



Design of Animal Breeding Programs/Strategies

Overview

Jack Dekkers

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

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

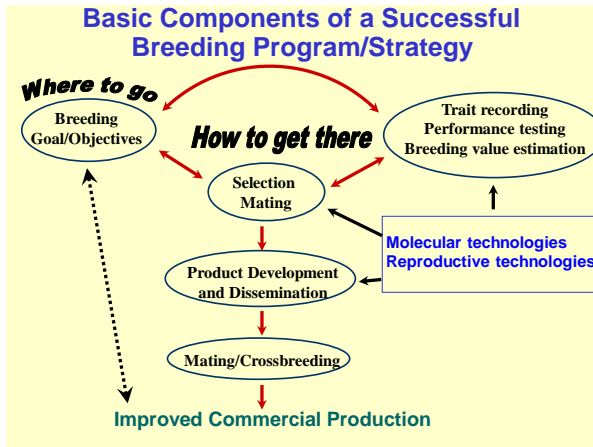
$$= \frac{\text{intensity} \times \text{accuracy} \times \text{genetic st. dev.}}{\text{generation interval}}$$

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?

BREEDING STRATEGIES



Basic Components of Breeding Strategies

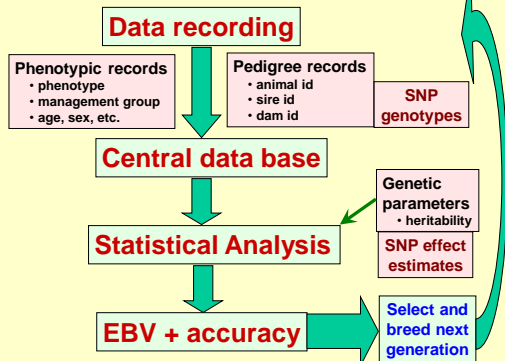
- **Breeding Goal or Objectives - where should we go?**
 - ◆ Which traits must be improved? - Economic traits
 - ◆ How important is each trait? - Economic values
 - ◆ Focus on improvement of Economic efficiency/profit
 - ◆ Consider (future) consumer demands
- **Trait recording, Performance testing, Br.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

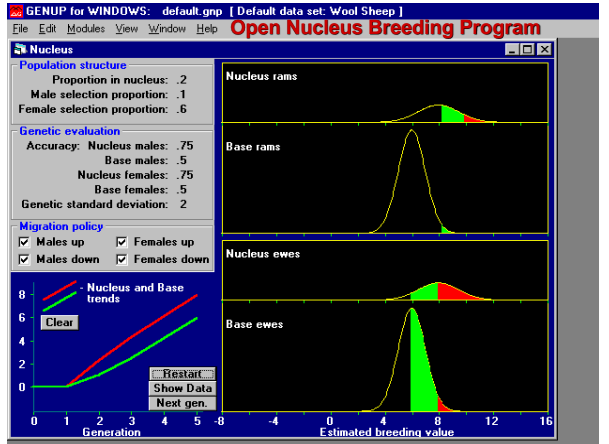
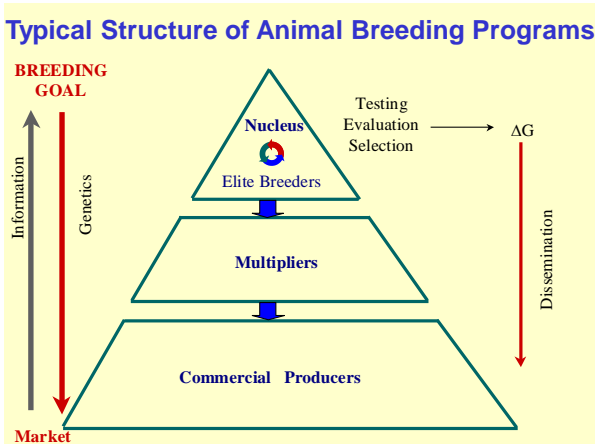
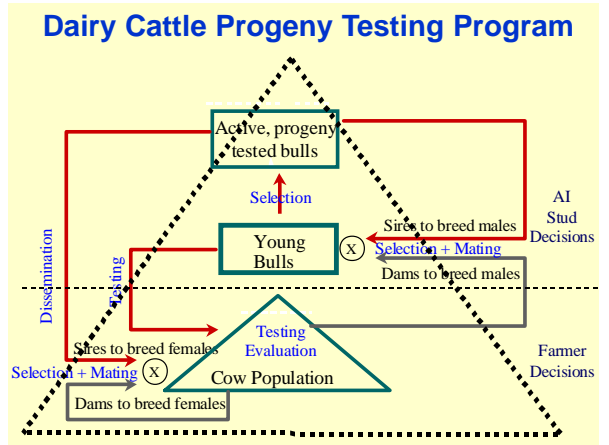
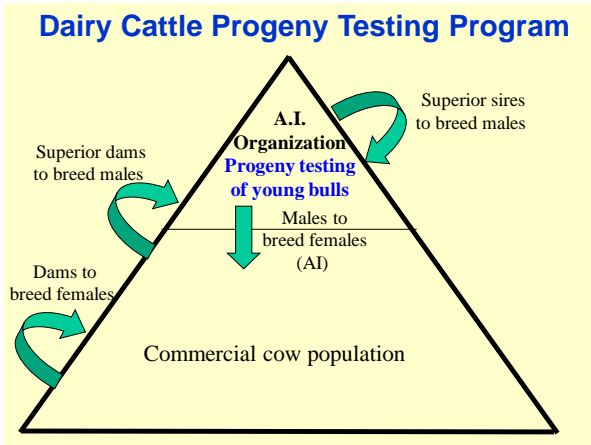
Genetic Evaluation → Selection Index (Total merit index)

