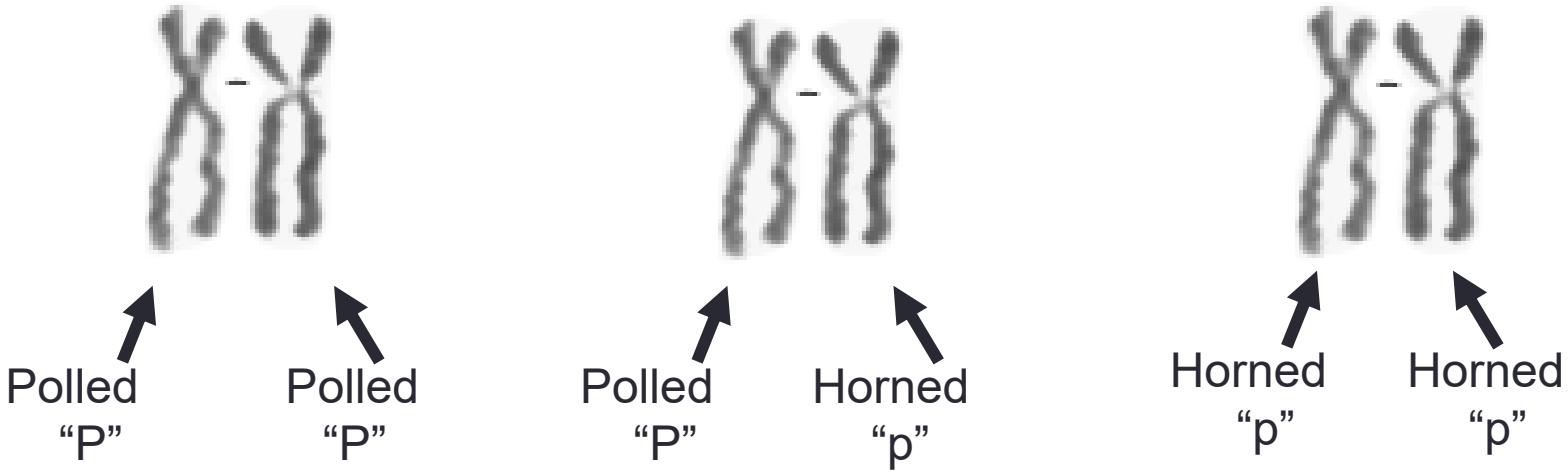
# GENETICS

# Definitions

- Genotype: The genetic makeup of an organism
- Phenotype: The observable physical characteristics of an organism

# Inheritance

Incomplete dominance




**PP**

Polled sheep

**Pp**

Scurred sheep

**pp**

Horned sheep

homozygous vs. heterozygous

# Traits

- Qualitative – have it or don't have it
  - Based on one or a few genes
  - Can be predicted relatively simply
  - Examples: polled vs. horned
- Quantitative – have it to various degrees
  - Based on many genes
  - More work required to predict
  - Examples: birth weight, weaning weight

# Genetic Value

Trait = Additive + Interactive + Environment

- Additive component
  - The effect of a single gene
  - Can be inherited
  - Often referred to as the Breeding Value
- Interactive component
  - Interaction between genes
  - Cannot be inherited

# Heritability ($h^2$)

Heritability = $\frac{\text{variability Additive}}{\text{variability Trait}}$

- The proportion of the variability in a trait that belongs to the additive component of a trait is the heritability.

Gardner et al. 1991
New Mexico State U

**Heritability of traits in sheep**

| Trait | Percent |
|---|---|
| Birth weight | 0.15 |
| Weaning weight (60 days of age) | 0.20 |
| Weaning weight (120 days of age) | 0.25 |
| Mature body weight | 0.40 |
| Rate of gain (post-weaning) | 0.40 |
| Face cover | 0.35-0.55 |
| Skin folds | 0.20-0.50 |
| Grease fleece weight | 0.25-0.60 |
| Clean fleece weight | 0.25-0.60 |
| Clean yield | 0.30-0.40 |
| Staple length | 0.30-0.65 |
| Fleece grade | 0.20-0.60 |
| Multiple birth | 0.10 |
| Milk production | 0.10 |
| Ewe productivity | 0.20 |
| Loin-eye area | 0.35 |
| Fat thickness over loin eye | 0.30 |
| Carcass weight | 0.35 |
| Retail cut weight | 0.45 |
| Dressing percentage | 0.10 |
| Worm resistance | 0.25 |

