award

Omaha, Nebraska – The Beef Improvement Federation (BIF) honored Martin and Mary Jorgensen, Ideal, South Dakota, with the Pioneer Award at the 34th Annual Meeting and Research Symposium on July 12, 2002, in Omaha, Nebraska. The purpose of this award is to recognize individuals who have made lasting contributions to the improvement of beef cattle.

Martin and Mary live on the farm that his family homesteaded in 1909 near Ideal, South Dakota. Martin and Mary have four children: Judy, Mary Jean, Greg, and Bryan. Greg and Bryan are actively involved with Martin in the operation and management of Jorgensen Land and Cattle. This is a dynamic and productive operation that includes commercial and seedstock beef production, commercial swine production, and numerous row crops.

The Jorgensens are truly pioneers in the development of innovative management practices and the implementation of new technologies. They were one of the first to embrace the concepts of integrated resource management (IRM), and Martin served as the first Chairman of the National IRM Coordinating Committee during the early 1990's. From its inception, Jorgensen Land and Cattle has been operated as a whole, with each enterprise contributing synergistically to the success of the entire farm. Martin was an original member of the South Dakota Livestock and Production Records System. Production and performance records have provided the foundation for the development of the famous Jorgensen Angus herd as well as all of their other enterprises. Martin has been involved with BIF since its inception in 1968, and he served as President of the BIF Board from 1976-78.

Martin and Mary have given unselfishly to public service activities associated with improving agriculture and rural life. They have served on numerous local, state, and national boards and committees. They have been instrumental in the construction of numerous community buildings and in helping to bring rural water to their community. Martin was appointed to, and served on the South Dakota Board of Economic Development for nine years. He also served as a speaker in several of the Agri-Service Foundation Stockmen Schools, including a trip to Russia and the Ukraine in 1993.

Martin Jorgensen has received many honors and recognitions. These include the Eminent Farmer of South Dakota Award from South Dakota State University, the National Cattlemen's Beef Association Businessman of the Year Award, and the South Dakota Master Pork Producer Award. He was inducted into the Angus Heritage Foundation of the American Angus Association in 1990, and Martin was chosen as an honorary member of the Rosebud Sioux Tribe in 1995.

BIF is pleased and honored to recognize the many contributions of Martin and Mary Jorgensen by presenting them with the BIF Pioneer Award.

L. Dale Van Vleck Receives BIF Pioneer Award

The Beef Improvement Federation (BIF) honored L. Dale Van Vleck with the Pioneer Award at the organization's 34th annual convention July 12, 2002, in Omaha, Neb. The award recognizes individuals who have made significant and lasting contributions to the genetic improvement of beef cattle.

Van Vleck was born June 11, 1933. His parents farmed near Clearwater, Neb., at the edge of the Nebraska sandhills. He earned his bachelor's degree with high distinction in technical science of agriculture a master's degree in genetics at the University of Nebraska in 1954 and 1955, respectively. After serving in the U.S. Army Chemical Corps from 1955-1957, he received his doctoral degree from Cornell University. He then joined the faculty at Cornell as research geneticist (1959), assistant (1962), associate (1967) and then full professor (1973).

Van Vleck concentrated on applications to dairy cattle improvement programs. In 1988, he retired as emeritus professor and moved to the U.S. Meat Animal Research Center (MARC) as a research geneticist with appointment as professor at the University of Nebraska. He has been located on campus at the University of Nebraska, where he directs activities of many graduate students, most of whom conduct research in cooperation with MARC scientists.

Van Vleck has emphasized accurate measurements of genetic variation in performance traits and their effective use in selecting for desired genetic changes in all species of livestock. He and his students developed what is the prototype for genetic evaluations with the animal model utilizing all relationships among animals and accounting for prior genetic selection, which has been implemented in dairy cattle in the U.S., Canada, and many other countries since 1989. He then showed how to extend the procedure to both direct and maternal genetic effects for beef cattle evaluations.

Since joining ARS in 1988, Van Vleck and post-doctoral associates developed a statistical research that reduced computing time by a factor of 200 to 600. Their software, with its accompanying manual, was released in 1993 and is now being used on a wide range of computers by more than 170 scientists around the world. Each year he conducts analyses to estimate factors that can be used to estimate across-breed expected progeny differences in beef cattle. Van Vleck has been very active in BIF's Genetic Prediction Committee and has played a key role in revision of the last three editions of BIF Guidelines for Uniform Improvement of Beef Cattle.

He is author of the classic text, Selection Index and Introduction to Mixed Models, and co-author of Genetics for the Animal Sciences, Principles of Dairy Science and The Horse. Dale has taught in 13 different undergraduate and graduate courses and in numerous shortcourses and workshops. He has directed 35 doctoral students and 28 master's students, served on 65 other graduate committees, directed 18 undergraduate honors theses, and worked with 30 visiting fellows. He is first author of some 137 scientific publications, joint author of 210 others and author or joint author of six books, seven book chapters, 143 published abstracts of reports at scientific meetings, as well as some 142 interpretive articles.

