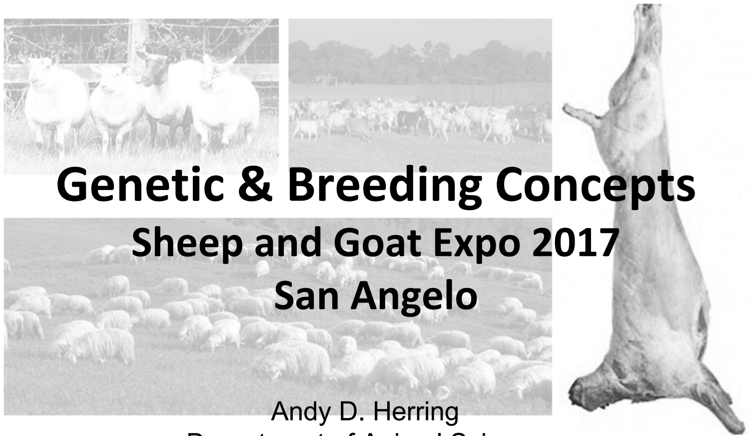

Genetic & Breeding Concepts

Sheep and Goat Expo 2017
San Angelo

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Presentation Overview

- General breeding and genetics terms and concepts
- Types of breeding systems & crosses
- Considerations for what works best for different operations
- Questions and discussion

In most places of the world, ideal meat animal production systems involve some type of “crossbreeding.”

The ideal type of animal (or management) for one production environment may be a wreck in others.

The choice of breeds (mates) and the choice of breeding (mating) systems

Breed (and animal) <u>choices dictated by:</u>

- Environmental constraints
- Product-type considerations

Breeding system choices <u>dictated by:</u>

- Ease of management
- Replacement animals
- Hybrid vigor (heterosis)

Both of these concepts are important for sustainability.

Mating Systems

Straightbreeding
- All animals are of the same breed
  - "Typical" purebreds
  - Linebreeding
  - Outcrossing

Crossbreeding
- At least two breeds are involved
  - Terminal
  - Continuous
  - Combination

Straightbreeding

- Straightbred animals are purebred animals.
- Appropriate animals may be "registered" through a breed association or herd book.

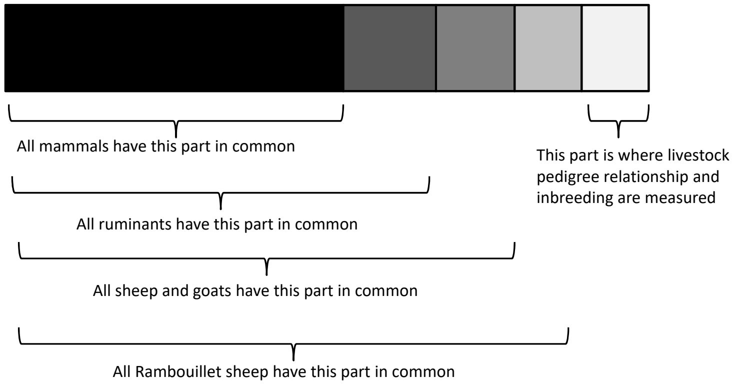


What are some advantages and disadvantages to straightbreeding/purebreeding systems?

What does "relationship" mean?

- Depends on what groups are being compared
  - Full brothers and sisters share 50% of their genetics
  - People and chimpanzees have over 96% of the same DNA.
- Relationship in the "pedigree" sense

Different groups share different amounts of DNA/genes:



Not drawn to scale.

Why would someone want to use inbreeding in livestock?

If your family tree don't branch, you might be a redneck....

- Jeff Foxworthy

Genetic uniformity within a breed comes from *homozygosity* of genes

- There are different forms of genes called "alleles."
- Animals that are __% more inbred are __% more homozygous than non-inbred animals in that breed.
- Non-inbred animals are heterozygous (AaBbCcDdEeFf) for most genes.

Structured inbreeding systems

- Linebreeding
- Full-sib (or other close relative) mating
- Self-fertilization
- Breeding back to same ancestor

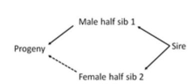
Line 1 Hereford bulls at the USDA-ARS research station in Miles City, MT.

Closed line since late 1930s.

