Design of Animal Breeding Programs/Strategies

Overview

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What do we mean by Breeding Strategies?

- Tactics designed to integrate new technologies and to improve old ones, for the purpose of maximizing performance of existing stock (Charles Smith).
- Integration of the components of a breeding program into a structured system for genetic improvement, with the aim to maximize an overall objective.

General aim for animal breeding strategies:

Obtain future generations of animals that will produce more efficiently under future production circumstances

Basic Principle of making genetic progress in a population

Mate the "best" to the "best"
and do that as quickly as possible

$$\text{Genetic Gain/Yr} = \frac{\text{genetic superiority selected parents}}{\text{generation interval}}$$

$$= \frac{\text{intensity} \times \text{accuracy} \times \text{genetic st. dev.}}{\text{generation interval}}$$

Mate the "Best" to the "Best" and do that As Quickly As Possible

Some Questions

- How to find/identify the "best"?
- "Best" for what?
- What are the limits to use of only the "best"? - Inbreeding
- How can we shorten the generation interval?
- What are the limits?
- How can a breeding company make a profit from this?
  - "Breeding is a business" Lush, 1945
- How do technologies enter into this?

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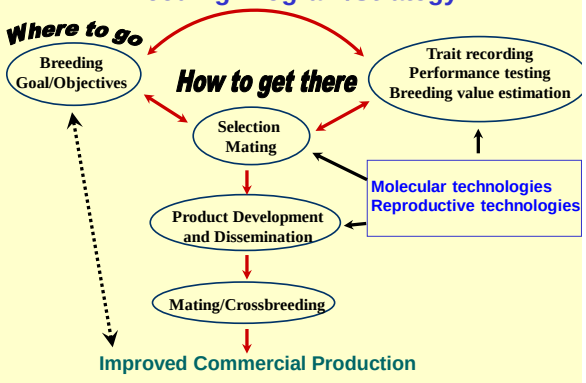
BREEDING STRATEGIES

Basic Components of a Successful Breeding Program/Strategy



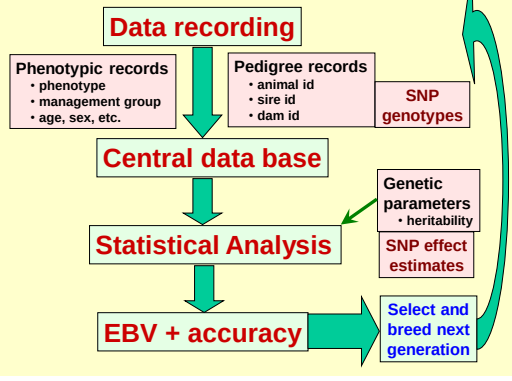
Basic Components of Breeding Strategies

- **Breeding Goal or Objectives - where should we go?**
  - Which traits must be improved? - Economic traits
  - How important is each trait? - Economic values
    - Focus on improvement of Economic efficiency/profit
    - Consider (future) consumer demands
- **Trait recording, Performance testing, Br. value estimation**

  Identify animals with "best" genetics - relative to breeding goal
  - performance recording and testing programs
    - which traits should be recorded and on which animals?
      - field recording
      - performance test stations / nucleus herds
      - progeny testing
  - pedigree registration
  - Which animals should be genotyped? High vs. low density

  Genetic Evaluation ⟷ Selection Index (Total merit index)

