Animal Biotechnology

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April, 2008

Part 1: Animal Breeding and Genomics
Part 2: Animal Cloning & Other Issues

Biotechnology in the News

Science, June 16, 2006

TIME, July 10, 2006

Animal Biotech, Parts 1 and 2

- Overall: Introduce biotechnology as used in animal agriculture
- Part 1 (Thursday, April 10th)
  - Breeding and genomics
  - Video (UCD Animal Biotech)
- Part 2 (Tuesday, April 15th)
  - Genetic engineering
  - Animal cloning
  - Biotech in animal husbandry
  - Social & ethical concerns

Part 1: Breeding & Genomics

Describe the breeding industry in animal agriculture

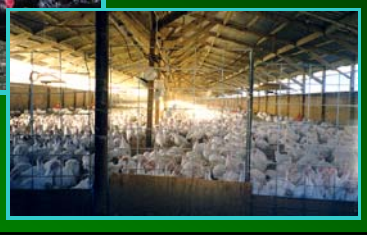
- Historical, technical and social context
- Approaches to breeding
- Highlight milestones
- Identify problems and challenges
- Are breeders responsive to social pressures?

Business as usual?

Social and market forces are pressuring animal industries to re-examine their practices.

Public concerns and animal welfare

Modern animal agriculture: times have changed



Similar types of changes have occurred throughout animal agriculture

Technologies in Poultry Breeding

Technique	Introduced
Trap nesting	1930
Hybridization	1940
Pedigree Control	1940
Artificial Insemination	1960
Index selection/evaluation	1960
Feed Efficiency Testing	1970
Electronic Data Collection	1980
BLUP selection/evaluation	1990
DNA Markers	1990
Individual feed efficiency	2000
Sequence, SNPs	2000

← White feathers. Why?

Modified from Arthur & Albers, 2003

Phenotype encompasses Genotype and Environment

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$P = G + E$

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$V_P = V_G + V_E$

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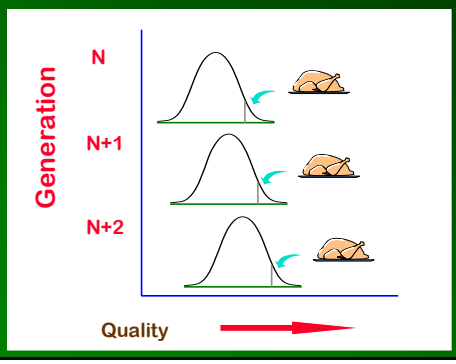
$P = G + E$

$V_P = V_G + V_E$

heritability (h^2): V_G / V_P

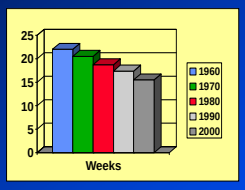
h^2 ranges from 0 to 1 (like a correlation) and measures the relative degree of genetic vs. environmental influence (nature & nurture)

Traditional Breeding: Select Best Individuals & Families

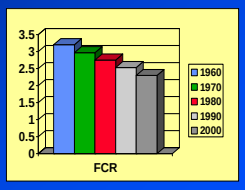


Changes in growth rate and feed efficiency, 1960-2000
(Target: Male @ 22 lbs.)

Weeks to target weight

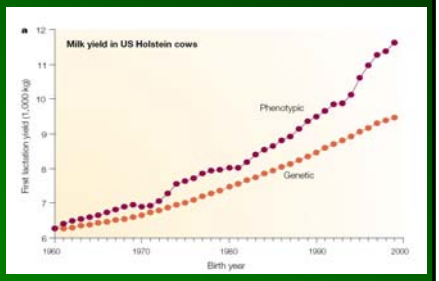


Feed Efficiency (FCR)



Milk Production in Holstein Cows

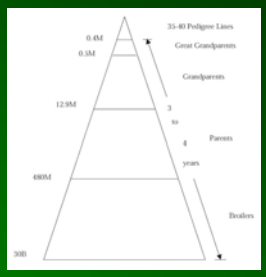
- Total milk production has doubled in 40 years
- Overall gains reflect improvements in both husbandry and breeding
- Genetic improvement is substantial! How has it been accomplished?