Continuing Service Award Recipients

Clarence Burch	OK	1972
F. R. Carpenter	CO	1973
E. J. Warwick	DC	1973
Robert DeBaca	IA	1973
Frank H. Baker	OK	1974
D. D. Bennett	OR	1974
Richard Willham	IA	1974
Larry V. Cundiff	NE	1975
Dixon D. Hubbard	DC	1975
J. David Nichols	IA	1975
A. L. Eller, Jr.	VA	1976
Ray Meyer	SD	1976
Don Vaniman	MT	1977
Lloyd Schmitt	MT	1977
Martin Jorgensen	SD	1978
James S. Brinks	CO	1978
Paul D. Miller	WI	1978
C. K. Allen	MO	1979
William Durfey	NAAB	1979
Glenn Butts	PRI	1980
Jim Gosey	NE	1980
Mark Keffeler	SD	1981
J. D. Mankin	ID	1982
Art Linton	MT	1983
James Bennett	VA	1984
M. K. Cook	GA	1984
Craig Ludwig	MO	1984
Jim Glenn	IBIA	1985
Dick Spader	MO	1985
Roy Wallace	OH	1985
Larry Benyshek	GA	1986
Ken W. Ellis	CA	1986
Earl Peterson	MT	1986
Bill Borror	CA	1987
Daryl Strohbehn	IA	1987
Jim Gibb	MO	1987
Bruce Howard	CAN	1988
Roger McCraw	NC	1989
Robert Dickinson	KS	1990
John Crouch	MO	1991
Jack Chase	WY	1992
Leonard Wulf	MN	1992
Henry W. Webster	SC	1993
Robert McGuire	AL	1993
Charles McPeake	GA	1993
Bruce E. Cunningham	MT	1994
Loren Jackson	TX	1994
Marvin D. Nichols	IA	1994
Steve Radakovich	IA	1994
Dr. Doyle Wilson	IA	1994
Paul Bennett	VA	1995
Pat Goggins	MT	1995
Brian Pogue	CAN	1995
Harlan D. Ritchie	MI	1996
Doug L. Hixon	WY	1996
Glenn Brinkman	TX	1997
Russell Danielson	ND	1997
Gene Rouse	IA	1997
Keith Bertrand	GA	1998
Richard Gilbert	TX	1998
Burke Healey	OK	1998
Bruce Golden	CO	1999
John Hough	GA	1999
Gary Johnson	KS	1999
Norman Vincil	VA	1999
Ron Bolze	KS	2000
Jed Dillard	FL	2000
William Altenburg	CO	2001
Kent Andersen	CO	2001
Don Boggs	SD	2001
S.R. Evans	MS	2002
Galen Fink	KS	2002
Bill Hohenboken	VA	2002

2002 BIF Continuing Service Awards

S.R. Evans Jr. Receives BIF Continuing Service Award

The Beef Improvement Federation (BIF) honored S.R. Evans Jr., Greenwood, Miss., with its Continuing Service Award at the organization's 34th annual meeting July 12, 2002, in Omaha, Neb.

Evans graduated from Mississippi State University with a degree in chemical engineering in 1960. He then received his master's degree from the University of Mississippi Medical School and trained in general surgery and gynecologic surgery during the next six years in Memphis and New York before returning to his hometown to open his practice in 1972. In his free time he joined his father in the farm and cattle operation and expanded the purebred Angus program.

He served as president of the Mississippi Angus Association, as well as serving as the association's longtime secretary-treasurer. Evans began attending BIF almost 20 years ago, after taking an active interest in the Mississippi Beef Cattle Improvement Association (BCIA). He has served on the board for six years. He received the Purebred Producer of the Year award from the Mississippi Cattlemen's Association in 2001.

The ranch consists of approximately 1,550 acres of gently rolling hills and fertile creek bottoms. Pastures consist of improved bermuda, Pensacola bahia and native grasses. The land is fenced into 20-30 acre plots in order to facilitate the intensive grazing program. The cow herd is made up of about 500 brood cows, mostly purebred Angus, with a few commercial cows. They are split into two calving seasons, the fall season being September to October, and the spring season being February to March. These cows are run on grass in the same fashion as commercial customers. At weaning, all calves are retained and run on grass as stockers, with a minimum of supplemental feed provided to maintain a moderate rate of growth. All bulls participate in a grass-based performance test. All heifer calves are retained and given a chance to become a brood cow. Any calves culled are fed with Evans Angus retaining ownership until slaughter.

