MULTIBREED EVALUATION: THEORY AND APPLICATION

M. A. Elzo
University of Florida

- Multibreed Populations
- Genetic and Environmental Effects
- Modeling Strategies
- Multibreed Model
- Covariance Estimation Procedure
- Results From Experimental Herds
- Implications for National Sire Evaluations

Multibreed Population

Population composed of purebred and crossbred animals that interbreed

- Complete
- Incomplete

Numbers of Sires

	BGS					
BGD	A	.75A	.50A	.25A	B	Br
A	16	7	9	10	15	16
.75A	13	9	9	9	17	13
.50A	16	11	9	11	18	15
.25A	11	6	7	7	12	10
B	13	11	9	11	20	16
Br	10	7	8	10	12	16

Numbers of Dams

	BGS					
BGD	A	.75A	.50A	.25A	B	Br
A	69	24	22	28	40	40
.75A	13	20	23	22	24	29
.50A	50	36	38	47	54	50
.25A	21	16	23	16	25	24
B	45	40	36	43	107	44
Br	21	15	19	23	23	66

Numbers of Calves

	BGS					
BGD	A	.75A	.50A	.25A	B	Br
A	117	25	22	28	40	40
.75A	29	21	25	24	27	32
.50A	62	41	46	57	65	66
.25A	24	20	24	19	32	28
B	53	44	39	49	195	50
Br	23	16	19	26	25	106

Number of Sires

BGD	BGS		
	Sanmar	½S½B	Brahman
Sanmar	88	0	14
½S½B	14	10	18
¾S¼B	14	0	0
Brahman	41	1	22

Number of Dams

BGD	BGS		
	Sanmar	½S½B	Brahman
Sanmar	410	0	80
½S½B	39	68	75
¾S¼B	29	0	0
Brahman	75	1	110

Number of Calves

BGD	BGS		
	Sanmar	½S½B	Brahman
Sanmar	1309	0	147
½S½B	92	242	242
¾S¼B	88	0	0
Brahman	264	1	371

Genetic and Environmental Effects

- Additive
- Nonadditive
- Direct
- Maternal
- Intrabreed
- Interbreed

Genetic and Environmental Effects

1/2AD 1/2AD 1/2AM 1/2AM

AD + ND
AM + NM

1/2AD 1/2AD 1/2AM 1/2AM

EM
(AM + NM)

(AD + ND) + (AM +NM) + ED (AD + ND) + EM (AM + NM)

Chart of Genetic Effects

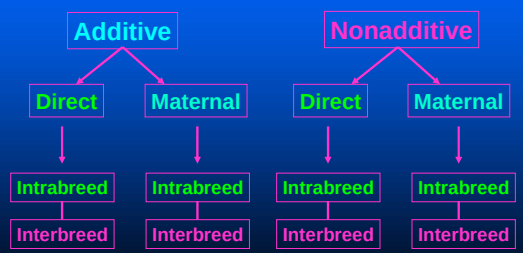
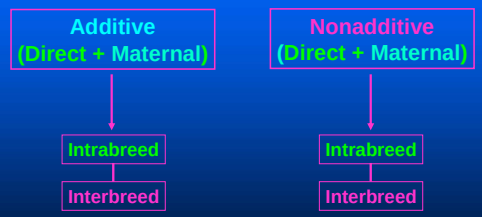


Chart of Environmental Effects



Modeling Strategies Considered

All Subclass Effects

All Regression Effects

A Combination of Subclass and Regression Effects

Actual Modeling Strategy

Effects	Prediction	Covariance Components
Additive	Subclass	Regression
Nonadditive	Regression	Regression
Environmental	Subclass	Regression

Additive Regression Effects

Intra and interbreed allelic effects from all parental breeds

2 Breeds

Intrabreed (A)
Intrabreed (B)
Interbreed (m_A-m_B)

Nonadditive Regression Effects

Intra and interbreed interaction effects between alleles of all parental breeds

2 Breeds

Intrabreed A/A
Intrabreed B/B
Interbreed A/B, B/A

Multibreed Model

Record

Multibreed Contemporary Group
Age Dam-Sex Calf-Dam Group

Sire Group and Mgs Group
(A, N, D, M)

Sire and Mgs
(A, N, D, M)

