Genetics:
Past, Present and Future

Dominic Elfick
Per Capita Consumption of Meat (kgs)

Livestock, Dairy and Poultry Situation and Outlook, Economic Research Service, USDA.
Genetic Selection Criteria

- Liveweight
- 2005
- Skeletal Integrity
- Eggs
- Hatchability
- Weight
- Breast Meat
- Meat Quality
- Feed Conversion
- Growth Profile
- Immune Response
- Cardio Vascular Fitness

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## Improvements in Broiler Performance

<table>
<thead>
<tr>
<th>Year</th>
<th>Weight</th>
<th>Age</th>
<th>FCR</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1925</td>
<td>2.2 lb</td>
<td>16 Weeks</td>
<td>4.7</td>
<td>18%</td>
</tr>
<tr>
<td>1945</td>
<td>3.1 lb</td>
<td>12 Weeks</td>
<td>4.0</td>
<td>10%</td>
</tr>
<tr>
<td>1965</td>
<td>3.5 lb</td>
<td>9 Weeks</td>
<td>2.4</td>
<td>6%</td>
</tr>
<tr>
<td>1985</td>
<td>4.2 lb</td>
<td>7 Weeks</td>
<td>2.0</td>
<td>5%</td>
</tr>
<tr>
<td>2005</td>
<td>5.3 lb</td>
<td>6 weeks</td>
<td>1.7</td>
<td>4%</td>
</tr>
</tbody>
</table>
EGG LAYER  MEAT CHICK

AT 4 DAYS OLD
<table>
<thead>
<tr>
<th>Trait</th>
<th>Annual rate of Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to reach 5lb</td>
<td>- 0.89 days, better</td>
</tr>
<tr>
<td>F.C.R. at 5lb</td>
<td>- 0.03, better</td>
</tr>
<tr>
<td>Eviscerated Yield</td>
<td>+ 0.43 %, better</td>
</tr>
<tr>
<td>Breast Meat Yield</td>
<td>+ 0.44 %, better</td>
</tr>
<tr>
<td>Broiler Liveability</td>
<td>+ 0.17 %, better</td>
</tr>
<tr>
<td>Plant condemnations</td>
<td>- 0.13 %, better</td>
</tr>
<tr>
<td>Broiler chicks</td>
<td>0.6 Chicks, better</td>
</tr>
</tbody>
</table>

Source: Industry reporting Service
Comparison of selected and control broilers at 42 days of age

Unselected 1972 control broiler

Selected pedigree broiler
Direction of Aviagen Breeding

RAPID BALANCED PROGRESS

BREEDER
- Chicks
- Metabolic Fitness
- Welfare Traits
- Liveability

LIVE BROILER
- Growth
- FCR
- Disease Resistance
- Pathogen Freedom

PROCESSING
- Breast Meat
- Skeletal Strength

SUPPORT
- Liveability
- Disease Resistance
- Pathogen Freedom
Influence of Genetics

Factors Effecting Potential Performance

- Egg Production
- Fertility
- Hatchability
- Egg size
- Body Weight
- Feed Conversion
- Breast Meat

% Performance

- Health status
- Nutrition
- Management
- Stockmanship
- Genetics

Reproductive Traits

Performance traits

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Product Development is Market Driven

- Must meet the needs of a broad range of customers with varying:
  - Types of end products
  - Production environments
  - Health challenges
  - Nutritional programs
Broiler Production by Type

Billion birds

- **Deboning/Further Processed** – from >5.25lb (>2.4kg) chickens
- **Retail** – Fresh, unprepared for meat cases, 4.21-5.25lb (2.0-2.4kg) chickens
- **Quick Service** – Cut-up for fried chicken from <4.21b (<2.0kg) chickens
What to select for?

Affect of a 1% change in a trait
Based on 1,000,000 birds processed per week
2.4kg kill weight, 60% debone, 40% tray pack

<table>
<thead>
<tr>
<th>Trait</th>
<th>Base Margin</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs</td>
<td>$15,128,448.00</td>
<td>0.35</td>
</tr>
<tr>
<td>LWT</td>
<td>$15,192,584.00</td>
<td>0.77</td>
</tr>
<tr>
<td>FCR</td>
<td>$15,385,557.00</td>
<td>2.05</td>
</tr>
<tr>
<td>Liveability</td>
<td>$15,156,393.00</td>
<td>0.53</td>
</tr>
<tr>
<td>Breast yield</td>
<td>$15,770,962.00</td>
<td>4.61</td>
</tr>
</tbody>
</table>
Biggest Challenges Facing Live Production

- Environmental
- Animal Welfare
- Biosecurity/ Disease
- Pressure to reduce Cost
- Urbanization
- Grower Relations
- Recruiting / retaining growers
- Food Safety
- Elimination / reduction of sub / therapeutic drugs
- Recruiting / retaining servicemen
- Shrinking resources for universities, etc.