(Austral. Dept. of Agr. & Food)

# Interactive Component

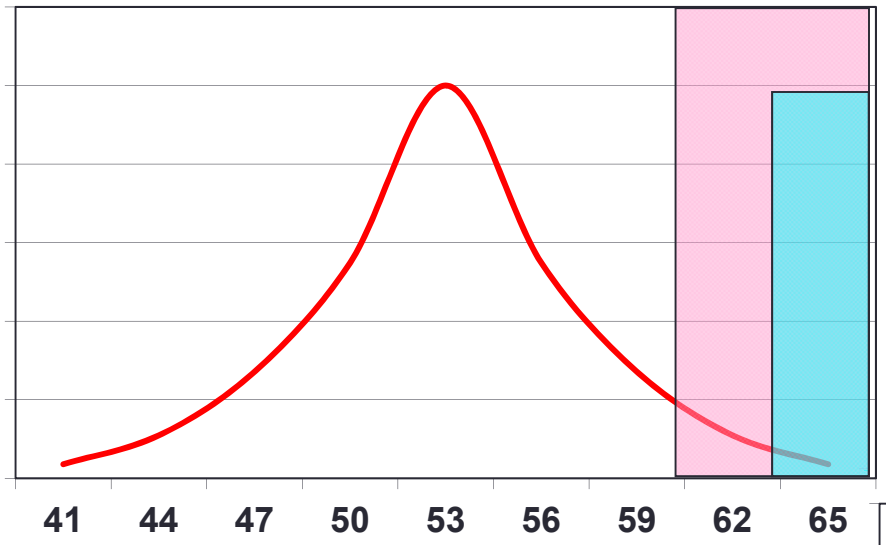
- Inbreeding
  - Increasing homozygosity (both positively and negatively)
  - High risk of increasing negative interaction of traits (inbreeding depression)
- Cross breeding
  - Increasing heterozygosity
  - High possibility of increasing positive interaction of traits (hybrid vigour)

# Genetic Improvement

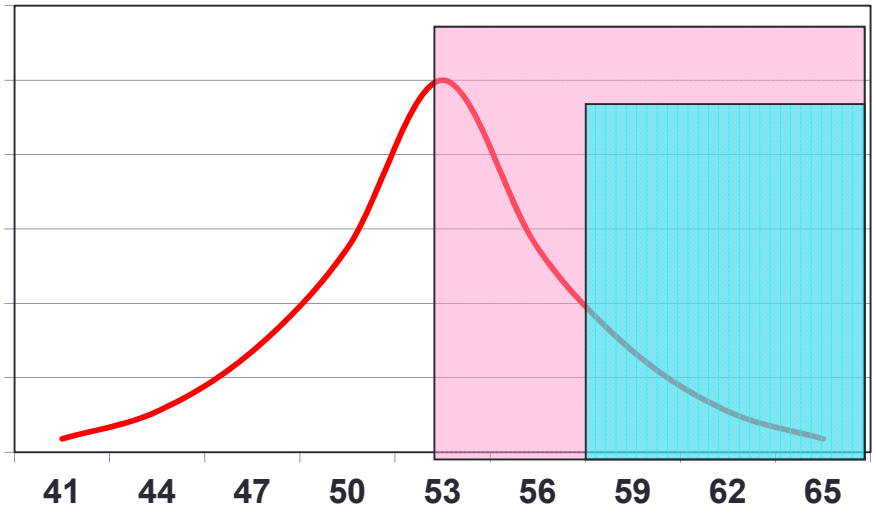
1. Selection Accuracy
    - How sure you are of a breeding value
    - The ability to predict breeding value based on phenotypic observations
    - Methods to improve:
        - Many records (parents, progeny, sibs, half-sibs)
        - Consistent record-keeping
    - Methods to deteriorate:
        - Preferential treatment
        - Variability in treatment