The breeding program begins with an extensive embryo and artificial insemination (AI) program, and then the farm's bulls are used as herd bulls. The program is concentrating on carcass merits in order to improve their final product. With the improvements in technology, the farm has been able to take ultrasound readings of every calf, and the breeding program is run using expected progeny differences (EPDs) as major criteria. The cattle have been performing well, gaining nearly 5 pounds a day in the feedlot, grading 95%-100% low-Choice or above, and about 45% qualifying as Certified Angus Beef® (CAB®) product. Evans Angus Farm also runs a stocker program, with the calves coming from their buy-back program with bull customers. The farm runs this program knowing that the only reason for a purebred operation is to raise quality seedstock, mainly bulls, for the commercial producer.

Evans has taken an active role in the Boy Scouts of America, serving as assistant scoutmaster, camping committee chairman, and on the medical staff at national jamborees. He received the Silver Beaver award. Evans is married to June and is the father of three children, S.R. Evans III, Claire Evans and Caroline Evans.

Galen Fink Receives BIF Continuing Service Award

The Beef Improvement Federation (BIF) honored Galen Fink, Manhattan, Kan., with the Continuing Service Award at the organization's 34th annual meeting July 12, 2002, in Omaha, Neb.

Fink was raised on a small diversified farm in southeast Kansas. He realized early he would have to forge his own business if he wanted to remain involved in the beef industry. He began by managing the Kansas State University beef research herd after graduation.

In 1977 Galen and Lori Fink possessed one Angus cow and the determination to develop a respected source for quality beef cattle genetics. Through determination and hard work, their goals have been met and exceeded. Today Fink Beef Genetics is known world wide as a source of outstanding Angus, Charolais and F-1 genetics. Their business incorporates all segments of the beef industry, from conception to consumption, including a heifer development business and ownership of the Little Apple Brewing Co. The Manhattan, Kan., restaurant is a licensee of Certified Angus Beef LLC (CAB).

The Finks have used high-accuracy, proven sires, exclusively through artificial insemination (AI) since 1977. They rely extensively on cooperator herds as recipients for more than 1,000 embryos implanted each year to produce offspring sold private treaty and through their annual production sale. A major component of the Fink program is customer service, including feeder calf sales for their genetics customers, commercial female sales and working relationships with various feedlots and alliances.

Service to the industry has been a priority to Galen. He has served the BIF as vice president and president and played a major role in hosting the 2000 BIF Convention in Wichita, Kan. He has chaired the Kansas Livestock Association Purebred Council and the Kansas Beef Expo and has served as president of the Kansas Angus Association. His industry knowledge and foresight make him a frequent speaker at cattlemen's events across the country.

The Finks have received numerous honors for their achievements and dedication to the beef industry. They were named the 2000 BIF Outstanding Seedstock Producer. In 2001 they were honored as the Kansas State University Alumni Fellows for the College of Agriculture. And in 2002 they received the Intervet/National Cattlemen's Foundation Vision Award for Region VII.

Bill Hohenboken Receives BIF Continuing Service Award

William D. Hohenboken is Professor Emeritus at Virginia Tech. Bill was raised on crop and livestock farm in Geneseo, Illinois. In 1963, he received the B.S. degree in Agriculture from Oklahoma State University. Following a two-year tour of duty in the U.S. Army, he earned the M.S. degree (1968) and Ph.D. (1969) from Colorado State University, working with Dr. Jim Brinks in beef cattle breeding research. During 1969 and 1970, Dr. Hohenboken was a postdoctoral research fellow at the University of Wisconsin, working with Drs. Ed Hauser and A. B. Chapman on beef cow efficiency.

Dr. Hohenboken joined the faculty of Oregon State University in 1970 as an Assistant Professor. He was appointed to Associate Professor in 1976 and Professor in 1981. In 1987, he was appointed Professor at Virginia Polytechnic Institute and State University. Dr. Hohenboken retired from that position June 2001. Following his retirement, he spent the spring semester of 2002 as a Fulbright Fellow teaching animal breeding and experimental design in Turkey.

Dr. Hohenboken's research interests have emphasized the development of computer-assisted decision aids for beef cattle breeding, management and marketing as well as the study of genotype x management system interactions. His most recent research focused on the study of genetic variation in fescue toxicosis in beef cattle using the mouse as an experimental model. He supervised 17 M.S. and 12 Ph.D. students, including students from 11 foreign countries.

At Oregon State University and Virginia Tech, Dr. Hohenboken taught introductory animal breeding, applied meat animal genetics, sheep production, population genetics, and quantitative genetics to hundreds of undergraduate and graduate students. In 1993, he was awarded the Rockefeller Prentice Award in Animal Breeding and Genetics by the American Society of Animal Science.

Dr. Hohenboken's service to B.I.F. includes his recently completed editorship of the 8th edition of the Guidelines for Uniform Beef Improvement."

Edited by Darrh Bullock, Extension Beef Cattle Breeding Specialist

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