# Genetics Discussion for the American Black Hereford Association

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# Topics

- **Managing Genetic Defects in Cattle Populations**
- **Contemporary Groupings**
- **Data Collection and Reporting**

# Genetic Abnormalities

- **Prominent examples**
  - **Dwarfism in the 20$^{th}$ century**
  - **Curly calf syndrome**
- **Economics of seedstock production**
  - **Loss of the production cycle**
  - **Public relations and reputation**

# Some Terms in Genetics

- Locus—place in the genome
- Gene—yields a product with a function
- Allele—alternate version of a gene/locus; e.g. $A, a, A_1, A_2$
- Diploid—2 copies of genomic material (DNA); 1 each of paternal and maternal origin
- Genotype—the 2-allele designation of gene or locus in a diploid animal; e.g., $AA, Aa, aa$, $A_1A_1, A_1A_2, A_2A_2$

# Phenotype

- something observable of an animal (trait)
  - Quantitative (infinitely divisible) & many genes (usually unknown) influence
    - Weight, height, blood pressure
  - Qualitative (large discrete) & generally one or a few genes that are known
    - Eye color, coat color, presence/absence of horns

# Additive Genetic Action

**One locus (gene) with two alleles $A_1, A_2$**

- **3 genotypes are possible**
- **$A_1A_1$, $A_1A_2$, $A_2A_2$ with corresponding values of 0, 1, 2 (some trait units)**
- **In this example, every $A_2$ allele adds a value of 1**
- **Quantitative traits**

# Dominance as Genetic Action

**One locus (gene) with two alleles $A, a$**

- **3 genotypes are possible**
- **$AA$, $Aa$, $aa$ with values 1, 1, 0 (arbitrary)**
- **Allele $A$ covers up the effect of allele $a$**
- **Allele $a$ is recessive to allele $A$**
- **Qualitative traits—eye color in humans; coat color in cattle**

# Genetic Abnormalities in Livestock

- **Single gene**
- **Dominance: the recessive genotype (e.g., $aa$) is responsible for the abnormality.**
- **Deleterious: or lethality**
- **Carrier: individual that has a (covered up) recessive allele (heterozygote)**
- **Homozygous Dominant: confirmed as having 2 dominant alleles**

# In the following examples, assume

- **Dominance as the genetic action**
- **The recessive genotype is responsible for the abnormality**

# Matings of $AA \times AA$

| | Sire alleles (frequency) | |
|---|---|---|
| Dam alleles (frequency) | $A$ (1) | |
| A (1) | $AA$ (1) | |
| | | |

# Matings of $aa \times aa$

| | Sire alleles (frequency) | |
|---|---|---|
| Dam alleles (frequency) | $a$ (1) | |
| $a$ (1) | $aa$ (1) | |
| | | |

# Matings of $Aa \times aa$

| | Sire alleles (frequency) | |
|---|---|---|
| Dam alleles (frequency) | $A$ (1/2) | $a$ (1/2) |
| $a$ (1) | $Aa$ (1/2) | $aa$ (1/2) |
| | | |

# Matings of $Aa \times Aa$

| | Sire alleles (frequency) | |
|---|---|---|
| Dam alleles (frequency) | $A$ (1) | |
| $A$ (1/2) | $AA$ (1/2) | |
| $a$ (1/2) | $Aa$ (1/2) | |

# Matings of $Aa \times Aa$

| | Sire alleles (frequency) | |
|---|---|---|
| Dam alleles (frequency) | $A$ (1/2) | $a$ (1/2) |
| $A$ (1/2) | $AA$ (1/4) | $Aa$ (1/4) |
| $a$ (1/2) | $Aa$ (1/4) | $aa$ (1/4) |

# Mating of Heterozygotes $Aa$

- **These are the problem matings.**
- **$Aa$ are phenotypically indistinguishable from $AA$**
- **How can $Aa$ individuals be identified?**
  - **Pedigree and associated probability**
  - **Test matings and reassessment of probability**
  - **Genomic testing**