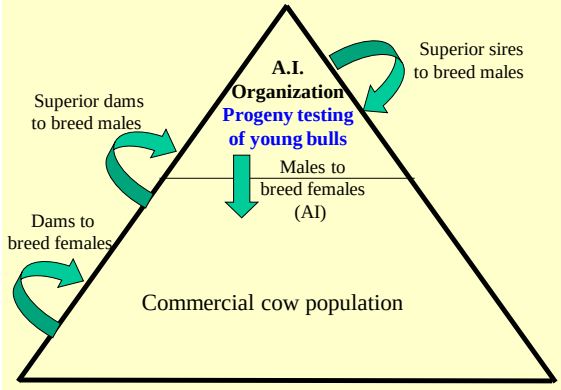
Process of Genetic Evaluation



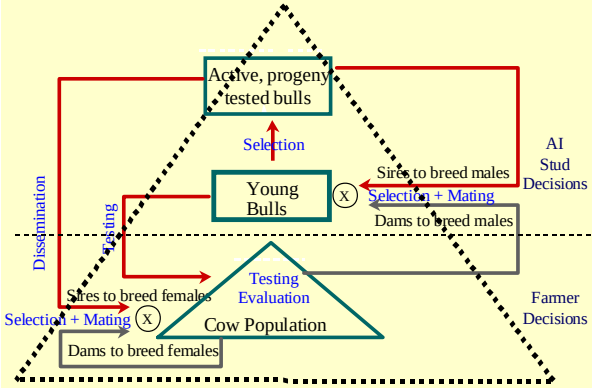
Basic Components of a Successful Breeding Strategy (cont'd)

- **Selection and mating**
  - use best animals to breed next generation ⟶ genetic improvement
    - How many and which animals should we select?
    - How should we mate them?
    - Should Marker-Assisted or Genomic Selection be implemented? How?
    - Should reproductive technology be used to increase # progeny/parent?
    - balancing rate of genetic gain and inbreeding (and cost)
- **Product Development and Dissemination**
  - program for marketing and distribution of superior genes into the commercial sector
    - progeny testing, AI
    - multipliers
- **Mating/Crossbreeding**
  - optimize combinations of genetic material in commercial animals

