Evolution of Genetic Improvement Practices in Domestic Animal Populations

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University of Florida

Characterization of Genetic Improvement Programs

Genetic Evaluations in Time: Past, Present, Future

Role of Universities, Government Institutions, Private Industry

Final Thoughts

Characterization of Genetic Improvement Programs

Population

Domestic Animal Populations (Cattle, Sheep, Swine)

Number and Type of Subpopulations (Unibreed, Multibreed)

Reproductive Rates and Procedures (NS, AI, ET; Generation Interval)

Complete Multibreed Population

UFL Angus-Brahman Multibreed Herd

Composed of purebred and crossbred animals that interbreed

Angus
¾ A ¼ B
½ A ½ B
¼ A ¾ B
Brahman
Brangus

Sires mated to dams of all breed groups

Angus-Brahman Multibreed Herd

12 years of data (1989-2001)

153 sires (12 to 42 per BG)
1124 dams (113 to 293 per BG)
2910 calves (143 to 951 per BG)
### Numbers of Sires

<table>
<thead>
<tr>
<th>BGS</th>
<th>BGD A</th>
<th>.75 A</th>
<th>.50 A</th>
<th>.25 A</th>
<th>B</th>
<th>Br</th>
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<tbody>
<tr>
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<td>B</td>
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<td>Br</td>
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### Numbers of Dams

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<tr>
<th>BGS</th>
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<th>.75 A</th>
<th>.50 A</th>
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<td>32</td>
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### Incomplete Multibreed Population

Sanmartinero-Brahman Multibreed Herd

Sanmartinero
Colombian Criollo Breed
Beef - Dairy

### Number of Sires

<table>
<thead>
<tr>
<th>BGS</th>
<th>BGD</th>
<th>Sanmar</th>
<th>½S½B</th>
<th>Brahman</th>
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<td>½S½B</td>
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<td>¾S¾B</td>
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<tr>
<td>Brahman</td>
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### Number of Dams

<table>
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<tr>
<th>BGS</th>
<th>BGD</th>
<th>Sanmar</th>
<th>½S½B</th>
<th>Brahman</th>
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<td>¾S¾B</td>
<td>29</td>
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<tr>
<td>Brahman</td>
<td>75</td>
<td>1</td>
<td>110</td>
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</table>
### Number of Calves

<table>
<thead>
<tr>
<th>BGD</th>
<th>BGS</th>
<th>Sanmar</th>
<th>½S½B</th>
<th>Brahman</th>
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<tr>
<td>Brahman</td>
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### Incomplete Multibreed Population

**DPO Multibreed Population**

**Holstein, Native, Brahman, Red Sindhi, Sahiwal, Jersey, Red Dane**

*Bos taurus - Bos indicus*

Holstein - Other

(Native, Brahman, Red Sindhi, Sahiwal, Jersey, Red Dane)

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### Numbers of Sires

<table>
<thead>
<tr>
<th>BGD</th>
<th>BGS</th>
<th>H</th>
<th>(.63-.99)H</th>
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<tr>
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<td>(.6-.79)H</td>
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<td>(.4-.59)H</td>
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<td>(.2-.39)H</td>
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<tr>
<td>(0-.19)H</td>
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### Numbers of Dams

<table>
<thead>
<tr>
<th>BGD</th>
<th>BGS</th>
<th>H</th>
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<td>9</td>
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<tr>
<td>(.6-.79)H</td>
<td>168</td>
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<td>2</td>
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### Numbers of Daughters

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<th>BGS</th>
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<th>(.63-.99)H</th>
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<tbody>
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<td>9</td>
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<tr>
<td>(.6-.79)H</td>
<td>178</td>
<td>12</td>
<td></td>
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<tr>
<td>(.4-.59)H</td>
<td>106</td>
<td>7</td>
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</tr>
<tr>
<td>(.2-.39)H</td>
<td>17</td>
<td>2</td>
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<tr>
<td>(0-.19)H</td>
<td>15</td>
<td>2</td>
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### Traits and Effects

**Number and Type of Selection Traits**

(continuous, categorical, biological, synthetic)

**Genetic and Environmental Effects**

- Additive
- Nonadditive
- Direct
- Maternal
- Intrabreed
- Interbreed
Data Collection and Maintenance

Data for Current and Future Traits
Data on All Effects Related to All Traits
Complete Pedigree (Animals, Sires, Dams)
Breed Identification and Breed Composition (Animals, Sires, Dams)

Date1, {Measurements1}, ...

Chart of Genetic Effects

Additive
Direct
Maternal
Nonadditive
Direct
Maternal
Intrabreed
Intrabreed
Interbreed
Interbreed

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
### Computational Procedures

- **Population Size**
  - Small
  - Large

- **Type of Trait**
  - Categorical
  - Continuous
  - Biological
  - Synthetic

- **Direct**
- **Iterative**

- **Systemic**
  - (Systems Analysis)

### Multibreed Genetic Evaluations

  - Growth Traits (Pre & Postweaning)
  - Carcass Traits

- **Romosínano-Brahman – Colombia (1998)**
  - Growth Traits (Pre & Postweaning)

- **Sanmartinero-Brahman – Colombia (1999)**
  - Growth Traits (Pre & Postweaning)

- **Holstein-Other, BT-B1 – Thailand (2002)**
  - Dairy Traits (Milk Yield, Fat Yield, Fat %)

### Selection and Mating Strategies

- **Selection**
  - Unitrait
  - Multitrait

- **Mating Strategies**
  - Unibreed
  - Multibreed
  - Multitrait
    - (Index)
  - Unibreed
    - Multibreed
      - (Upgrading)
      - (Rotational Crossbreeding)