Dekkers & Hospital, 2002

Structure of Chicken Breeding Industry

- Separate programs for egg layers vs. meat-type (broilers)
- A few multinational firms, compete for market share
- Highly specialized to accomplish breeding goals
  - excellent growth & production
  - hardy and healthy
  - free of contagious diseases
- Sell breeding stock (parents & grandparents)



Rocks et al 2003

Production pipeline for meat-type chickens ("broilers" are consumed)

Dairy and swine breeding following a similar path (less so for beef, fish)

Early efforts: Mapped DNA markers

- Maps & markers, mid-1990's
- Consensus maps, 2000
- Specific DNA tests
  - fast-feathering
  - MHC & blood groups
  - pigments
  - others…
- Breeding companies explored pilot-scale projects, and are now ramping up

Sequenced Animal Genomes

Pig sequence is also underway

Genome Sequence and SNPs

(Single Nucleotide Polymorphisms)

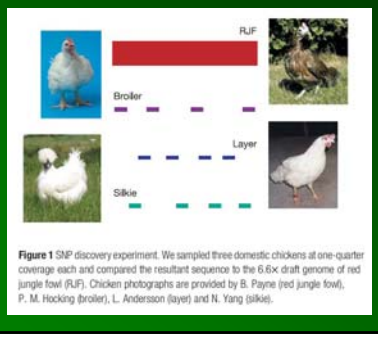
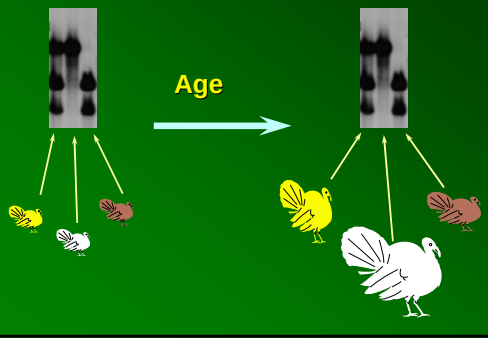


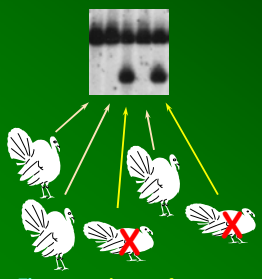
Figure 1 SNP discovery experiment. We sampled three domestic chickens at one-quarter coverage each and compared the resultant sequence to the 6.6× draft genome of red jungle fowl (RJF). Chicken photographs are provided by B. Payne (red jungle fowl), P. M. Hocking (broiler), L. Andersson (layer) and N. Yang (silkie).

December 9, 2004

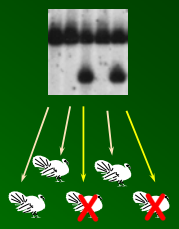
Genetic makeup is constant for the life of an individual



How might genetic markers accelerate breeding?

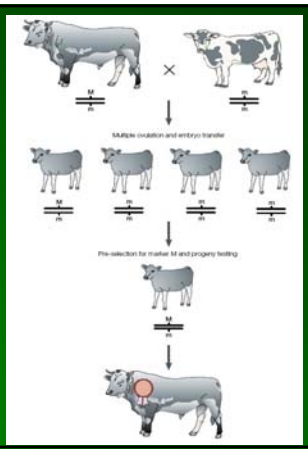


First, associate performance and genetic makeup



Then, evaluate genetic makeup early to select young birds

"Pre-selecting" with markers before testing progeny

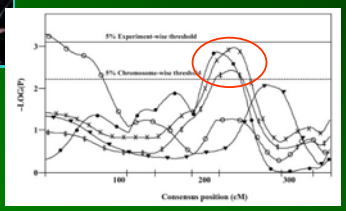


Validated marker tests are available for several traits & species

- Halothane and ryanodine receptor gene (Ryr)
  - porcine stress syndrome
  - defective allele discovered by comparing to known human condition
  - used with great success in industry
- MHC tests (predicts disease resistance) in chicken
- Meat quality in beef