Residual

Multibreed Contemporary Groups


= Sex

≈ Age

≈ Environment

Connectedness

Contemp Group			
1	X	X	
2	X		X
3	X	X	X
4		X	X
5	X	X	X
6	X		X
7	X		

Age of Dam

Age of Dam x Sex of Calf x Breed Group of Dam Subclass

Regression of Age of Dam (within Sex of Calf) on their fraction of Breed A

Additive Genetic Groups

Group of Sire (Direct, Maternal)

Intrabreed A
Intrabreed B
Interbreed (m_A-m_B)

Subclass Groups (Accumulated)
Regression Groups (Deviated from A)

Nonadditive Genetic Groups

Group of Sire x Group of Dam (Direct, Maternal)

Interbreed A/B, B/A

Regression Groups (Deviated from A/A and B/B)

Additive Genetic Deviations

Sire (Direct, Maternal)

Intrabreed A
Intrabreed B
Interbreed (m_A-m_B)

Multibreed Additive Genetic Covariances

Nonadditive Genetic Deviations

Sire x Breed Group of Dam (Direct, Maternal)

Interbreed A/B, B/A

Interbreed Nonadditive Genetic Covariances

Multibreed Genetic Predictions

MEPD	Direct (D)	Maternal (M)
Additive (A)	AD	AM
Nonadditive (N)	ND	NM
Total (T=A+N)	TD	TM

Covariance Estimation Procedure

Multibreed REML GEM Algorithm (MREMLEM)

Sire-Mgs Model

Cholesky Elements of Base Cov Matrices

Base Cov Matrices

Multibreed Cov Matrices

Variance Ratios & Correlations

Multibreed Herds

Angus-Brahman - U. Florida (1998)
Growth Traits (Preweaning)
Carcass Traits
Romosinuano-Brahman - Turipaná (1998)
Growth Traits (Pre & Postweaning)
Sanmartinero-Brahman - La Libertad (1999)
Growth Traits (Pre & Postweaning)

Traits

Birth Weight

Weaning Weight

Postweaning Gain

Carcass Weight
Longis. Muscle Area

Fat over LMA
KPH Fat

Marbling
W-B Shear Force

Objectives

Estimation of Genetic Parameters

Prediction of Genetic Values

Model

Record

Contemporary Group and Age of Dam

Sire Group and Mgs Group
(A, N, D, M)

Sire and Mgs
(A, N, D, M)

Residual

Base Covariances
(2 Breeds & 2 Traits)

Additive Genetic
10 Intrabreed Angus {D,M}
10 Intrabreed Brahman {D,M}
10 Interbreed AB {D,M}

Nonadditive Genetic
10 Interbreed AB {D,M}

Environmental
3 Intrabreed Angus {D&M}
3 Intrabreed Brahman {D&M}
3 Interbreed AB {D&M}

Genetic Ratios

heritability
=
Additive Var/Phenotypic Var

interactibility
=
Nonadditive Var/Phenotypic Var

Estimates of Genetic Ratios
Growth Traits

	Heritab A	Heritab B	Interact A/B
BWD	.22	.23	.15
WWD	.25	.29	.18
BWM	.17	.18	.16
WWM	.18	.21	.20

Estimates of Genetic Ratios
Carcass Traits

	Heritab A	Heritab B	Interact A/B
CW	.46	.39	.27
LMA	.42	.53	.28
FAT	.14	.24	.02
KPH	.03	.14	.05
MB	.16	.16	.12
WBS	.58	.17	.07

Straightbred and Crossbred
Heritabilities

	BWD	BWM	WWD	WWM
A x A	.22	.17	.25	.05
B x B	.23	.18	.29	.09
A x B	.19	.15	.22	.07
.5A.5B x A	.16	.32	.18	.44

Straightbred and Crossbred Heritabilities

	CW	RA	FR	KP	MB	SF
A x A	.46	.42	.14	.03	.16	.58
B x B	.39	.53	.24	.14	.16	.17
A x B	.30	.34	.18	.07	.13	.25
.5A.5B x A	.37	.33	.03	.02	.19	.43

Correlation Estimates

r_A(BWD,WWD) .24 A and .22 B

r_A(WWD,WWM) -.28 A and -.22 B

r_N(BWD,WWD) .18 A/B

r_N(BWM,WWM) .12 A/B

r_A(CWD,LMAD) .45 A and .40 B

Multibreed Predictions

Comparison of sires of any fraction of parental breeds

Graphs assumed sires to be mated to ½A ½B cows

Multibreed Genetic Bases

Additive Genetic Base
=
Mean of Brahman Alleles from Purebred and Crossbred Animals

