Basic Principles in Animal Breeding

- The genetic make-up or genotype of any animal determined by the genes – passed onto it by parents
- Genetic changes (good and bad) within any population – by mating of individuals
  - ➢ mating randomly
  - ➢ mating by human interventions
- Positive change – through selection of superior individuals for mating
- Selection and mating – basic tools of animal breeding and breed improvement

Variation

- Production characteristics such as milk production or growth rate known as traits
- These traits are determined by – genetic and environmental factors
- For any trait within a population – variation observed
- Because animals are genetically unique and they live in their own environment
- This variation is important for animal breeding
- Positive changes to this variation – possible by selection
- Objective of breeding program;

➢ improve performance of a trait or number of traits

➢ Reduce the degree of variation

The Whole Picture

- $P = G + E$
- Where *P* is Phenotype can also mean production
- *G* is Genotype
- *E* is Environment **in which the animal is raised, i.e. nutrition, health program, housing, temperature, humidity, parasite challenge, etc.**
- Changing G is the overarching goal of any breeding programme

Selection

- Natural selection by the environment and selection by human occurred for generations in farm animals

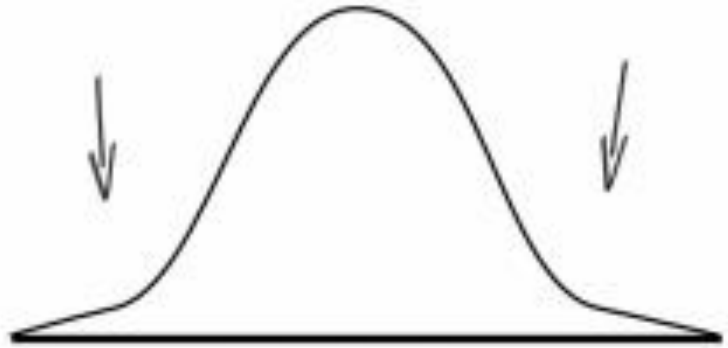
What is selection?

- Choosing which animals get to be parents.
- Choosing which male and female mate.

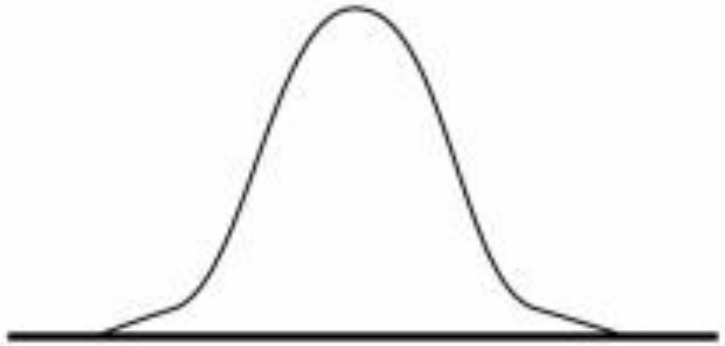
Replacement females

Top-performing bucks

- The individual animal is not the main objective in genetic selection but the population as a whole
- The success of the programme depends on the **breeding goals**, **record keeping** and **management**



Before Selection



After Selection

Two kinds of selection

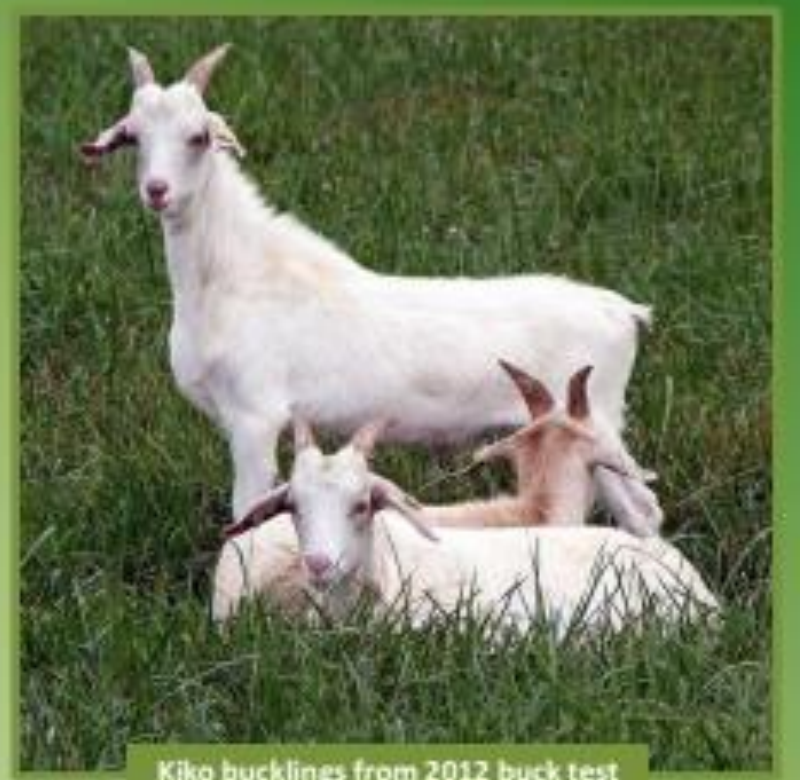
1. Natural - "survival of the fittest"
2. **Artificial** - breeding plants or animals for specific traits (human intervention)

