



Beef Genetics and Measurement Basics

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AL, LA, MS Beef Genetics Shortcourse



History of Selection

- 1st purebred animals introduced into the US after the Revolutionary War (dairy & sheep)
- 1st Purebred beef cattle imported just before the Civil War
- Breed associations formed in late 1800's
 - Purebred sires could improve livestock production
 - Registered was equivalent to "something special" in the early days
 - Question became "Which is best?"

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History of Selection

- Which is best?
 - Show ring competitions
 - General conclusion was the correlation between type and performance was low
 - Performance Testing
 - Expected Progeny Differences
 - DNA based analyses
- Don't forget hybrid vigor or heterosis in the commercial cattle herd

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What is Selection?

Definition: The causing or allowing of certain individuals to produce the next generation. Selection in beef cattle is a result of both natural selection and artificial selection by man

Determining what is best

Typical cattle chromosomes
Source: Cytogenetics, p. 196



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A little about cattle chromosomes

- Cattle have 58 chromosomes
- Chromosomes occur in pairs
 - Cattle have 28 pair of autosomes
 - Cattle have 1 pair of sex chromosomes



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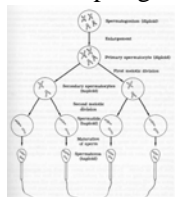


Both sides of the pedigree are important in selection

A parent passes a random one-half of their genetic material on to their offspring



Female



Male

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Determination of Phenotype

- Genes express themselves basically in 2 ways:
 - Additively
 - Non-additively





Additive Gene Action

- The addition of each gene for a trait adds to the overall phenotypic expression of the trait
 - Most of the economically important traits are expressed in this manner. Many genes will control a trait and affect other traits too!





Example of Additive Gene Action

- Suppose weaning weight for beef cattle was controlled by 5 genes – A, B, C, D, E. There are also a, b, c, d, e alleles. For each capital letter, add 10 lbs to weaning weight. For each small letter add 2 lbs to the base weaning weight of 450 lbs





Example of Additive Gene Action

- Calf with genotype AABbccDd
 - Weaning weight = $450 + 10 + 10 + 10 + 2 + 2 + 2 + 10 + 2 = 498$ lbs
- Calf with genotype aabbCCDd
 - Weaning weight = $450 + 2 + 2 + 2 + 2 + 10 + 10 + 10 + 2 = 490$ lbs
- Each gene the calf possesses adds to weaning wt





Non-Additive Gene Action

- Each gene affecting a trait may not add to the phenotypic expression, but together the genes will interact to produce a phenotype
 - Basis of hybrid vigor or heterosis
 - Basis of qualitative traits like horned/polled or coat color





Example of Non-Additive Gene Action

- The polled vs. horned condition in cattle is an example of non-additive gene action
- In cattle, the polled gene, P, is dominant over the horned gene, p





Example of Non-Additive Gene Action

- Cattle with the genotype PP or Pp are polled. One P gene makes that determination
- Only cattle with genotype pp express the horned phenotype





What causes variation in Phenotypes

- There is 1 equation which describes the phenotype of an individual:

$$P = G + E$$

This equation will provide the basis for almost all discussions the remainder of the course






Why isn't a bull or cow's progeny more similar?

- Due to Phenotypic Variation
- Phenotypic Variation is present because:
 - Individual parents are not homozygous for all the genes they possess
 - Only animals genetically identical are animals formed from one fertilized egg
 - Inbred or linebred animals will be more homozygous at more loci than non-inbred animals




Individual	Genotype of Parents		No. of different genotypes
	Father	Mother	
1	AABBCCDD	AABBCCDD	1
2	AABBCCDD	aabbccdd	1
3	AaBBCCDD	AaBBCCDD	3
4	AaBbCCDD	AaBbCCDD	9
5	AaBbCcDD	AaBbCcDD	27
6	AaBbCcDd	AaBbCcDd	81


Now imagine with 29 gene pairs and thousands of genes!



Why isn't a bull or cow's progeny more similar?