Nonadditive Genetic Base
=
Mean of A/A and B/B Intralocus Interactions from Purebred and Crossbred Animals

MEPD Graphs - Growth Traits

WW A N T Direct

WW A N T Maternal

Angus-Brahman

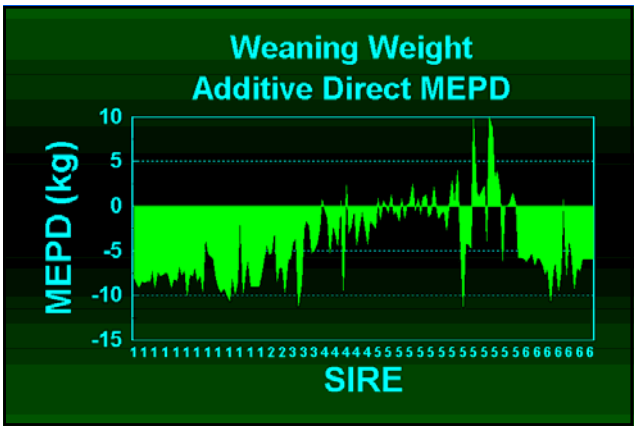
Sanmartinero-Brahman

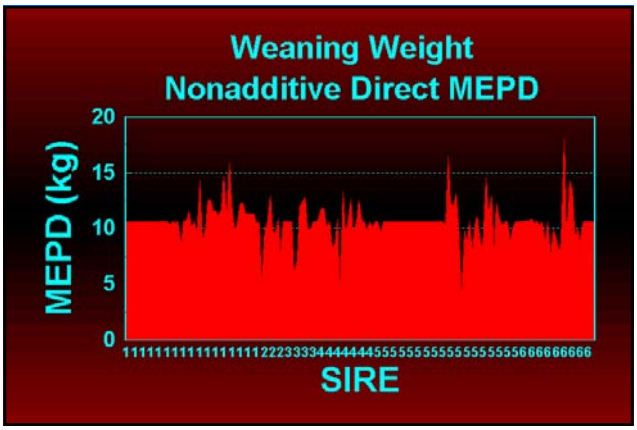
MEPD Graphs - Carcass Traits

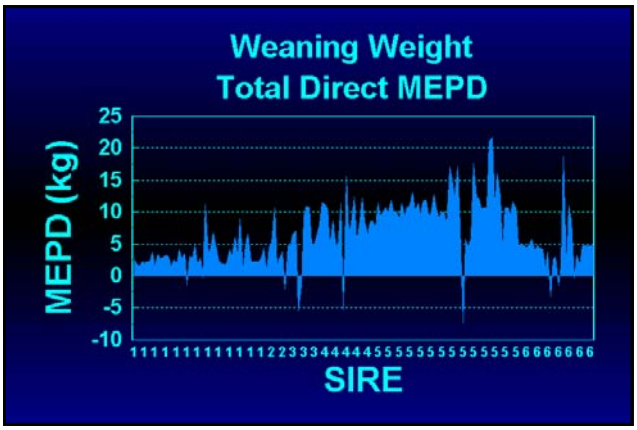
CW
LMA
MB
WBS

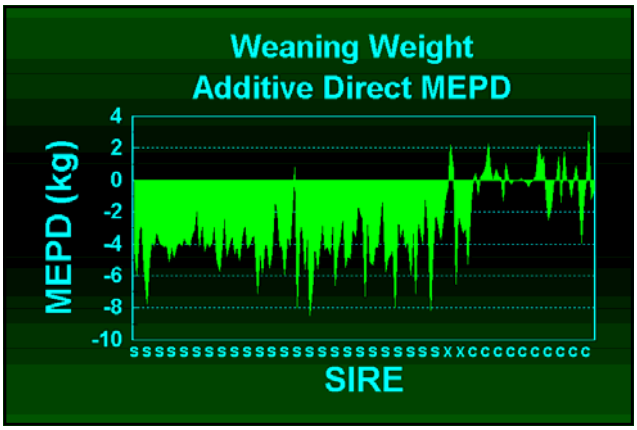
A N T Direct