# Genetic Improvement

## 2. Intensity of Selection



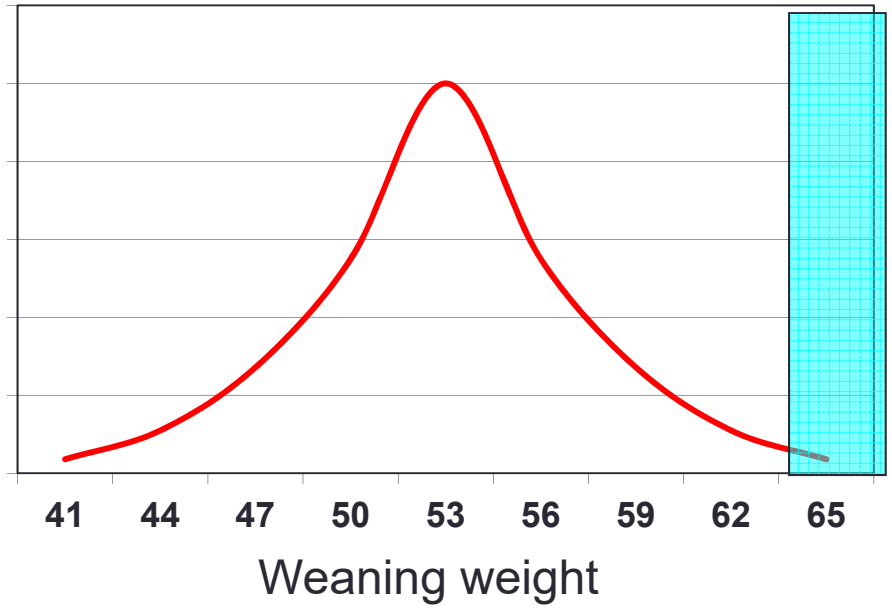

Weaning weight

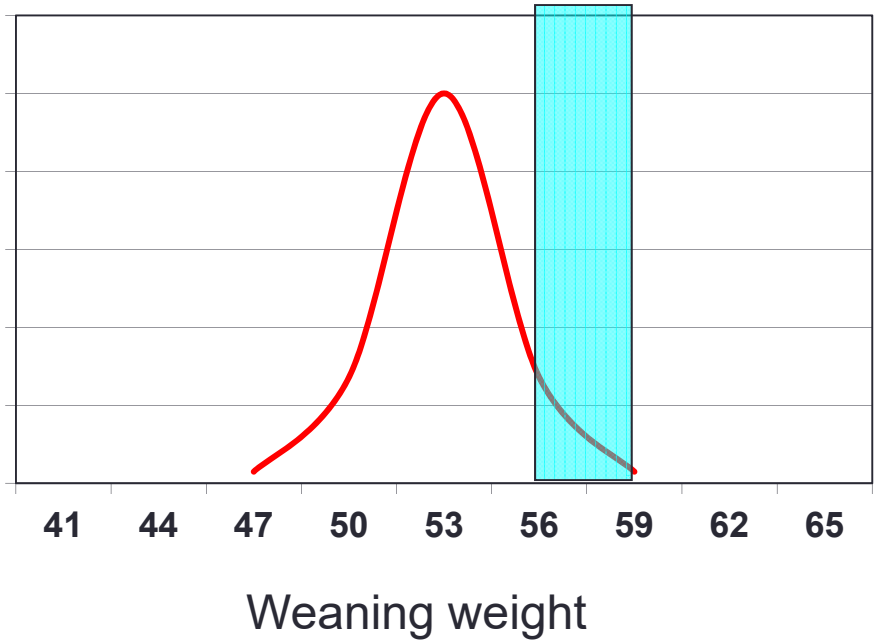



Weaning weight

# Genetic Improvement

## 3. Variability in Breeding Values



# Genetic Improvement

4. Generation Interval

| Parity | Generation Interval | Relative to 1st |
|---|---|---|
| 1st | 12 months | 1.0 |
| 2nd | 24 months | 2.0 |
| 3rd | 36 months | 3.0 |
| 4th | 48 months | 4.0 |
| 5th | 60 months | 5.0 |
| 6th | 72 months | 6.0 |

# Genetic Improvement

5. Genetic Correlation
   - Related to Interactive component

| Multiple birth | Pre-weaning mortality | Correlation | |
|---|---|---|---|
| Increases | Increases | Positive | Bad |
| Increases | Decreases | Negative | Good |

| Multiple birth | Weaning weight | Correlation | |
|---|---|---|---|
| Increases | Increases | Positive | Good |
| Increases | Decreases | Negative | Bad |