- Phenotypic Variation is present because:
 - Environments are different.
 - Disease, nutrition, weather, etc
 - Interactions between genetics and environment
 - Example: Weight gains of *Bos indicus* and *Bos taurus* influenced cattle in southeast vs. northeast in January






Economically Important Traits and How to Measure Them

- Efficiency of beef cattle production in the United States depends upon:
 - Amount of lean meat yielded per animal at harvest
 - Quality and appearance of beef produced
 - Efficiency of production – including reproductive efficiency



Economically Important Traits and How to Measure Them

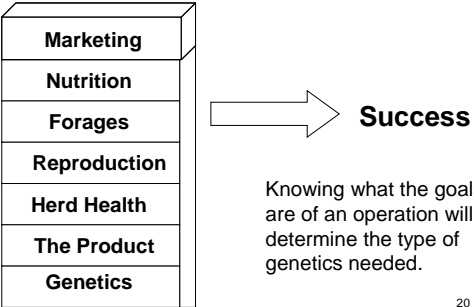
- The improvement of beef cattle through breeding methods requires accurate records be taken and used on all animals in the herd



CALF INFORMATION				
ID	BD	Sex	WT	COW
N101	9/1/03	H	68 lbs	9101
N102	9/1/03	B	78 lbs	3808

Alabama Beef Cattle Improvement Association
NCSA
IRM
2003
Integrated Resource Management
Member in controlling the economic
viability of cattle operations through
efficient resource management.

Beef Cattle Toolbox



Marketing

Nutrition

Forages

Reproduction

Herd Health

The Product

Genetics

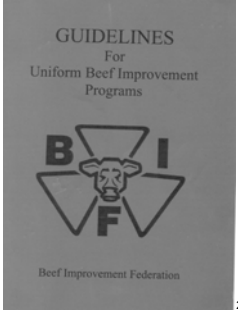
Success

Knowing what the goals are of an operation will determine the type of genetics needed.

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Economically Important Traits and How to Measure Them

- In the beef industry throughout the world, the Beef Improvement Federation (BIF) sets the standards for what traits to measure, how to measure them and when to measure them.



GUIDELINES
For
Uniform Beef Improvement
Programs

B I F

Beef Improvement Federation

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Economically Important Traits and How to Measure Them

- The improvement of beef cattle through breeding methods requires accurate records be taken and used on all animals in the herd
- Which means they must be identified

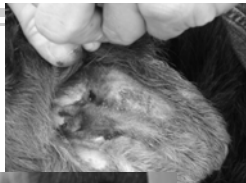


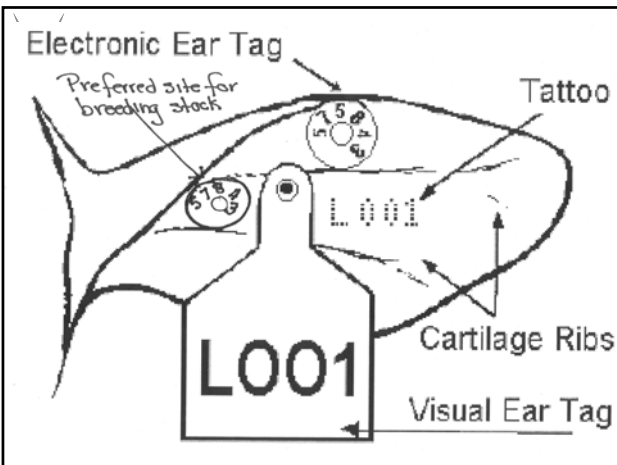
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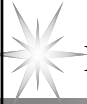


Unique Identification Systems

- Permanent Ink Tattoos in the Ear
- Ear Tags
- Hot Branding
- Freeze Branding







Letter and Corresponding Year

Note: The letters I, O, Q, U are not used in this system.