Goal of linebreeding – maintain relationship to admired ancestor(s) but with minimal inbreeding accumulation

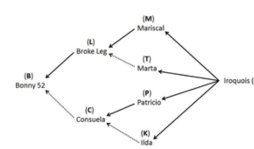
Linebred to:

one grandparent



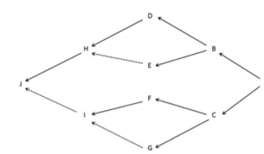
12.5%

one great grandparent



6.25%

one great great grandparent



3.1%

Inbreeding percentages

There is no set "structure" to linebreeding in general across all situations, and it may vary considerably in level of inbreeding due to breeder preferences.

Why would someone want to cross different breeds of animals?



Crossbreeding major concepts:

1. Blending of breed characteristics – *The foundation*
2. Hybrid vigor (heterosis) for direct and maternal effects – estimated from gene loci heterozygous for breed alleles
3. Some crossbred progeny may be made more than one way, and some ways can make more sense than others
4. Sustainability – population size, replacements, market acceptance

X

=


Be careful of the term "F_1 type" in advertisements….
The F_1 is genetically unique because of how it is made.

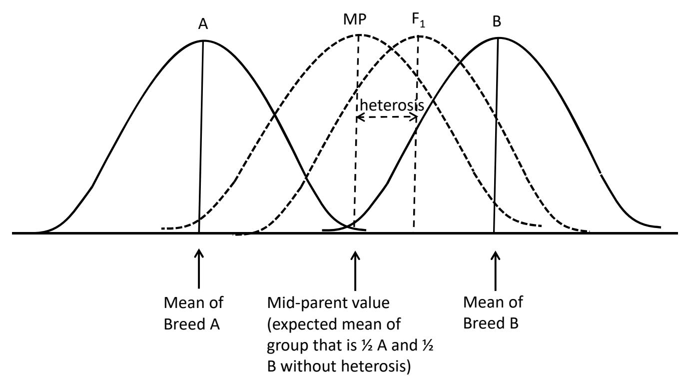


Figure 3.6 When crossing two breeds (A and B), the mid-parent value is half-way between the purebred means. The amount of deviation of the crossbred population mean from the mid-parent value is the amount of heterosis.

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Relative potential for hybrid vigor and inbreeding depression for some traits

Type of trait	Heterosis
Female fertility, lamb/kid survival, overall health	High (15-20%)
Male fertility, growth, early life body size, milk production, gain efficiency	Moderate (10%)
Product-type traits, loineye area, fat depth, mature size, linear body measurements	Low (5%)

Inbred animals tend to breed better than they perform, crossbred animals tend to perform better than they breed…

Some crossbreeding concepts

Terminal breeds/types:

- Breeds or animals that are more useful as sires or as market animals

Maternal breeds/types:

- Breeds or animals more useful as females in breeding flocks/herds

Direct hybrid vigor:

- Increased performance *of progeny* because they are crossbred

Maternal hybrid vigor:

- Increased performance *of dams* because they are crossbred

Terminal vs. Continuous crossbreeding

Terminal:

- Progeny are genetically different than either parent type (no replmts)
- Most potential for heterosis (but not for all crosses)
- Most potential to use complementarity (different specialized sire and dam types)

Continuous:

- Progeny can be used as replacements for at least one parent type
- Typically less heterosis, but not always with only 2 breeds involved
- Less potential for use of specialized sire and dam types (less complementarity)

Some "terminal" crossbreeding terms

- F_1 cross:
  - First cross between two pure breeds:

    A x B ➡ ½A ½B F_1
- Backcross:
  - When F_1 is bred back to one parent breed:

A x ½A ½B F_1 ➡ ¾A ¼ B

½A ½B F_1 x A ➡ ¾A ¼ B

- F_2 cross:
  - The parents are both the same F_1 crosses:

½A ½B F_1 x ½A ½B F_1 ➡ ½A ½B F_2

- Reciprocal cross:
  - Some crosses can be made more than one way

    Suffolk x Rambouillet

    Rambouillet x Suffolk

Some other terminal crosses

- Three-breed terminal cross:
  - Purebred sires bred to F_1 dams (no overlap of breeds)

C x ½A ½B F_1 ➡ ½C ¼A ¼B

- Four-breed terminal F_1:
  - Sires and dams are both F_1 of different breeds

½C ½D F_1 x ½A ½B F_1 ➡ ¼C ¼D ¼A ¼B

Terminal vs. Continuous crosses

- *Is it possible for someone's (or some flock's) terminal cross to be someone else's (or some other flock's) replacement animals?*
- *Are there some scenarios where at least some terminal crosses must be made to eventually get to a continuous system?*