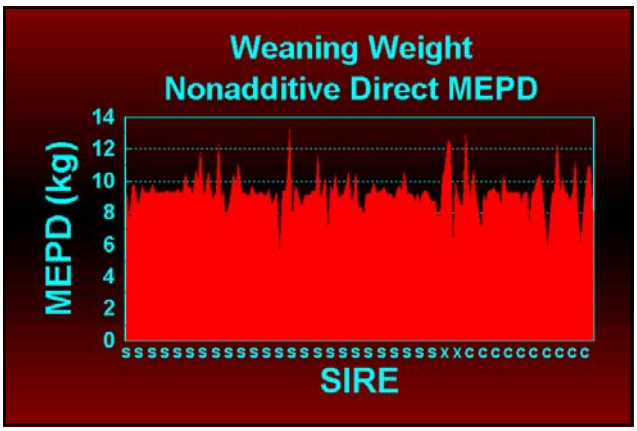
Angus-Brahman

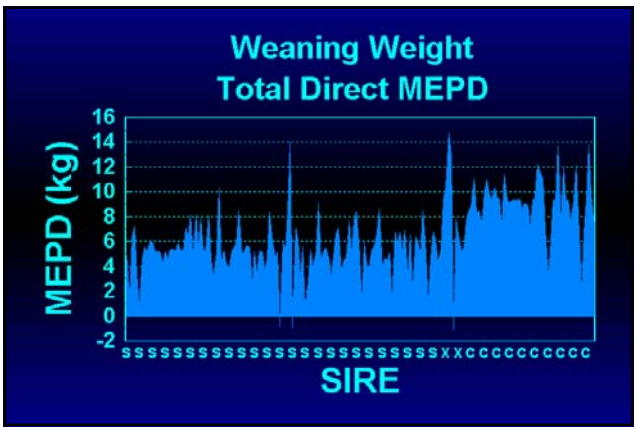

Weaning Weight
Additive Direct MEPD
MEPD (kg)
10
5
0
-5
-10
-15
SIRE

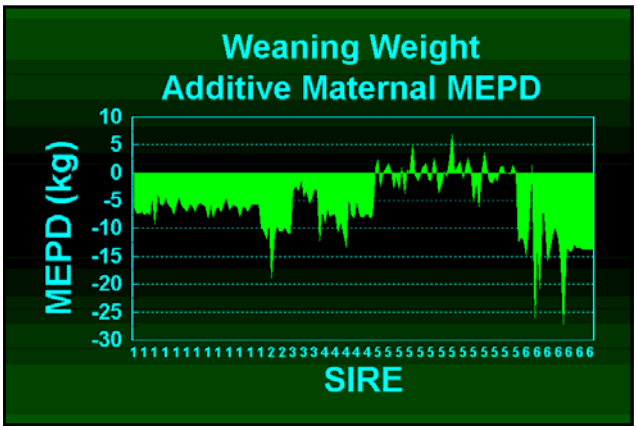

Weaning Weight
Nonadditive Direct MEPD
MEPD (kg)
20
15
10
5
0
SIRE

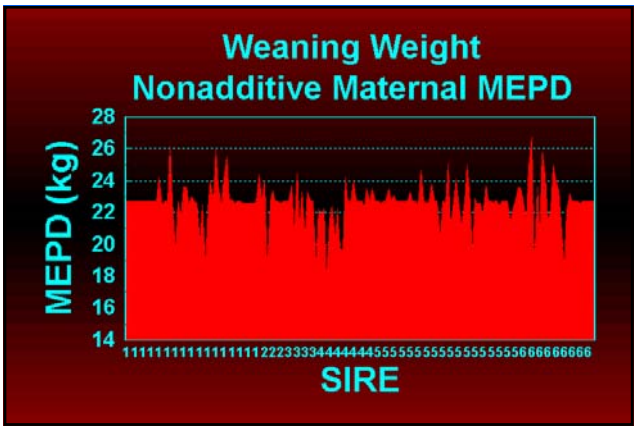

Weaning Weight
Total Direct MEPD
MEPD (kg)
25
20
15
10
5
0
-5
-10
SIRE

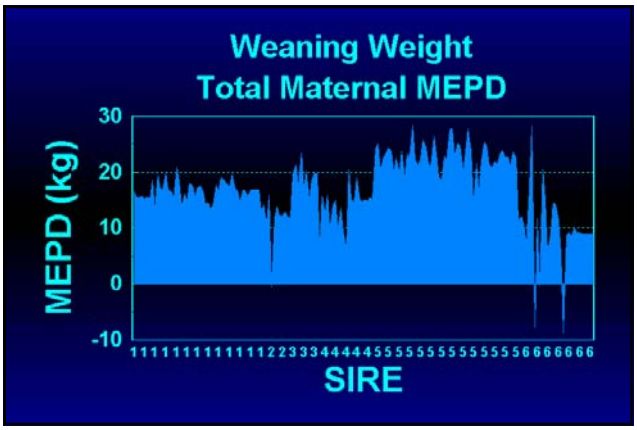