### Genetic Evaluations in Time

- **Past**
- **Present**
- **Future**

### Past Genetic Evaluations

- **Unibreed**

- **Unitrait**

- **Multitrait**
  - (Selection Index)

- **Additive Genetic Effects**

- **Progeny Test**

- **Herdmate Comparison**

- **Sire Model**

- **Single-Trait Additive Analysis**

- **Selection Index**

- **Economic Weights**
Present Genetic Evaluations

Unibreed
Multibreed

Multitrait
Quantitative Trait Loci (QTL)
(BLUP, Bayesian Methods)

Additive and Nonadditive Genetic Effects
(Interbreed)

USA - Dairy Holstein

Milk
Fat
Animal Model

Unibreed BLUP

Index

Multiple-Trait Additive Analysis
Economic Weights

USA - Dairy Crossbreeding

Milk
Fat
Animal Model

Unibreed BLUP

Index

Multiple-Trait Additive Analysis
Economic Weights

Chile - Dairy Multibreeding

Milk
Fat
Sire-Maternal
Grandsire Model

Unibreed BLUP

Index

Multiple-Trait Additive Analysis
Economic Weights

Thailand - Dairy Multibreeding

Milk
Fat
Animal Model

Unibreed BLUP

Index

Multiple-Trait Additive Analysis
Economic Weights

DPO Multibreed Population

Dairy Traits
Milk Yield
Fat Yield
Fat %

Bos taurus
Bos indicus
Holstein
Other
(Native, Brahman, Red Sindhi, Sahiwal, Jersey, Red Dane)
DPO Multibreed Genetic Predictions

<table>
<thead>
<tr>
<th>MEPD</th>
<th>Direct (D)</th>
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<tbody>
<tr>
<td>Additive (A)</td>
<td>AD</td>
</tr>
<tr>
<td>Nonadditive (N)</td>
<td>ND</td>
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<tr>
<td>Total (T=A+N)</td>
<td>TD</td>
</tr>
</tbody>
</table>

BTBI Model - Sires

Milk Yield Additive MPGV (kg)

BTBI Model - Sires

Milk Yield Nonadditive MPGV (kg)

BTBI Model - Sires

Milk Yield Total MPGV (kg)
Angus-Brahman Multibreed Herd

Growth Traits
Birth Weight
Weaning Weight
550-day Weight

Carcass Traits
Hot Carcass Wt
Ribeye Area
Marbling
Tenderness

Multibreed Genetic Predictions

<table>
<thead>
<tr>
<th>Trait</th>
<th>MEPD</th>
<th>Direct (D)</th>
<th>Maternal (M)</th>
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<tbody>
<tr>
<td>Additive (A)</td>
<td>AD</td>
<td>AM</td>
<td></td>
</tr>
<tr>
<td>Nonadditive (N)</td>
<td>ND</td>
<td>NM</td>
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<tr>
<td>Total (T=A+N)</td>
<td>TD</td>
<td>TM</td>
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USA - Beef Crossbreeding

Wean Wt
Yearl Wt
Animal Model
Grp Multibreed BLUP
Index
Additive-Nonadditive Multiple-Trait Analysis
Economic Weights

Angus     75A Brangus  50A    25A     Brahman
Future Genetic Evaluations

- Multitrait
- Discrete
- Continuous
- Unibreed
- Multibreed
- Economic Traits
- Quantitative Trait Loci
- Actual Genes
- Gene Combinations
- Synthetic Traits

Additive and Nonadditive Genetic Effects (Intrabreed and Interbreed)
**New Models**

- Basic Traits
- Traditional Traits
- Biological Models
- Linear Models
- Comprehensive Models
- Nonlinear Models
- Composite Traits

**Current Research**

- New Relationships
  - Ninth Month
  - Seventh Month
  - First Month
  - Fifth Month
  - Third Month
  - Growth Traits
  - Dairy Traits
  - Level of Activity
  - Active Genes
  - Groups of Genes
  - Relationships Among Genes
  - Oxytocin
  - GH
  - Digestive Efficiency
  - Heat Resistance
  - Immunologic Resistance
  - Parasite Resistance

**New Groups of Traits**
Current Flow of Information

Future Flow of Information

New Informatics Structure

Less Control over their Data ?

Less Access to Databases ?

Large Number of Private Databases

Private Companies

Universities

Breed Associations

New Research Structure

Expensive Research Projects (Equipment, Personnel)

Large Number of Simultaneous Measurements (Biochips)

Private Companies Will Collect Most of the Genetic Information ?

Role of Breed Associations and Private Industry ?

Role of Universities and Government Institutions ?

Role of Universities

Larger Integration with the Private Sector

Joint Basic and Applied Research Projects with the Private Sector

Participation in Joint Product Development and Commercialization with the Private Sector

Participate in Research Parks

Participate in National Research Committees

Role of Government Institutions

Support National Infrastructure and Agricultural Services

Support Research and Development Projects of National Interest

Support Development of Economically Viable Dairy and Beef Cattle Industries

Support the Development of New Technology and Development Programs
Role of Breed Associations
- Suppliers of Genetic Material
- Alliances with Private Companies
- Larger Investment in Research and Development
- Agreements with Universities
- Applied Research

Role of Private Industry
- Users and Suppliers of Genetic Material
- Vertical Integration (Poultry, Swine, Cattle)
- Cooperatives and Alliances
- Larger Investment in Research and Development
- Basic and Applied Research

Impact of Globalization
- International Companies
- International Databases
- Larger Genetic Changes
- International Projects in Research and Development
- Regional Agreements
- Larger Economic Benefits

Final Thoughts
- Genetic Evaluation will change substantially in the future
- New Traits
- New Genetic-Statistical Methods
- New Population Structure
- New Data Structure
- New Economic Structure
- New Selection Goals