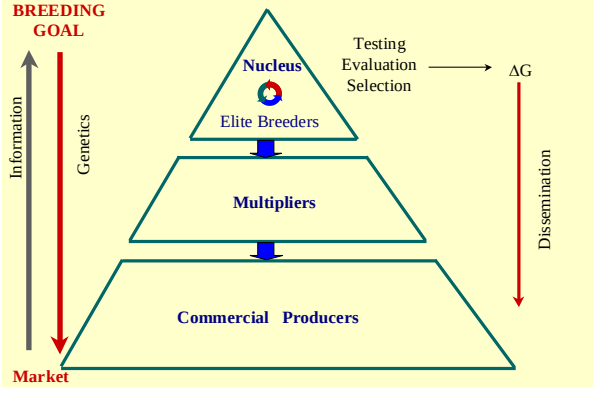
Dairy Cattle Progeny Testing Program

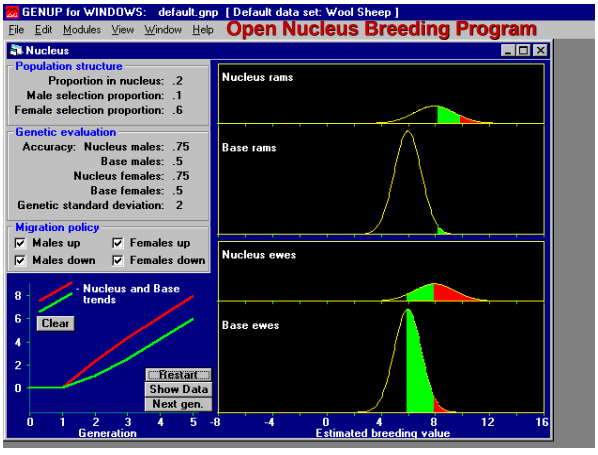


Dairy Cattle Progeny Testing Program

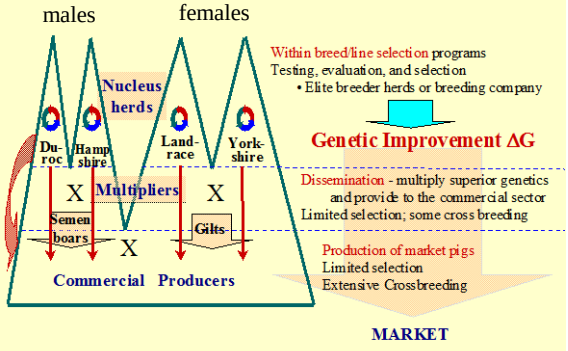


Typical Structure of Animal Breeding Programs

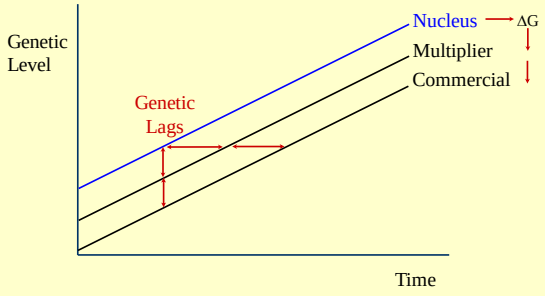




Structure of Swine/Poultry Breeding Programs
Closed Nucleus + Crossbreeding



Genetic Improvement in a Hierarchical Breeding Structure



Why use Cross Breeding?

1) **Averaging of additive breed effects in crossbreds**
   - often undesirable, unless intermediate is optimal
2) **Direct heterosis**
3) **Maternal heterosis**
   - crossbred dam - heterosis for maternal performance

Importance of Selection for Additive Effects versus Heterosis

$$P_{sire} = \mu + BV_{sire} + D_{sire} + I_{sire} + E_{sire}$$

Additive effects

Depends on genes inherited from dam

Random environments are independent

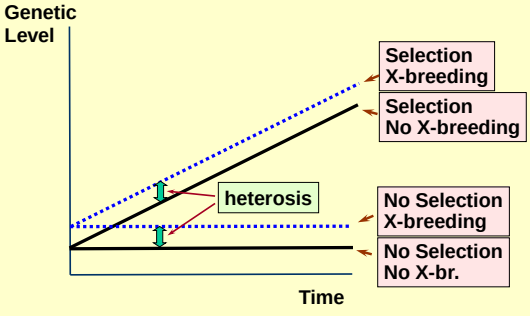
$$P_{prog} = \mu + BV_{prog} + D_{prog} + I_{prog} + E_{prog}$$

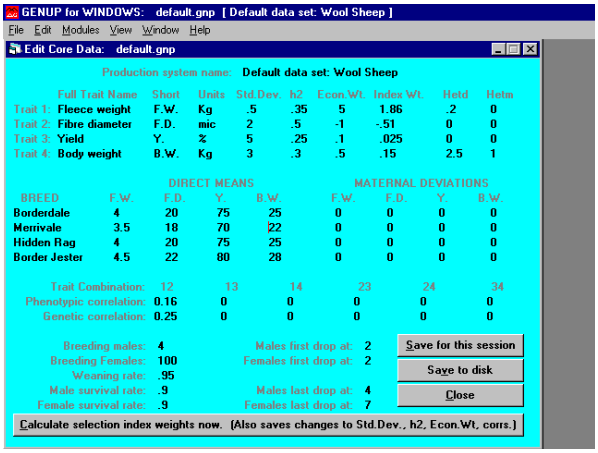
Only Additive Effects of genes (=Breeding Value) are transmitted from a parent to its progeny

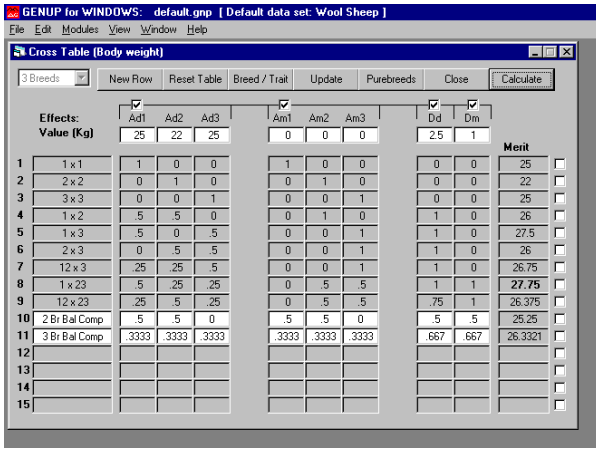
(regardless of mating)