Weaning Weight
Additive Direct MEPD
MEPD (kg)
4
2
0
-2
-4
-6
-8
-10
SIRE

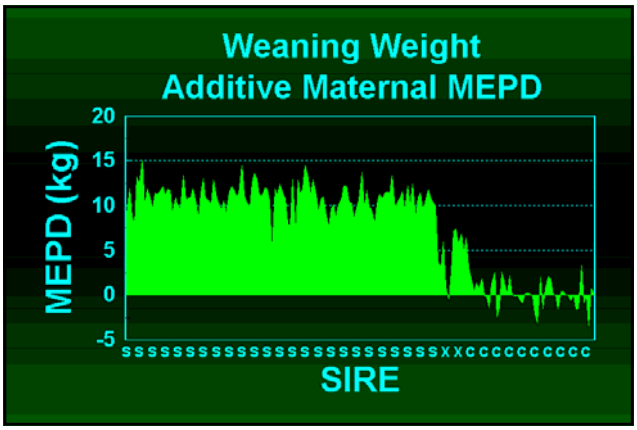

Weaning Weight
Nonadditive Direct MEPD
MEPD (kg)
14
12
10
8
6
4
2
0
SIRE

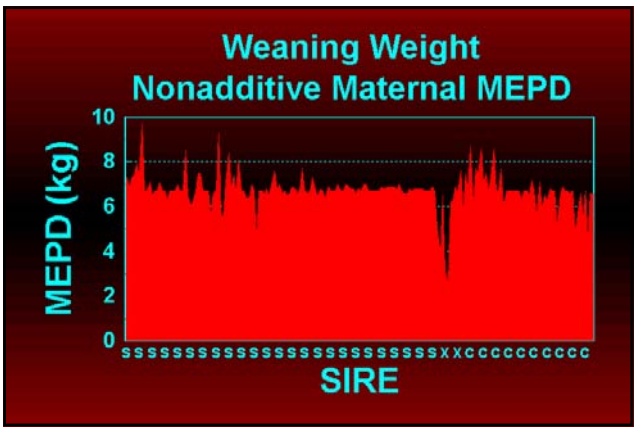

Weaning Weight
Total Direct MEPD
MEPD (kg)
16
14
12
10
8
6
4
2
0
-2
SIRE

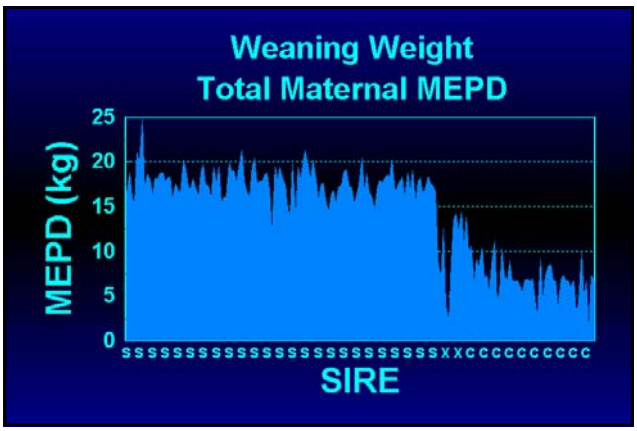

Weaning Weight
Additive Maternal MEPD
MEPD (kg)
10
5
0
-5
-10
-15
-20
-25
-30
SIRE