Merino- artificial selection

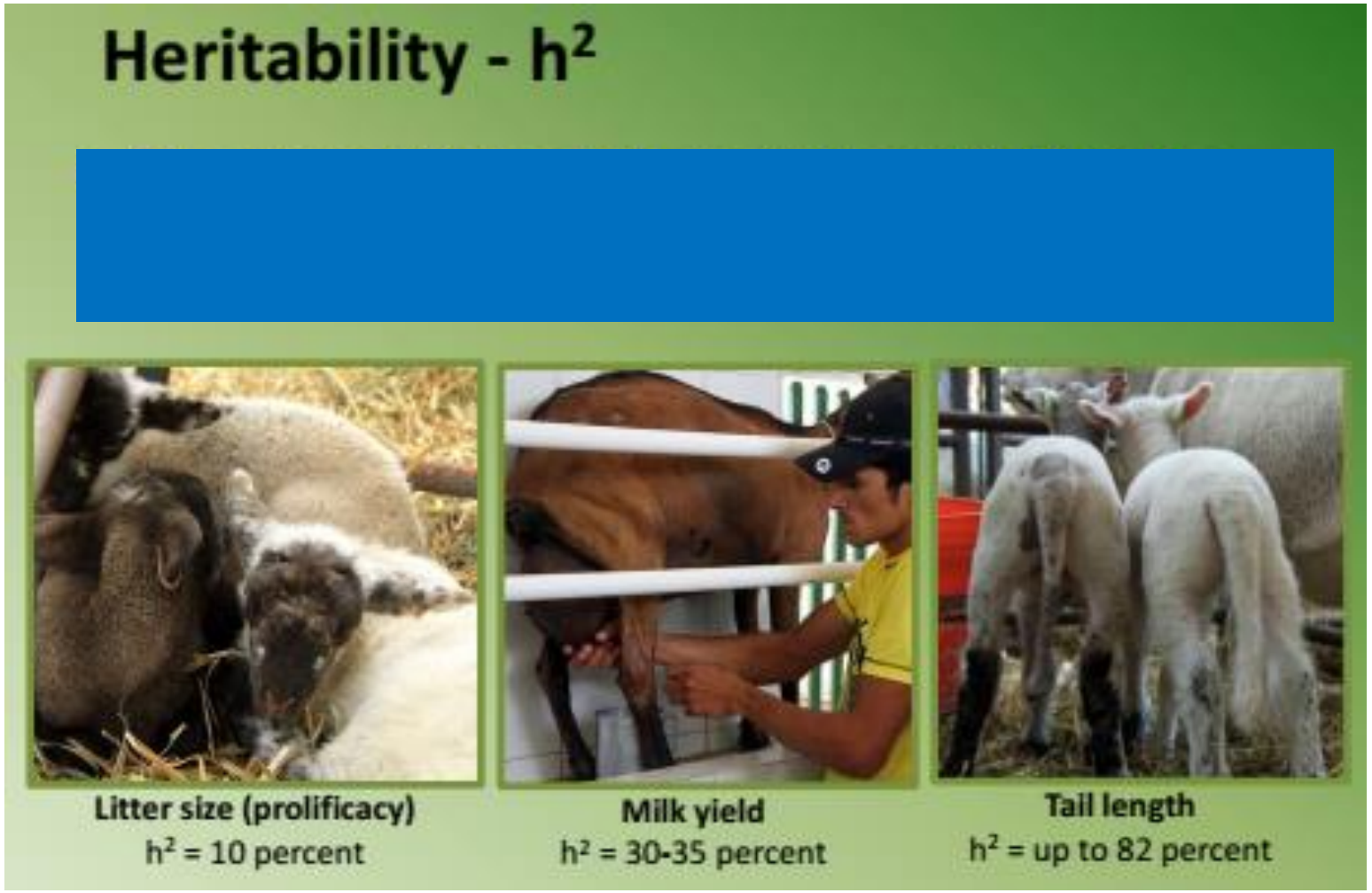
Soay - natural selection

Selection basics

- Heritability (h^2)
- Repeatability (R)
- Selection differential (SD)
- Generation interval (L)
- Genetic progress ($\triangle G$)



Kiko bucklings from 2012 buck test



- Heritability describes the likelihood of passing on a characteristics from the parents to the offspring.
- If a trait has heritability of 50%, it is highly heritable. If the parents have this trait, good chance of passing it to he offspring.