Process of Genetic Evaluation

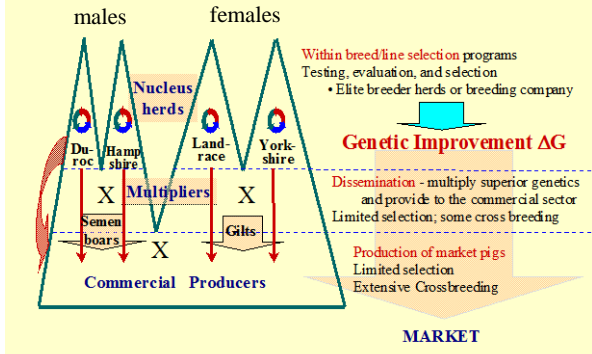


Basic Components of a Successful Breeding Strategy (cont'd)

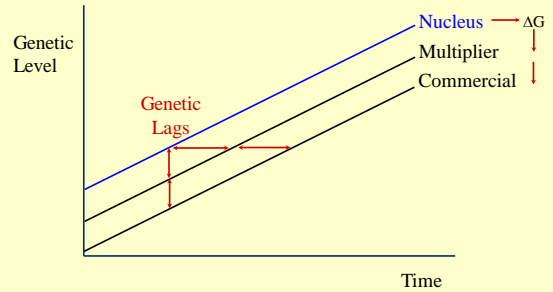
- **Selection and mating**
 - ◆ use best animals to breed next generation → genetic improvement
 - ◆ How many and which animals should we select?
 - ◆ How should we mate them?
 - ◆ Should Marker-Assisted or Genomic Selection be implemented? How?
 - ◆ Should reproductive technology be used to increase # 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



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 crossbreeds
 - 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

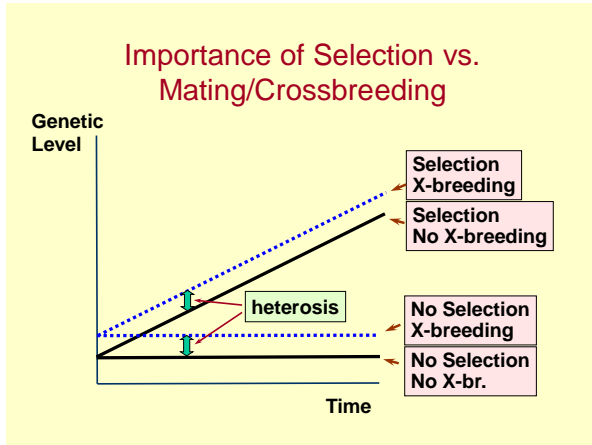
$$P_{\text{sire}} = \mu + BV_{\text{sire}} + D_{\text{sire}} + I_{\text{sire}} + E_{\text{sire}}$$

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

Annotations in the diagram:

- Additive effects:** Indicated by a red arrow pointing down from the BV term in the sire equation to the BV term in the progeny equation.
- Inherited from dam:** A bracket groups D_{sire} and I_{sire} in the sire equation, with an arrow pointing to D_{prog} and I_{prog} in the progeny equation.
- Depends on genes:** A bracket groups D_{sire} and I_{sire} in the sire equation, with an arrow pointing to D_{prog} and I_{prog} in the progeny equation.
- Random environments are independent:** A bracket groups E_{sire} and E_{prog} in their respective equations, with an arrow pointing to 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



GENUP for WINDOWS: default.gnp [Default data set: Wool Sheep]

File Edit Modules View Window Help

Edit Core Data: default.gnp

Production system name: Default data set: Wool Sheep

Full Trait Name	Short	Units	Std.Dev	h2	Econ Wt.	Index Wt.	Hold	Helm
Trait 1: Fleece weight	F.W.	Kg	.5	.35	5	1.86	.2	0
Trait 2: Fibre diameter	F.D.	mic	2	.5	-1	-.51	0	0
Trait 3: Yield	Y.	%	5	.25	.1	.025	0	0
Trait 4: Body weight	B.W.	Kg	3	.3	.5	.15	2.5	1