Dominance and Epistatic effects depend on mating

Importance of Selection vs. Mating/Crossbreeding







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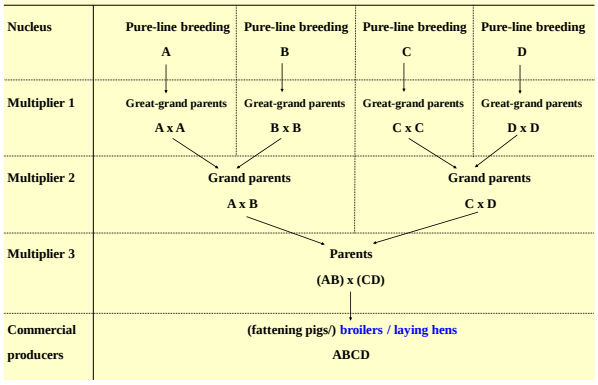
2) Direct heterosis
3) Maternal heterosis
   - crossbred dam - heterosis for maternal performance
4) **Sire-Dam complementation in production system**
   e.g. (large) fast-growing sire breed
   x (small) prolific dam breed
5) **Protect purebred genetics**
6) **Use of cheap source of breeding animals**
   (e.g. Merino ewes/dairy cows to produce meat animals)
6) **Widest use of genetic resources**
   - get best genetics across breeds
   - greatest flexibility
   - reduce impact of inbreeding

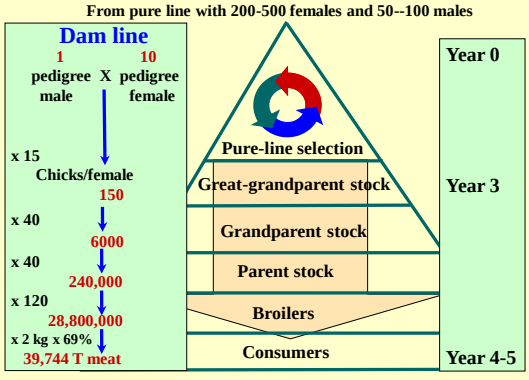
General structure of (swine and) poultry breeding programs



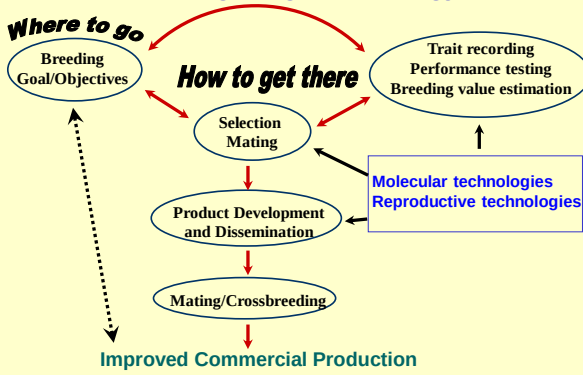
Multiplication in Broiler Breeding Programs

Adapted from: Poultry Breeding and Genetics, Crawford (ed). Elsevier, 1990

From pure line with 200-500 females and 50--100 males



Basic Components of a Successful Breeding Program/Strategy



Developing and Optimizing Breeding Strategies

1 Identify the product and the product goal

- maximize genetic gain
- maximize profit from genetic improvement at farm level
  - supply high quality genetics at lowest cost
- maximize profit from sale of genetic material (dissemination)
  - appropriate with competitive market for breeding stock

2 Identify constraints

- test resources
- facilities
- market
- Finances, Technology costs
- Need to maintain genetic variation (control inbreeding

Developing and Optimizing Breeding Strategies (cont'd)

3 Identify factors that affect the goal of the breeding program and which of those are under your control.

4 Determine how the factors that are under your control can be manipulated in order to maximize the goal.

Development of Breeding Strategies Summary

- Integration of the components of a breeding program into a structured system for genetic improvement, with the aim to maximize an overall objective (genetic gain, market share).
- Evaluate opportunities for improving upon current strategies.
- Evaluate the potential of new technologies.
  - How can they best be incorporated into current strategies?
  - Can their benefits best be capitalized on in a redesigned breeding structure?

Breeding Strategies - Summary

What tools are necessary to develop optimal strategies?

- Quantitative genetics theory
  - Predicting response to selection, selection index, inbreeding, etc.
- Systems analysis
  - Predicting and optimizing response in overall objective
- Common sense
- An open mind