How is heritability used in breeding programs?

- Heritability tells the breeder how much confidence to place in the phenotypic performance of an animal when choosing parents of the next generation.

- For highly heritable traits where h2 exceeds 0.40, the animal's phenotype is a good indicator of genetic merit or breeding value.

- For low heritable traits, where h2 is below 0.15, an animal's performance is much less useful in identifying the individuals with the best genes for the trait.

Estimates of heritability

- Estimates of heritability for a trait can differ between breeds and may change slowly over time.

- Heritability is estimated from performance records on animals and pedigree information used to establish genetic relationships between those animals.
- Heritability, is a ratio of genetic variance (Vg) to total variance (Vp)
- h2 = Vg/Vp).

  Total variance (or phenotypic variance) includes variance caused by genetic and environmental factors (i.e., Vp = Vg + VE).

Heritability of Various Traits in Livestock

Trait	Sheep	Swine	Cattle
Weaning weight	15-25%	15-20%	15-27%
Post-weaning gain efficiency	20-30%	20-30%	40-50%
Post-weaning rate of gain	50-60%	25-30%	50-55%
Feed efficiency	50%	12%	44%
Fertility			1.0%

Heritability of different traits in Sheep

Trait type	Heritability	Genetics	Environment
Reproductive	Low	5-20%	85-100%
Growth	Moderate	10-50%	50-90%
Carcass	Moderate	10-45%	55-90%
Fleece	Moderate to high	25-55%	45-75%
Lactation	Moderate	15-35%	65-85%

Heritability of production traits of dairy goats

Dairy goat production traits are moderate to highly heritable (20-50%).

Sannen doe in Maryland

Trait	Avg. h^2
Milk yield	0.35
Fat yield	0.35
Protein yield	0.37
Protein: fat ratio	0.37
Fat and protein yield	0.36
Fat percentage	0.52
Protein percentage	0.54
Age at first kidding	0.23
Kidding interval	0.05

Source: Breed differences over time and heritability estimates for production and reproduction traits of dairy goats in the United States (Journal of Dairy Science, 2012).

Repeatability (accuracy)

- Correlation (reliability) between repeated measurements.
- Indicates the upper level of heritability.
- Traits with high heritability usually have high repeatability.

Top-performing buck (Kiko) from 2009 Test

E.g.