# Genetic Improvement

## 6. Number of Traits Selecting On

- The more factors selected on will slow progress for all factors

- Thumb rule:

$$\text{Genetic Improvement} = \frac{1}{\sqrt{n}}$$

  - n is the number of traits selecting on
  - If traits are uncorrelated

# Cross breeding

- Improve the performance of the whole production system by crossing complementary breeds.
  - For example, breeding maternal line (Dorset, Rideau Arcott, etc.) and a terminal line (Suffolk, Texel, etc.)
- Heterosis

# Heterosis

- A great advantage over purebreds for:
  - Reproductive traits
  - Productive traits
  - (Generally lower inheritable traits)
- Not much advantage over purebreds for:
  - Carcass composition traits
  - (Generally higher inheritable traits)

# Heterosis

Heterosis in Crossbred Market Lamb

| Trait | Percent heterosis |
|---|---|
| Birth weight | 3.2 |
| Weaning weight | 5.0 |
| Pre-weaning ADG | 5.3 |
| Post-weaning ADG | 6.6 |
| Yearling weight | 5.2 |
| Conception rate | 2.6 |
| Prolificacy of dam | 2.8 |
| Lamb survival | 9.8 |
| Carcass traits | 0 |
| Lambs born/ewe exposed | 5.3 |
| Lambs reared/ewe exposed | 15.2 |
| Weight of lamb weaned/ewe | 17.8 |

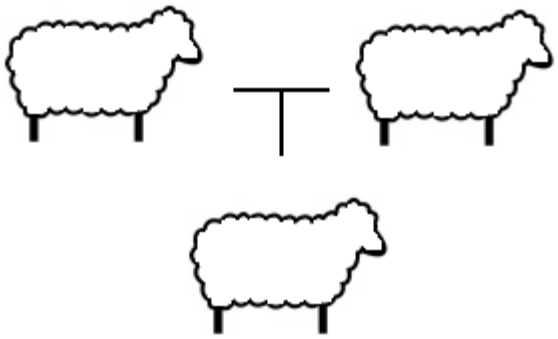
Heterosis in Crossbred Ewe

| Trait | Percent heterosis |
|---|---|
| Fertility | 8.7 |
| Prolificacy | 3.2 |
| Pre-weaning ADG | 5.3 |
| Body weight | 5.0 |
| Lamb birth weight | 5.1 |
| Lamb weaning weight | 6.3 |
| Lamb survival | 2.7 |
| Lambs born/ewe exposed | 11.5 |
| Lambs reared/ewe | 14.7 |
| Weight of lamb weaned/ewe | 18.0 |

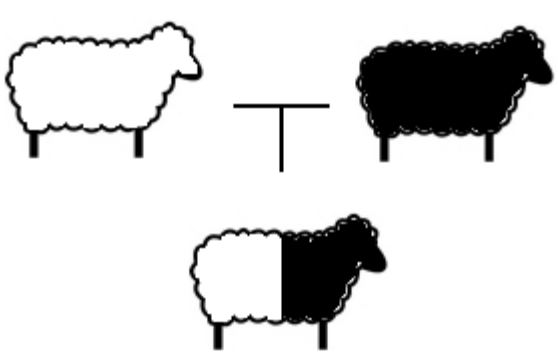
# Breeding Systems

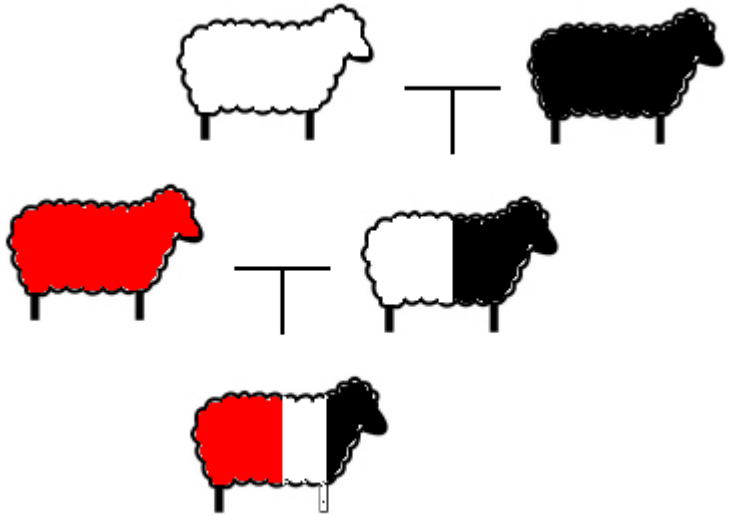
- Purebred cross
- Terminal cross
- Rotational cross
- Roto-terminal cross
- Composite cross/breed

