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

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

= \text{intensity} \times \text{accuracy} \times \text{genetic st. dev.} \times \frac{1}{\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 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?
Basic Components of a Successful Breeding Program/Strategy

**Breeding Goal/Objectives**
- Trait recording
- Performance testing
- Breeding value estimation

**Selection**
- Mating

**Product Development and Dissemination**
- Molecular technologies
- Reproductive technologies

**Mating/Crossbreeding**

**Improved Commercial Production**

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, Breeding 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

**Data recording**
- Phenotypic records
  - phenotype
  - management group
  - age, sex, etc.
- Pedigree records
  - animal id
  - sire id
  - dam id
- SNP genotypes

**Central data base**

**Statistical Analysis**
- Genetic parameters - heritability
- SNP effect estimates

**EBV + accuracy**

**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

Dams to breed females

Superior dams to breed males

Males to breed females (AI)

Active, progeny tested bulls

Selection

Cow Population

Testing

Selection + Mating

A.I. Organization

Progeny testing of young bulls

Dairy Cattle Progeny Testing Program

Typical Structure of Animal Breeding Programs

BREEDING GOAL

Inheritance

Evaluation

Selection

Dissemination

Nucleus

Elite Breeders

Multipliers

Commercial Producers

Market

Open Nucleus Breeding Program

Nucleus

Population structure

Proportion in nucleus: 2

Male selection proportion: 3

Female selection proportion: 6

Genetic evaluation

Accuracy: Nucleus males: 75%

Base males: 5%

Nucleus females: 75%

Base females: 5%

Genetic standard deviation: 2

Migration policy

Males up

Males down

Females up

Females down

Nuclear and Base trends

Clear

Base lines

Nuclei names

Base names

Estimated breeding value

Generation

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
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

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

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
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)
7) Widest use of genetic resources - get best genetics across breeds - greatest flexibility - reduce impact of inbreeding
**General structure of (swine and) poultry breeding programs**

<table>
<thead>
<tr>
<th>Nucleus</th>
<th>Pure-line breeding</th>
<th>Pure-line breeding</th>
<th>Pure-line breeding</th>
<th>Pure-line breeding</th>
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<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Multiplier 1</td>
<td>Great-grand parents A x A</td>
<td>Great-grand parents B x B</td>
<td>Great-grand parents C x C</td>
<td>Great-grand parents D x D</td>
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<td>Multiplier 2</td>
<td>Grand parents A x B</td>
<td>Grand parents C x D</td>
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<td></td>
</tr>
<tr>
<td>Multiplier 3</td>
<td>Parents (AB) x (CD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial producers</td>
<td>(fattening pigs) breeders / laying hens ABCD</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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**

- Breeding Goal/Objectives
- Breeding
- Selection
- Mating
- Product Development and Dissemination
- Mating/Crossbreeding
- Improved Commercial Production
- Trait recording
- Performance testing
- Breeding value estimation
- Molecular technologies
- Reproductive technologies

**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.

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

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?