Economically Important Traits and How to Measure Them

- Reproductive Efficiency
 - Pounds of calf weaned per cow exposed during the breeding season
 - Composed of many traits
 - Conception rate
 - Survival to weaning (this includes calving ease/birth weight)
 - Weaning weight
 - Lowly heritable
 - Non-additive gene effects and the environment significantly affect these traits



Economically Important Traits and How to Measure Them

- Weaning Weight
 - Taken between 160 and 240 days of age
 - Weights adjusted for sex of calf, age of calf (205 days) and age of dam
 - Dependent on milking ability of dam and ability of calf to efficiently grow
 - Tells you how your factory is performing



Economically Important Traits and How to Measure Them

- Adjusted Weaning Weight

$$\left[\frac{\text{Actual weaning wt} - \text{birth weight}}{\text{Actual age in days}} \right] \times 205 + \text{birth wt} + \text{AOD adj.}$$

- Breed Associations and computer programs have age of dam adjustment factors
- Can adjust entire calf crop to bull or steer basis

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Economically Important Traits and How to Measure Them

- Yearling Weight
 - Measures post-weaning growth
 - Needs to be taken between 330 and 400 days of age
 - Can assist with both bull and heifer selection





Economically Important Traits and How to Measure Them

- Adjusted Yearling Weight

$$\left[\frac{\text{Actual final wt} - \text{actual weaning wt}}{\text{No. days between wts}} \right] \times 160 + \text{adj 205 d wt}$$

- Some individuals chose to wait until 452 or 550 days to take weights
 - Feel more beneficial especially for heifers





Economically Important Traits and How to Measure Them

- Carcass Traits
 - Indication of how your breeding program is affecting the consumer
 - Carcass traits are highly heritable
 - Additive gene action at work!
 - Cow-calf sector controls the genetics of the beef end-product





Economically Important Traits and How to Measure Them

- Efficiency of Production
 - Many measures
 - Feed efficiency of males
 - Maintenance energy of females
 - Function of cow size and milking ability
 - Becoming more important due to environmental pressures
 - Waste management
 - Methane production





Economically Important Traits and How to Measure Them

- Individual adjusted measurements will not produce an effective selection program
 - Must be able to compare
 - Simplest measure is a ratio





Ratios

- Indicates position of calf for a trait within a contemporary group. Can be used as a within herd selection tool.

$$\text{Ratio} = \frac{\text{Individual Measurement}}{\text{Average of Group}} \times 100$$

- Average ratio of a group is 100.
- Ratios are only valid within the group the individual came from.

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Definition: Contemporary Group

- A contemporary group is a group of animals with the same:
 - Herd
 - Sex
 - Birth Season
 - Weigh date
 - Management



- The largest contemporary group is at birth. All subsequent traits are subsets of the birth contemporary group.

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Contemporary Group

- Contemporary groups are the basis for defining environmental effects

$$P = G + E$$

- If contemporary groups are not properly defined selection decisions will not be as accurate as they could be



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Consequence of incorrect grouping

- You wean a group of bull calves. The adjusted weights of the 5 calves are 661, 625, 600, 595 and 500 lbs.
- You are “disappointed” in the 500 lb calf. You decide to ignore his weight in calculating ratios and reporting the data to the breed association





Consequence of incorrect grouping

Calf	Adjusted Wt	Wrong Ratio
P101	661	107
P115	625	101
P126	600	97
P137	595	96
P138	500	--

Average wt of calves 1-4 is 620 lbs 38



Consequence of incorrect grouping

Calf	Adjusted Wt	Wrong Ratio	Correct Ratio
P101	661	107	111
P115	625	101	105
P126	600	97	101
P137	595	96	100
P138	500	--	83

Average wt of calves 1-5 is 596 lbs 39



Economically Important Traits and How to Measure Them

- Individual adjusted measurements will not produce an effective selection program
 - Must be able to compare
 - Simplest measure is a ratio
- Use adjusted measures to predict breeding values
 - Value of the individual as a parent
 - Dependent on definition of contemporary group

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Economically Important Traits and How to Measure Them

- Simplest definition of a breeding value (G):
 - $BV = h^2 (\text{ind. measure} - \text{avg of group})$
- If contemporary group definition is not correct, breeding value (G) is not correct either.

$$P = G + E$$





Conclusions

- Economically important traits can be controlled by additive or non-additive gene action
- Detailed, accurate records are needed to evaluate which are the best animals in the herd





Conclusions

- $P = G + E$ is the basis for all evaluations of genetic merit
- Defining E through contemporary groups is essential for accurate evaluations
- Goals for the operation will dictate which traits need to be measured