- Greater litter reuse, higher efficiency
- Larger birds / faster growth
- Higher standards
- Lower spec diets, poorer brooding
- Higher efficiency
- Biosecurity
- Biosecurity

Poultry USA June 2005
Global production facilities

1. Aviagen Ltd, Scotland
2. Aviagen Inc., U.S.
3. Agroceres, Brazil
4. Ross Poultry Breeders, South Africa
Historical Farming Strategy

- Large, multi-age
- Company owned
- Pedigree/GGP/GP

High Risk
Present-day Farming Strategy

- Two House Sites
- Restricted Access
- Shower-in

- Concrete Floors
- Drop Metal Ceilings
- Partial Block Walls
Pasteurized Feed
Health and Biosecurity
Farms are designed to maximize the health of our birds, our best weapon is **Biosecurity**
Effect of Biosecurity and Health Management

- Security of supply
- Security of performance
- Poultry breeding stock sold free of:
  - Mycoplasma,
  - Salmonella,
  - Avian Leukosis Virus
  - Avian Influenza
  - Etc.
Welfare and Growth
Market Driven Product Development

Multiple Environments and Nutritional Programs

- Select birds that perform well under the majority of conditions
High Input Environment

- High Input Levels
  - Drug free
  - Low immune challenge
  - High light intensity
  - Long light periods
  - Lower stocking densities
  - Best management practice
  - High labor
  - Breeder style vaccination
  - All in all out system

- Highly Biosecure
Impact of High Input Environment on Selection

• Pressure on the physiology of the bird
  - Heart and lung function
    • Mortality
    • ECG
    • Oximeter
  - Skeletal integrity
    • Freedom from Defects
    • Leg strength
    • Lixiscope
Welfare inspections on farms in Great Britain January – December 2002

- Full compliance
- Compliance
- Non-compliance
- Unnecessary pain or distress
Low Input Environment

- **Test bothers and sisters of pedigree**
- **Low Input Levels**
  - Drug free
  - Feed 15-20% below manual
  - Used litter
  - Short down time
  - High viral, bacterial and cocci challenges
  - Low light intensity
  - Commercial stocking densities
  - Low labor input
  - Fluctuating temperature

- **Non-Biosecure**
- **Dead-end test**
Impact of Low Input Environment on Selection

- Pressure on growth and rusticity of the bird
  - Gut and digestive function
    - Appetite
    - Gut integrity
  - Immune function
    - Mixed Challenge
    - Appropriate responses
  - Robustness
    - Uniformity
    - Livability
Mortality in other meat producing species

- Beef cattle
  - 8-10% to weaning (Canada)

- Sheep
  - 11-25% to weaning (Ireland)

- Pigs
  - Indoors 13.2% (range 5 – 20%) (UK)
  - Outdoors 16.7% (range 8.8 – 22.8%) (UK)
Broilers

- IRS statistics

- 4.5% Industry wide mortality in the USA
Humans

- WHO statistics

  - 5.2% of all children born in 2001 died before they were 1 year old
Efficiency and Environmental Improvements
Optimizing Growth

- Target different growth profiles for specific market sectors

![Graph showing growth profiles for Light Wt, Med Wt, and Heavy Wt over the 1st Week]
Optimizing FCR

- Collect data at ages that support the product specifications
- Record feed intake under different nutritional regimes
- Use differences in growth between the sexes
- Increase number of birds with FCR records
- Increase genetic progress by approx 25%

FCR Testing schedule

Early  Mid  Late

Growth Potential

Low Nutrition  High Nutrition
Lifetime FCR

- Record feed intake in a ‘commercial-like’ environment (multi-animal)
- Animal is required to expend energy to get to feed and water
- Allows for bird behaviour and competition
- Captures every meal (size, time & duration) during the birds life
- Large database of bird behaviour
- On average 750 meals for each bird

Vs.

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Data capture process

- Bird enters feed place
- Sensor is triggered
- Transponder ID is read
- Scale activity registered
- Bird leaves feed place
- Logical sensor off
- Record Written to file
Environmental Impact of Efficiency

- Increased Growth rate
- Improved FCR
- Increased Livability
- Increased Yield
- Higher chick output
- Faster turn around, less energy used
- Less Feed, less waste, lower trucking, lower energy, less water
- Less chicks required, less feed, fewer breeders
- Less birds required, higher throughput per lb, lower energy cost, less trucking
- Less breeder houses, lower energy costs, less feed, less trucking
Future Genetic Technology
Genomics

- The study of an organism's genome and the use of the genes.
- The genome of an organism is its complete DNA sequence.
- DNA is the genetic code for building and maintaining an organism.
- The DNA contains areas called genes; genes are templates for proteins.
- Differences in the sequence may alter the functionality of a protein.
- Differences in DNA make individuals unique.
Genomics

- Chicken genome
  - December 2004
  - Chicken genome = $1 \times 10^9$ (1 billion) base pairs long
  - 2.8 million SNPs mapped

- SNP = (single nucleotide polymorphism)
SNP – Single Nucleotide Polymorphism

- SNP = site of single base change in DNA sequence.

<table>
<thead>
<tr>
<th>Sample 1</th>
<th>Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>...GATGGCTCTTTGGAAGA\textcolor{red}{C}GATGACTATCATGCCACAACCGAG...</td>
<td>...GATGGCTCTTTGGAAGA\textcolor{red}{T}GATGACTATCATGCCACAACCGAG...</td>
</tr>
</tbody>
</table>

- SNP may alter protein sequence and have functional effect, or have no functional effect but have use as a marker.

- Particular SNP’s may be associated with traits of interest
Implications

- A new tool to help the selection process
- Faster, more efficient progress in key traits
- Progress in traits that are difficult to measure in the breeding programme:
  - Health, welfare and robustness type traits
  - Processing abnormalities, meat quality
  - Screening for rare genetic disorders
  - Sex limited traits (ex. egg production in males)
Product Performance

- Genetics
- Nutrition
- Health
- Management

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Product Performance

- Genetics
- Nutrition
- Health
- Management
Market / Industry Trends

- Birds will be killed bigger
- The retail sector will account for a smaller market %
- Yield will be the primary driver
- Biosecurity programs will increase in importance
- Welfare will be a significant issue for consumers
- Environmental concerns will become more acute
Conclusions

- Genetic change has been incremental
- Cumulative impact can be extreme
- Management can have more impact than genetics
- Understanding the changing bird and its needs is crucial
- Technical innovation is required to lead the market
- Genomics could create stepwise improvements