# Purebred

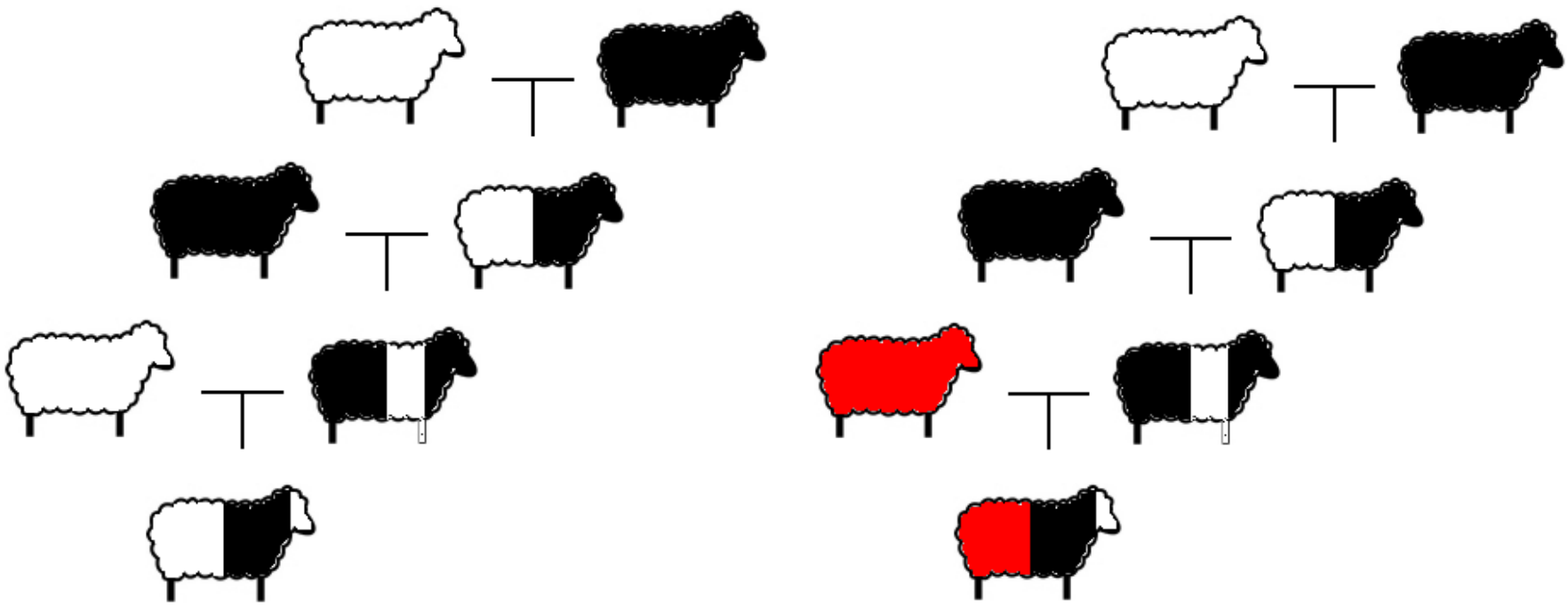


# Terminal cross





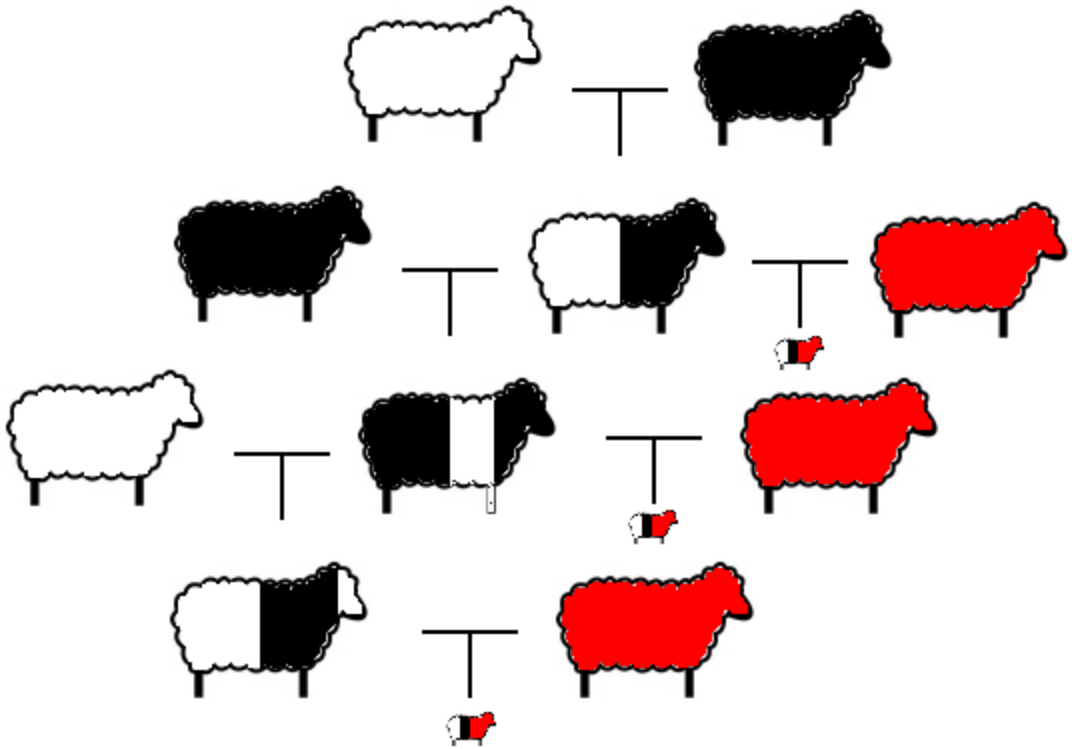
# Rotational Cross



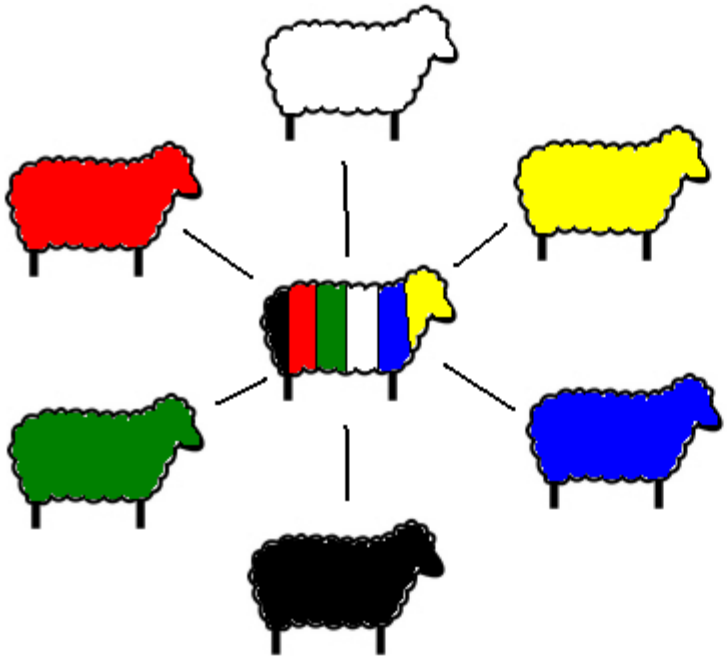
# Rotational Crosses

| Breeds of Rams | Percentage Heterosis |
|---|---|
| 2 | 66.7 |
| 3 | 85.7 |
| 4 | 93.3 |
| 5 | 96.8 |
| 6 | 98.4 |