Types of continuous crosses

• Two breed rotation	• Two breed composites
• Three breed rotation	• Three breed composites
• Four breed rotation	• Four breed composites
The number of sire breeds is also the number of breeding groups needed.	*All animals and are the same mixture of breeds.*

Two-breed rotational (criss-cross) crossbreeding system

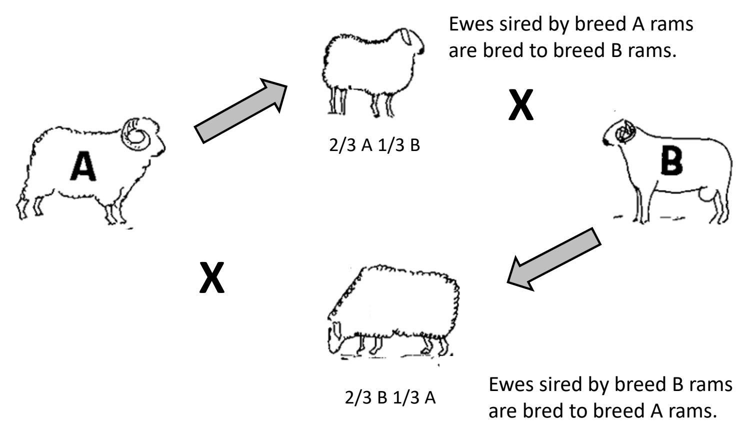

Table 3.11 Initiation and development of a two-breed rotation.

Sires	Dams	Progeny	%A in progeny	%B in progeny
A	B	1/2A 1/2B	50	50
B	1/2A 1/2B	3/4B 1/4A	25	75
A	3/4B 1/4A	5/8A 3/8B	62.5	37.5
B	5/8A 3/8B	11/16B 5/16A	31.25	68.75
A	11/16B 5/16A	21/32A 11/32B	65.6	34.4
B	21/32A 11/32B	43/64B 21/64A	32.8	67.2
A	43/64B 21/64A	85/128A 43/128B	66.4	33.6
B	85/128A 43/128B	171/256B 85/256A	33.2	66.8

This example illustrates how a 2-breed rotation (breeds A and B) starts as a cross of pure breeds and progresses over several generations toward a 2/3, 1/3 ratio at equilibrium.

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Example of two-breed composite:

- Dorper – Dorsett Horn and Persian Blackhead are foundation breeds.

Provided by Select Genes Ltd

Provided by Mr P J Cilliers

- Columbia - Rambouillet and Lincoln

The foundation animals (breeds and individuals) are very important, and the amounts of breed influence are important.

Heterozygosity in Composites

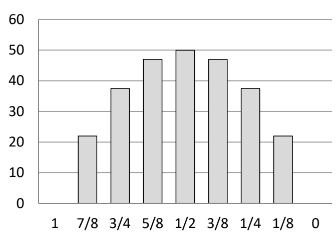
The interbreeding of crossbred animals is the foundation of a composite breeding program. The amount of heterozygosity in F_2 and later generations is a function of: (1) number of breeds, (2) amounts of the breeds, and (3) level of inbreeding.

Rams and ewes are 5/8 Suffolk and 3/8 Lincoln (5/8 S 3/8 L x 5/8 S 3/8 L)

From dams:

From sires:		5/8 S	3/8 L
	5/8 S	25/64 SS	15/64 SL
	3/8 L	15/64 SL	9/64 LL

The breed combinations expected to be heterozygous are 30/64, or 47%.



Percent heterozygosity retained in 2-breed composites (assuming no inbreeding).

Meatmaster composite in South Africa

(Based on Damara and Dorper cross foundation)

Döhne composite in South Africa

(Based on SA Mutton Merino and wool Merino)

Dormer composite in South Africa

(Based on original crosses of Dorset Horn rams on German Merino ewes)

How do I have more hybrid vigor retained in a composite?