Weaning Weight
Nonadditive Maternal MEPD
MEPD (kg)
28
26
24
22
20
18
16
14
SIRE


Weaning Weight
Total Maternal MEPD
MEPD (kg)
30
20
10
0
-10
SIRE


Weaning Weight
Additive Maternal MEPD
MEPD (kg)
20
15
10
5
0
-5
SIRE


Weaning Weight
Nonadditive Maternal MEPD
MEPD (kg)
10
8
6
4
2
0
SIRE

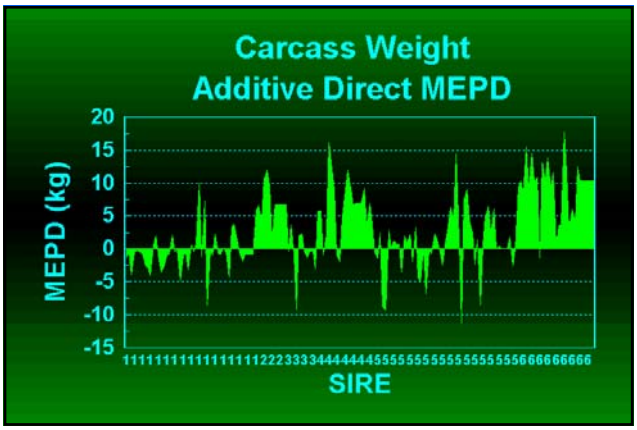

Weaning Weight
Total Maternal MEPD
MEPD (kg)
25
20
15
10
5
0
SIRE

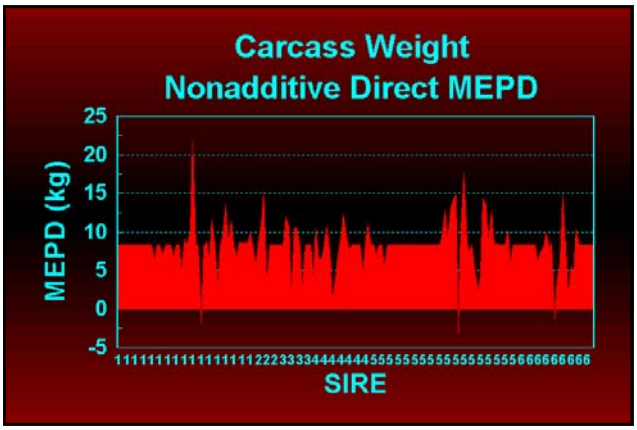
MEPD Graphs - Carcass Traits

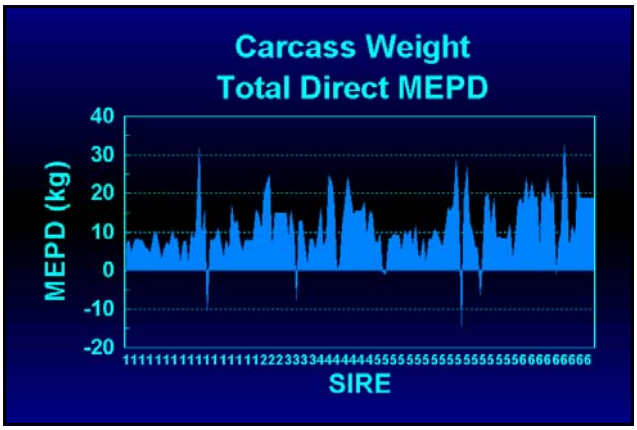
CW
LMA
MB
WBS

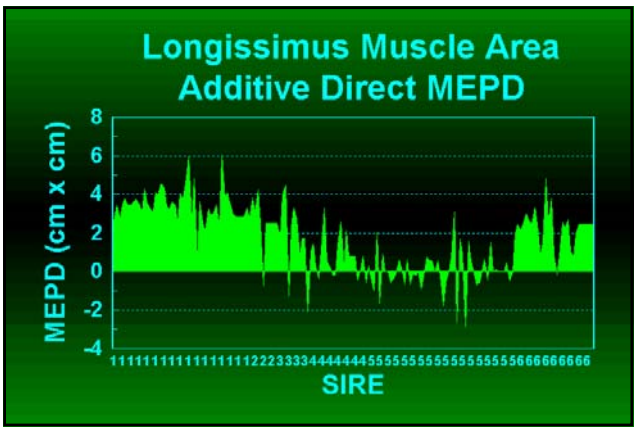
A N T Direct

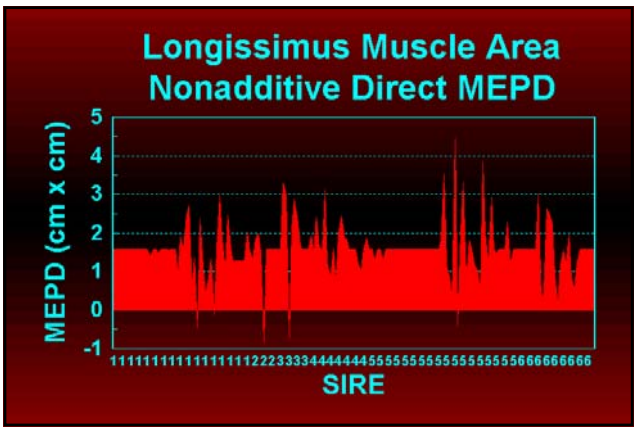
Angus-Brahman

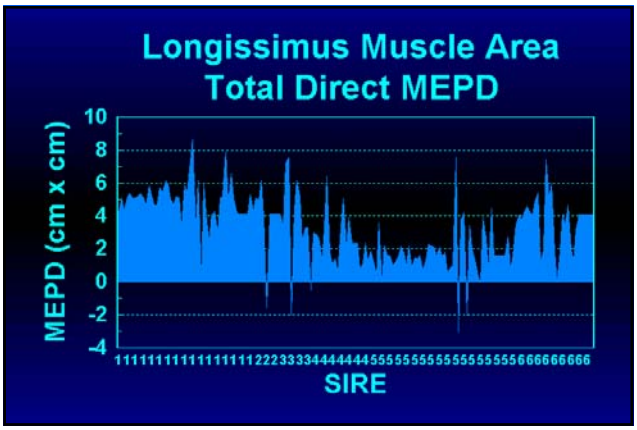


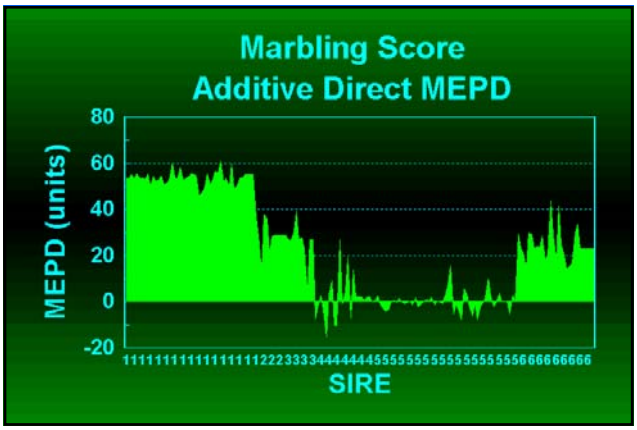


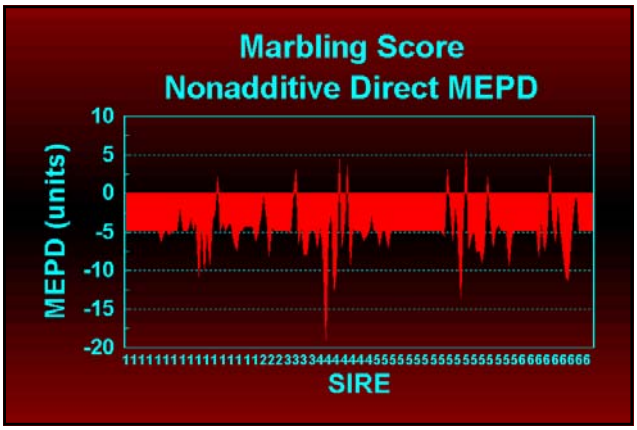


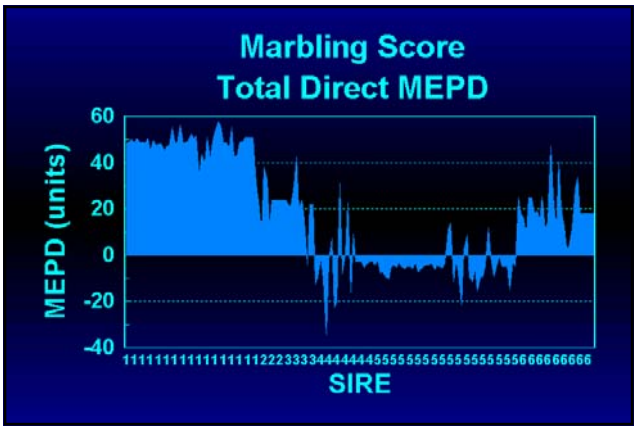


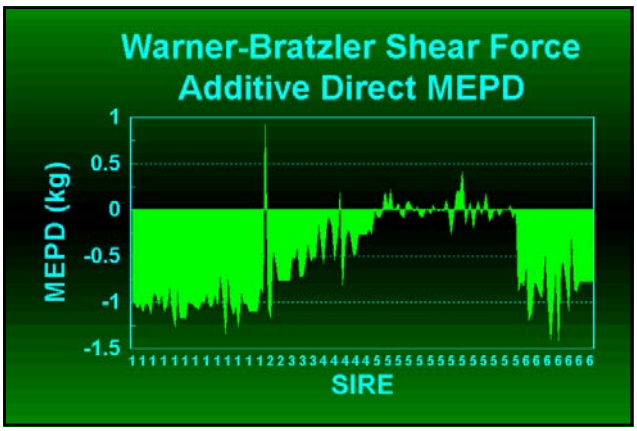


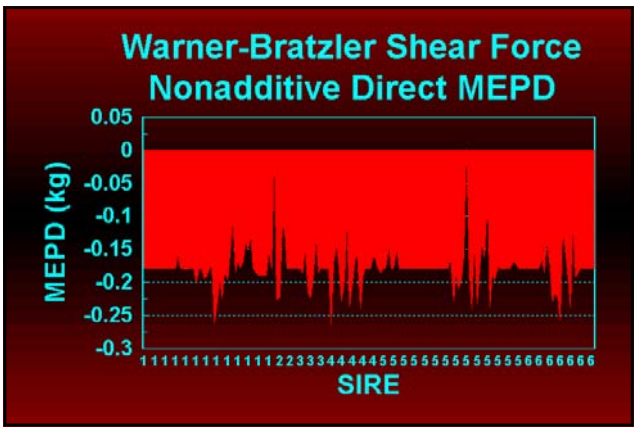

Longissimus Muscle Area
Total Direct MEPD
MEPD (cm x cm)
10
8
6
4
2
0
-2
-4
SIRE


Marbling Score
Additive Direct MEPD
MEPD (units)
80
60
40
20
0
-20
SIRE


Marbling Score
Nonadditive Direct MEPD
MEPD (units)
