The History of Animal Genetic Improvement “101”

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Genetic Selection – Animal Breeding

- Been going on for thousands of years
- Has accelerated dramatically last 100 yrs
- Massive progress in the last 50 yrs
- Extremely organized systems of genetic improvement in the livestock sectors
Selection Information – Genetic Process

- Visual appraisal
- Pedigree information
- Performance data
- Genetic merit values & accuracy
- **Genomic/DNA markers** enhanced genetic merit values
- Future technologies
The Toolbox

- In Vitro Fertilization
- Genetic Resources
  - ViaGen Cloning Technology
  - Biomedical
  - Precision Breeding
    - Gene Editing
- Sorted Semen
- Embryo Transfer
- Artificial Insemination

Animal Husbandry
Genetic Selection & Technology

Genetic Gain = \textcolor{red}{\text{acc}} x \textcolor{blue}{\text{genetic variation}} x \textcolor{green}{\text{intensity}}

\textcolor{red}{\text{generation interval}}

AI started in 1950’s
ET started in 1970’s
IVF started in 1990’s
Cloning started in late 1990’s (Dolly)
SS started in 2000’s
Today’s Industry- Flow of Genetic improvement

- **Nucleus selection lines/populations**
- Production of genetic product for the commercial sector – **Multiplier**
- **Commercial** production of product

Genetic targets
Genetic Improvement- Poultry

Growth rate
• 85-90% increase

Havenstein et al., 2003. Poultry Science 82, 1500-1508
Pork Production

1959 it took 8 pigs to produce 1000 lbs of pork, today it only takes 5 pigs

<table>
<thead>
<tr>
<th>Metric</th>
<th>1950s</th>
<th>Today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litter size weaned</td>
<td>5-7</td>
<td>10-11</td>
</tr>
<tr>
<td>Pigs weaned/sow/year</td>
<td>10-15</td>
<td>20-25</td>
</tr>
<tr>
<td>Market weight, lb</td>
<td>200-225</td>
<td>275-290</td>
</tr>
<tr>
<td>Days to market</td>
<td>180</td>
<td>165</td>
</tr>
<tr>
<td>Feed efficiency (feed/gain)</td>
<td>3.50</td>
<td>2.75</td>
</tr>
</tbody>
</table>

![U.S. Pigs Per Litter by Month](https://www.uky.edu/Ag/AnimalSciences/instruction/2009.pdf)
Dairy

1940s

- 25 M cows 4500 lbs per lactation
- 9.2 M cows 22,000 lbs per lactation

- 2.7 fold reduction in cow numbers
- 4.9 fold milk yield per cow increase

1940 cows required 4.5 times more land and produced 2.6 times more Methane.
Genetic Gain – Recent technology additions

Genomic/DNA enhanced genetic evaluations

- 1.47 million dairy animals genotyped since 2009 worldwide
- 1.16 million U.S. dairy animals genotyped since 2009

First Genomic enhanced genetic evaluation 2009
IVF TOG and Genetic Gain
Growth of IVF at TOG and genetic gain dairy
Genetic Gain – Recent technology additions

- Cloning before Dolly 1996 –
  - Splitting embryos clones 1980’s
  - Animal clones from embryonic cells 1984

- 2008, the U.S Food and Drug Administration (FDA) Risk Assessment Published

In January 2008, the U.S. Food and Drug Administration (FDA) published a risk assessment that concluded that the meat and milk products from cloned animals and their offspring are safe for human consumption and it is not any different from foods produced from other breeding methods. Under current FDA guidelines, food from animal clones will not require special labeling.

Animal clones will primarily be used for breeding stock to improve the health and quality of animals used for food production. Most consumers will likely never eat an animal clone.
Cloning

• Genomic rockstar in very high demand by farmers.
• Due to severe pneumonia as a calf, produced limited semen.
• Cloning produced a healthy bull with excellent semen production.
• The cloned bull produces ~100,000 units of semen per year which is in high demand globally.

Genetic Gain – Recent technology additions

Cloning

Saving Superior Outlier Genetics

Extending Reach of Rare Genetics

Prime beef is the highest grade of beef in the industry.
• But the hardest to achieve - 0.03% of all carcasses are Prime.
• Prime carcasses are identified at slaughter.
• Cloned males and females are produced for breeding to produce a whole line of Prime offspring.
Genetic Gain – Combining IVF, genomic genetic evaluation & cloning

Advanced reproductive technologies

3 weeks
- IVF embryos
- Embryo transfer
- Collect fetuses

Genomic selection
- Genotyping and genetic merit evaluation
- Frozen cell line aliquots
- Establish fibroblast cell lines

1-2 months

Somatic cell nuclear transfer (SCNT)

9 months
- Fibroblasts with desired genetics are used as SCNT donor cells
- Embryo transfer
- High genetic merit calves

Fetal cell line selection & Embryo cell line selection
Traditional Animal Breeding

- Novel natural occurring gene alleles segregating in population
- Traditional breeding will take 6-7 generations 15 yrs minimum

Myostatin

Pied x Wagyu

Backcrossing to produce purebred Wagyu with Myo-P allele.

1) f2-f6 genetic test
2) Select females Myo-P
3) Backcross to Wagyu
   - Repeat process 6x

98% purebred Wagyu f6 Containing the Myo-P allele

Myostatin

Wagyu
**Future of Animal Breeding – Adding tools**

1) Establish cell line

2) Edit Myostatin gene Piedmontese allele Myo-P/Myo-P

3) Use cloning to produce homozygous Myo-P/Myo-P Wagyu Bull

4) Mate bull with Wagyu females

5) Production of ideal 100% Wagyu progeny carrying a copy of the Myo-P allele - 3yrs
THANK YOU

QUESTIONS?

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