- More foundation breeds (2, 3, 4, etc.)
- Foundation breeds that are different types (fine wool, medium wool, hair, fat tail, etc.)
- Equal distribution of breeds
- Avoid inbreeding

1/4A 1/4B 1/4C 1/4D x 1/4A 1/4B 1/4C 1/4D

Sires and dams are the same type of cross and produce progeny that are the same type of cross

Gametes from sire:	Gametes from dam: P(A) = ¼	P(B) = ¼	P(C) = ¼	P(D) = ¼
P(A) = ¼	P(AA) = 1/16	P(AB) = 1/16	P(AC) = 1/16	P(AD) = 1/16
P(B) = ¼	P(BA) = 1/16	P(BB) = 1/16	P(BC) = 1/16	P(BD) = 1/16
P(C) = ¼	P(CA) = 1/16	P(CB) = 1/16	P(CC) = 1/16	P(CD) = 1/16
P(D) = ¼	P(DA) = 1/16	P(DB) = 1/16	P(DC) = 1/16	P(DD) = 1/16

Figure 3.7 Expected levels of breed combinations in progeny of a composite that has equal amounts of four breeds is 12/16, or 75% (assuming no inbreeding).

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Comparing different breeding programs*

Name	Hybrid vigor potential	Production of replacements	Other aspects
Traditional straightbreeding	Very low	Yes, males & females	Required for registration & to produce F_1 animals.
Linebreeding	Lowest of all	Yes, males & females	More uniformity, selection needed to offset inbreeding
Terminal crossing	Highest of all	No	Can utilize specialized sire & dam types, can have uniformity
Rotational crossing	Medium to high (# breeds)	Yes, females only	Multiple breeding groups needed
Composite	Medium to high (# breeds & distribution)	Yes, males & females	Can have uniformity

*Choosing the right type of animals for the production environment and market is the true foundation of any breeding program. Knowing pedigree information is critical.

Grading up

(The transition over time from crossbreeding to straightbreeding)

- The scheme where two breeds are crossed, and each progeny generation is bred back to the same parental breed.
  - *This strategy does not automatically imply inbreeding*

Table 3.10 Concepts of grading up

Sires	Dams	Progeny	%A in progeny	%B in progeny
A	B	1/2A 1/2B	50	50
A	1/2A 1/2B	3/4A 1/4B	75	25
A	3/4A 1/4B	7/8A 1/8B	87.5	12.5
A	7/8A 1/8B	15/16A 1/16B	93.75	6.25
A	15/16A 1/16B	31/32A 1/32B	96.9	3.1
A	31/32A 1/32B	63/64A 1/64B	98.4	1.6
A	63/64A 1/64B	127/128A 1/128B	99.2	0.8

Repeatedly breeding successive crossbred generations back to the same breed (breed A in this example) over several generations produces animals that are essentially purebreds.

Heterosis considerations associated with grading up

Sires	Dams	Progeny	% progeny heterozygosity	% dam heterozygosity
A	B	1/2A 1/2B	100	0
A	1/2A 1/2B	3/4A 1/4B	50	100
A	3/4A 1/4B	7/8A 1/8B	25	50
A	7/8A 1/8B	15/16A 1/16B	12.5	25
A	15/16A 1/16B	31/32A 1/32B	6.25	12.5
A	31/32A 1/32B	63/64A 1/64B	3.13	6.25
A	63/64A 1/64B	127/128A 1/128B	1.56	3.13

Repeatedly breeding successive crossbred generations back to the same breed (breed A in this example) over several generations produces animals that are essentially purebreds.

Not the best strategy for livestock breeding programs…

Breeding Strategies & Questions

Purebred

- Who buys my lambs (kids)?
- How can I get paid more for added value?
- What extra information will help me the most?
- What is the ideal type of animal for (a) my flock and (b) my customers?

Commercial

- Who buys my lambs (or kids)?
- How can I get paid more for added value?
- What extra information will help me the most?
- What is the ideal type of animal for (a) my flock and (b) my customers?

Commercial producers should buy seedstock from purebred breeders that share the same philosophies…

People want simple answers to complex questions...

Can you recommend a good contractor for my fixer-upper?

Overall recommendations

- Know what causes differences in value (and in costs of production) among your animals
- Have realistic long-term goals
- Be able to trace/identify genetic influences for family lines
- Keep things as simple and as enjoyable as possible
- Combinations of genetics-environment-management-market make for success, not just any one of these factors

"Henry! Our party's total chaos! No one knows when to eat, where to stand, what to … Oh, thank God! Here comes a border collie!"