10
5
0
-5
-10
-15
-20
SIRE


Marbling Score
Total Direct MEPD
MEPD (units)
60
40
20
0
-20
-40
SIRE


Warner-Bratzler Shear Force
Additive Direct MEPD
MEPD (kg)
1
0.5
0
-0.5
-1
-1.5
SIRE


Warner-Bratzler Shear Force
Nonadditive Direct MEPD
MEPD (kg)
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
SIRE

Warner-Bratzler Shear Force Total Direct MEPD

Correlation between MEPD Growth Traits

	(A, N)	(A, T)	(N, T)
BWD	.25	.98	.42
WWD	.20	.94	.53
BWM	.40	.96	.65
WWM	.32	.98	.52

Correlation between MEPD Carcass Traits

	(A, N)	(A, T)	(N, T)
CW	.41	.93	.72
RA	.29	.94	.59
FR	.04	1.00	.06
KP	.16	1.00	.24
MB	.22	.99	.33
SF	.33	1.00	.39

Implications - Variability

Additive and Nonadditive Genetic Effects were important sources of variation for growth related traits

Feasible to Select for Additive and Nonadditive MEPD in Bos Taurus-Brahman Multibreed Populations

Implications - Predictions

No straightbred or crossbred sire group was completely superior to another group (Ranges Overlapped)

Conservative Selection Rule
First select Sires for Additive MEPD, and then for Total MEPD

National Multibreed Populations

A Single Multibreed Population
All breeds in the USA

Several Overlapping Multibreed Populations
Angus-Brangus-Brahman
Simmental (USA-Canada)-Simbrah-Brahman

Several Extended Breeds
(Straightbred Sires; Straightbred and Crossbred Dams)

Multibreed Genetic Bases

Single Multibreed Population
Single Base (Add, Nonadd)

Overlapping Multibreed Populations
Single Reference Base (Add, Nonadd)
Connected Reference Bases (Add, Nonadd)

Extended Breeds
Weak Connections (Mgs, Mgd ?)

Multibreed Genetic Evaluations

Single Multibreed Population
Additive, Nonadditive, Total

Overlapping Multibreed Populations
Additive, Nonadditive, Total

Extended Breeds
Additive, Nonadditive, Total (Within Ex Br)

Publication of MEPD

Paper Multibreed Sire Summaries
Additive (Feasible)
Nonadditive, Total (Unfeasible)

Electronic Multibreed Sire Summaries
Additive, Nonadditive, Total

Better Alternative
Mating Program Service

Final Remarks

Definition of USA Multibreed Populations

Methodological Research and Development

Publication of Genetic Predictions

Additional Services