Locating Genes? Mapping quantitative traits (QTL) in chickens

Genes in the circled region appear to affect breast-meat yield



Distance along chromosome Gga 3 (cM)

Preliminary Results on the Validation and Application of 3,072 Chicken SNPs by Genotyping 2,576 Commercial and Experimental Birds

Hans H. Cheng[1], Huanmin M. Zhang[1], William M. Muir[2], Martien A.M. Groenen[3], and Gane K.S. Wong[4]
[1]USDA, ARS, Avian Disease and Oncology Laboratory, East Lansing, MI 48823, USA
[2]Department of Animal Sciences, Purdue U., West Lafayette, IN 47907, USA
[3]Animal Breeding and Genetics Group, Wageningen U., Wageningen 6700 AH, The Netherlands
[4]Beijing Institute of Genomics, Chinese Academy of Sciences, Beijing 101300, P.R. China

- Goals and Results
  - High-throughput genotyping works well
  - Assay costs are modest (100-fold reduction over last 10 years)… and still going down
  - Applicable to commercial populations, not just experimental samples… Very important!!
  - Potential applications include
    - Track relatedness across multiple generations
    - Breeding application using "Genome-wide marker assisted selection" (GMAS)

OK, genetic gain is enhanced. Now what?! …

- What are the trade-offs?
  - Highly specialized (i.e. single-purpose) breeds
  - chickens: meat vs. eggs
  - cattle: beef vs. dairy
- "Commercial" breeds are commonplace
- Reduced genetic diversity?
- Too much emphasis in one direction can lead to problems in others

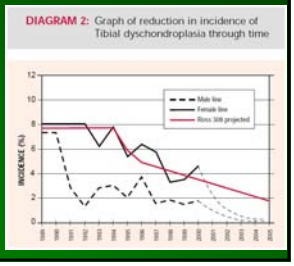
Trade-offs: Poultry

- Chickens
  - Evaluating genetic merit of individuals has resulted in aggressive behavior
  - Increased egg production can reduce calcium reserves in older layers (bone degeneration)
  - Rapid growth in broilers can cause locomotor (leg) problems
  - Increased crowding can increase stress thereby reduce immune function
  - Growth rate and fertility (egg production) are inversely correlated
  - US vs. European diets (corn vs. wheat)
- Turkeys
  - Commercial breeds show reduced variation in MHC
  - Rapid growth and leg problems
  - Large size can increase incidence of meat quality issues
  - US vs. European diets (corn vs. wheat)

Trade-offs: Cattle

- Dairy
  - Increases in milk yield (per lactation) can lead to reduced fertility (conception rate). Only cows that give birth produce milk!
  - Excessive milk production can lead to udder irritation (mastitis)
  - Artificial insemination
    - pedigree control (e.g. to avoid inbreeding)
    - overall relatedness within Holsteins is increasing
  - Holsteins are superior for
    - grain-based diets
    - milk with reduced butterfat
    - what if the market changes?
- Beef
  - Angus breed has superior carcass traits
  - "Certified angus" DNA tests now available
  - Angus were initially developed in UK, and do not thrive in hot-humid environments
  - "Brangus" (~5/8 Angus and ~3/8 Brahman)

Breeding progress in "Welfare traits"



Video: Animal Biotechnology

- Animal biotechnology
  - Broadly defined
  - Recently aligned with genetic engineering and cloning
- Genetic engineering
- Cloning
- Listen to some of the world's leaders!
- Reminder: Part 2 will emphasize these & other technologies

Thought Questions

What types of activities are included under the umbrella of "animal biotechnology."

If large-scale animal agriculture leads to problems, why do farmers continue using these practices?

How can animal breeding be managed to minimize long-term reductions in genetic diversity?

Genetic marker technology could be used to enhance breeding for disease resistance. How might this affect animal welfare?

Why might breeders pay attention to consumer attitudes?

Genetic engineering and animal cloning are similar, and yet different. How so?