# Rototerminal



# Composite Cross/Breed



- http://www.genovis.ca/section.php?p=66&lg=en

GenOvis

Top animals report (all EPDs) for breed SU Rams with progeny ordered by TX

includes disposed animals | from birth year 2004 |

| Rank | ID / Sex / Gx(%) / Tx(%) / GxM(%) / TxM(%) | Sire / Dam / Inbreeding / BirthDate / #Progeny | Owner | Estimated Progeny Differences | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Lamb Survival | | Birth Weight | | Ad. 50 Wt. | | 100-day Wt | Ultra Loin | Ultra Fat |
| | | | | EPD Dir | Mat | EPD Dir | Mat | EPD Dir | Mat | EPD Dir | EPD Dir | EPD Dir |
| | | | | Acc Dir | Mat | Acc Dir | Mat | Acc Dir | Mat | Acc Dir | Acc Dir | Acc Dir |
| | | | | % Dir | Mat | % Dir | Mat | % Dir | Mat | % Dir | % Dir | % Dir |
| | | | | Age First Lamb | | # Born First | | # Weaned First | | Lambing Interval | # Born Later | # Weaned Later |
| | | | | EPD | | EPD | | EPD | | EPD | EPD | EPD |
| | | | | Acc | | Acc | | Acc | | Acc | Acc | Acc |
| | | | | % | | % | | % | | % | % | % |
| 1 | **KXK83R** | KXK27P | 3070 | **-0.04** | **-0.04** | **0.57** | **-0.01** | **2.89** | **-0.05** | **5.18** | **2.64** | **-0.35** |
| | M | KXK30P | | 66 | 59 | 91 | 88 | 93 | 82 | 93 | 48 | 47 |
| | 6.73 (99) | 0.0408 | | 1 | 1 | 99 | 29 | 99 | 22 | 98 | 99 | 99 |
| | 9.46 (99) | 2005-03-04 | | **0.65** | | **-0.06** | | **-0.02** | | **-0.29** | **-0.07** | **-0.01** |
| | 3.04 (93) | | | 2 | | 13 | | 6 | | 10 | 35 | 14 |
| | 6.82 (98) | 179 | | 54 | | 30 | | 52 | | 78 | 33 | 62 |
| 2 | **SHF41S** | AIUK79274E | 43189 | **0.06** | **0** | --- | --- | **2.65** | **-0.05** | **5.47** | **1.25** | **0.7** |
| | M | HOP106N | | 33 | 26 | 0 | 0 | 74 | 50 | 76 | 77 | 76 |
| | 7.31 (99) | 0.0000 | | 99 | 33 | --- | --- | 99 | 22 | 98 | 92 | 2 |
| | 7.83 (98) | 2006-02-07 | | --- | | --- | | --- | | **-0.16** | **0.01** | **0.01** |
| | 4.93 (98) | | | 0 | | 0 | | 0 | | 14 | 60 | 28 |
| | 6.79 (98) | 38 | | --- | | --- | | --- | | 68 | 76 | 88 |
| 3 | **KXK1Y** | KXK29X | 250 | **0.09** | **0.02** | **0.14** | **0.04** | **2.82** | **-0.22** | **5.60** | **2.83** | **1.79** |
| | M | KXK30U | | 27 | 19 | 64 | 54 | 61 | 32 | 63 | 66 | 65 |
| | 7.38 (99) | 0.0519 | | 99 | 99 | 83 | 87 | 99 | 1 | 99 | 99 | 1 |
| | 7.69 (98) | 2011-02-03 | | **0.29** | | **-0.07** | | **-0.04** | | **0.01** | **-0.09** | **-0.02** |
| | 2.74 (91) | | | 3 | | 21 | | 9 | | 4 | 28 | 9 |
| | 4.56 (94) | 24 | | 85 | | 25 | | 33 | | 46 | 26 | 48 |
| 4 | **ROI7651R** | KVZ67L | 43100 | **0.06** | **0.02** | **0.16** | **0.03** | **1.97** | **-0.02** | **6.59** | **0.96** | **0.94** |
| | M | ROI193M | | 17 | 9 | 43 | 29 | 36 | 18 | 43 | 37 | 35 |
| | 7.7 (99) | 0.0021 | | 99 | 99 | 85 | 82 | 98 | 41 | 99 | 87 | 1 |
| | 7.66 (98) | 2005-01-19 | | --- | | --- | | --- | | **-0.4** | **-0.02** | **0.01** |
| | 4.41 (97) | | | 0 | | 0 | | 0 | | 4 | 24 | 7 |
| | 6.3 (97) | 4 | | --- | | --- | | --- | | 84 | 62 | 82 |

Genovis