# How Many $Aa$ in the Population?

- Many abnormalities are recessive.
- Since they are deleterious, we expect that selection would work against their presence.
- Therefore the frequency should be low (< 5%) and most (all) of the recessive alleles will be present in the heterozygous individuals ($Aa$)
- Frequency of the allele corresponds to probability of its presence

# Matings at Random in the Population

| | Sire alleles (frequency) | |
|---|---|---|
| Dam alleles (frequency) | $A$ (0.99) | $a$ (0.01) |
| $A$ (0.99) | $AA$ (0.9801) | $Aa$ (0.0099) |
| $a$ (0.01) | $Aa$ (0.0099) | $aa$ (0.0001) |

# All Sires Confirmed as Non-Carriers ($AA$)

| | Sire alleles (frequency) | |
|---|---|---|
| Dam alleles (frequency) | $A$ (1) | |
| $A$ (0.99) | $\boldsymbol{AA}$ (0.99) | |
| $a$ (0.01) | $\boldsymbol{Aa}$ (0.01) | |

# ABHA Required Testing

- **Arthrogryposis Multiplex—Curly calf**
- **Neuropathic Hydrocephalis—water head**
- **Developmental Duplication**
- **Idiopathic Epilepsy—shaker calf**

# EPD Runs

- **Linear Mixed Models—Best Linear Unbiased Prediction—extension of linear regression**
- **Effects statistically adjusted for "pollutants":**
  - **Preadjustment for dam age and calf age (BIF)**
  - **Contemporary group—Calves from same ranch, year, season, sex; minimum of 4**
  - **Breed of calf: HB and HX**
  - **Breed of dam: HB, HX, PH, HH, NR**

# Animal Effects = EPD

- **Associations among animals are included by using average pedigree relationships**
- **Expectation of the proportion of genes/DNA that animals share because of common or direct ancestry**
- **Separately for each trait analyzed**
- **Maternal animal effects—birth and weaning weight (Milk EPD)**

# Contemporary Groups

- Calves that are born and managed similarly
- Combinations of ranch, year, season, and sex
- Cases extreme
  - Show calves
  - Embryo transfer calves (recipient)
  - Calves out on the range

# Contemporary Groups

- **Beef Improvement Federation Guidelines https://beefimprovement.org/library-2/bif-guidelines**

  **say 20 as a minimum**

- **4 because ABHA is young and in a growing phase.**

# Sampling Weirdness

- **“Sampling Error”**
- **There is a population; we retrieve a sample to make inference about the population (this is the essence of statistics)**
- **How good is that sample?**
- **The bigger the sample, the less subject to extreme values or unusual occurrences**

# Average Number of Aliens Seen per US Citizen (~325 million people today)

- What is the real average?
- Random samples of
  - 1 million
  - 100,000
  - 1,000
  - 100
  - 4
- What kind of sample gives the best approximation of the true number?

# Example

**Assume a bull is used in a herd and has 100 cows bred. Imagine taking random groups of 4 from those 100—what could the cows be like?**

- **Some conceive and give birth early (or late)**
- **Only the young (or old) cows have calves in a group**
- **Most or all of the dams are NR for some group of calves**

# What Should CG Minimum Size Be?

- **BIF recommendations = 20**
- **Move there gradually**
- **Trade-off between record accumulation and CG size**
- **Inclusion of small breeding stock operations**
- **Set a target date and proposed change, e.g.: "Calves born in 2020, the new CG minimum size will be 10 instead of 4."**

# Data Collection and Reporting

- **Digital Beef—efficient data base management**
- **More EPD can be generated**
- **Whole Herd Reporting**

# Whole Herd Reporting

- https://beefimprovement.org/wp-content/uploads/2013/07/BIFGuidelinesFinal_updated0916.pdf pages 7-15 (search for "BIF Guidelines" and you will find)
- Collection of annual production and performance records on all cattle within a herd—registration not required
- Objective: accumulate reproductive and performance data on all animals in a breed

# Whole Herd Reporting

- **Does not seek to control which animals will be registered (individual breeder decision)**
- **Performance records (or disposal codes) are required on all calves produced by each breeder**
- **Strongly recommend ABHA adopt this as policy**

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# Thank you!