BREED	DIRECT MEANS				MATERNAL DEVIATIONS			
	F.W.	F.D.	Y.	B.W.	F.W.	F.D.	Y.	B.W.
Borderdale	4	20	75	25	0	0	0	0
Merivale	3.5	18	70	22	0	0	0	0
Hidden Rag	4	20	75	25	0	0	0	0
Border Jester	4.5	22	80	28	0	0	0	0

Trait Combination:	12	13	14	23	24	34
Phenotypic correlation:	0.16	0	0	0	0	0
Genetic correlation:	0.25	0	0	0	0	0

Breeding males: 4 Males first drop at: 2
 Breeding Females: 100 Females first drop at: 2
 Weaning rate: .95
 Male survival rate: .9 Males last drop at: 4
 Female survival rate: .9 Females last drop at: 7

Save for this session
Save to disk
Close

Calculate selection index weights now. (Also saves changes to Std.Dev., h2, Econ.Wt, corr.)

GENUP for WINDOWS: default.gnp [Default data set: Wool Sheep]

File Edit Modules View Window Help

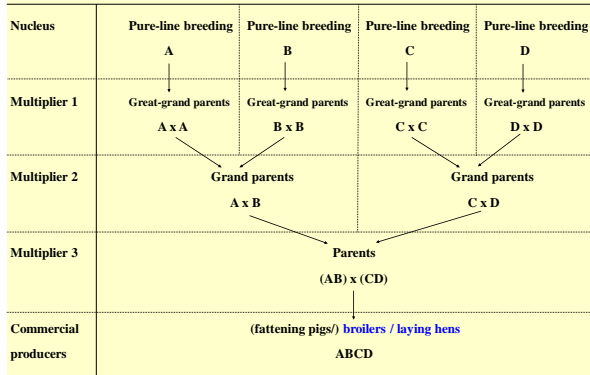
Cross Table (Body weight)

3 Breeds New Row Reset Table Breed / Trait Update Purebreeds Close Calculate

Effects:	Ad			Am			Dd		Dm		Merit
Value (Kg)	Ad1	Ad2	Ad3	Am1	Am2	Am3	Dd	Dm			
1 1 x 1	1	0	0	1	0	0	0	0	25		
2 2 x 2	0	1	0	0	1	0	0	0	22		
3 3 x 3	0	0	1	0	0	1	0	0	25		
4 1 x 2	.5	.5	0	0	1	0	1	0	26		
5 1 x 3	.5	0	.5	0	0	1	1	0	27.5		
6 2 x 3	0	.5	.5	0	0	1	1	0	26		
7 12 x 3	.25	.25	.5	0	0	1	1	0	26.75		
8 1 x 23	.5	.25	.25	0	.5	.5	1	1	27.75		
9 12 x 23	.25	.5	.25	0	.5	.5	.75	1	26.375		
10 2 Br Bal Comp	.5	.5	0	.5	.5	0	5	5	25.25		
11 3 Br Bal Comp	.3333	.3333	.3333	.3333	.3333	.3333	.667	.667	26.3321		
12											
13											
14											
15											

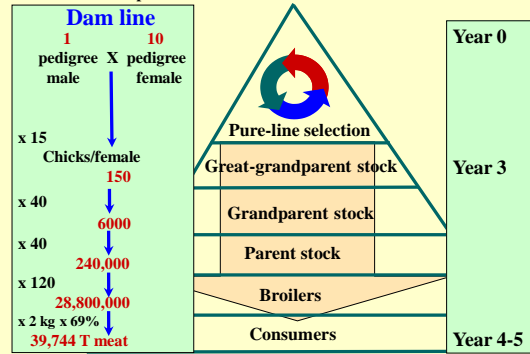
- ### Why use Cross Breeding?
- Averaging of additive breed effects in crossbreds**
 - often undesirable, unless intermediate is optimal
 - Direct heterosis**
 - Maternal heterosis**
 - crossbred dam - heterosis for maternal performance
 - Sire-Dam complementation in production system**
 - e.g. (large) fast-growing sire breed x (small) prolific dam breed
 - Protect purebred genetics**
 - Use of cheap source of breeding animals**
 - (e.g. Merino ewes/dairy cows to produce meat animals)
 - Widest use of genetic resources**
 - get best genetics across breeds
 - greatest flexibility
 - reduce impact of inbreeding

General structure of (swine and) poultry breeding programs

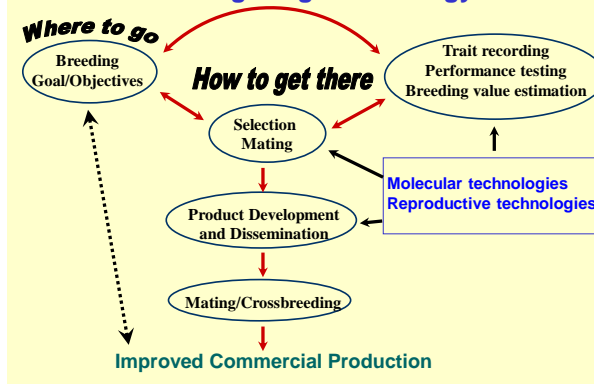


Multiplication in Broiler Breeding Programs

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