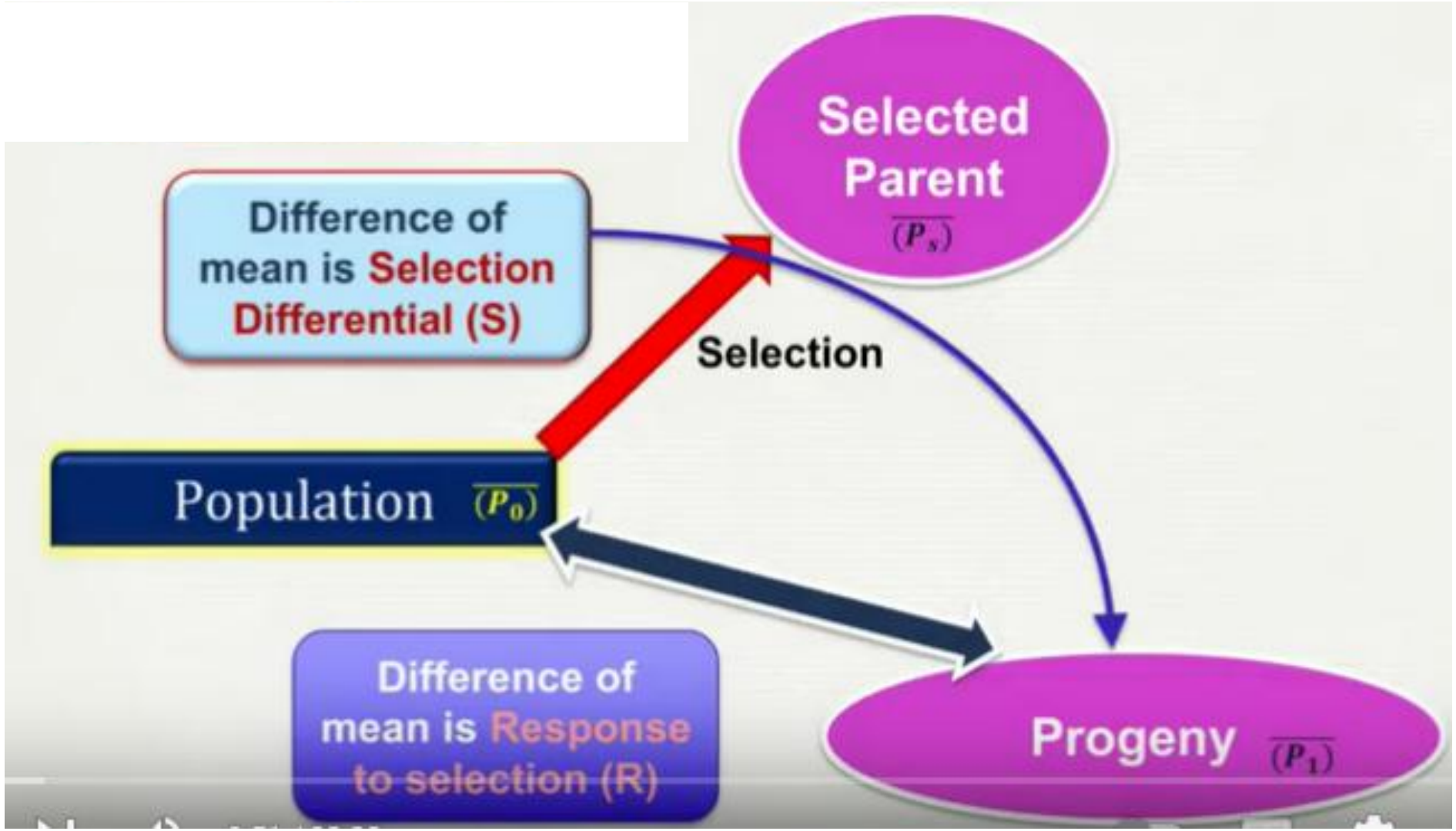
Milk production in each lactation

Use of repeatability

- Improvement of the accuracy of selection and breeding value
- Prediction of the future production performance

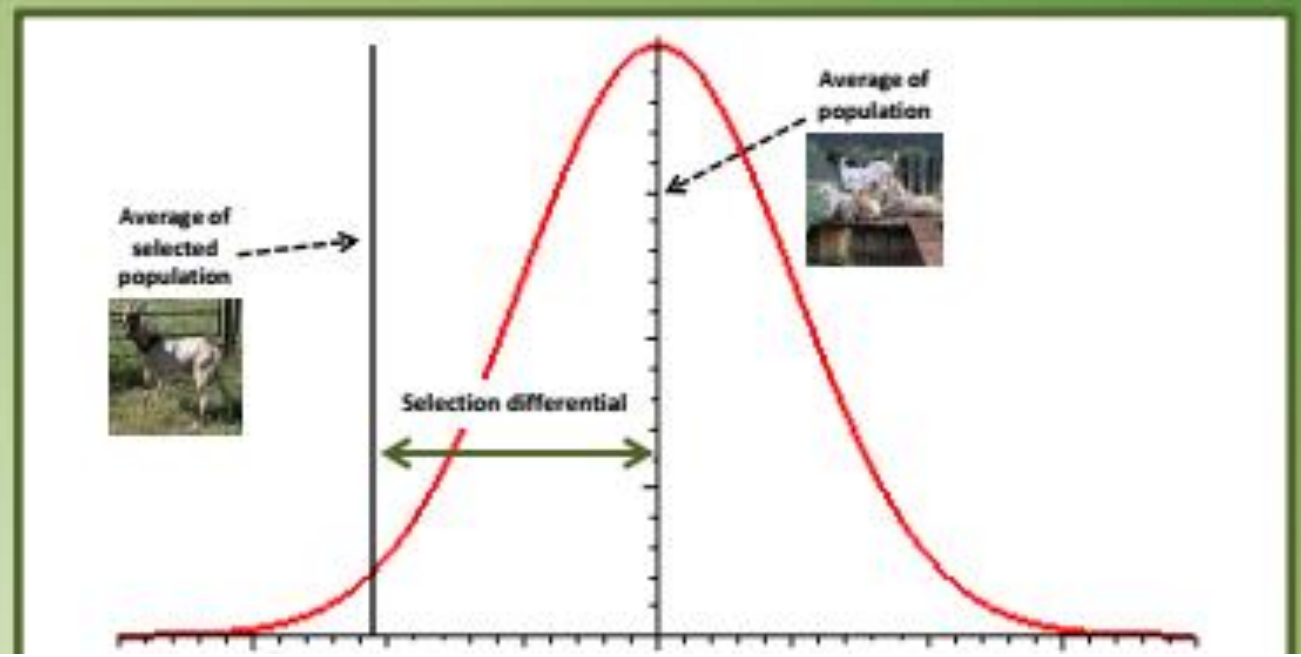
Selection differential

Expresses the degree of superiority of the selected parents over the rest of their generation.


Selected Parent
$\overline{(P_s)}$
Difference of mean is Selection Differential (S)
Selection
Population $\overline{(P_0)}$
Difference of mean is Response to selection (R)
Progeny $\overline{(P_1)}$

Selection differential (SD)

- Difference between selected animals and the average of the population from which they were selected.



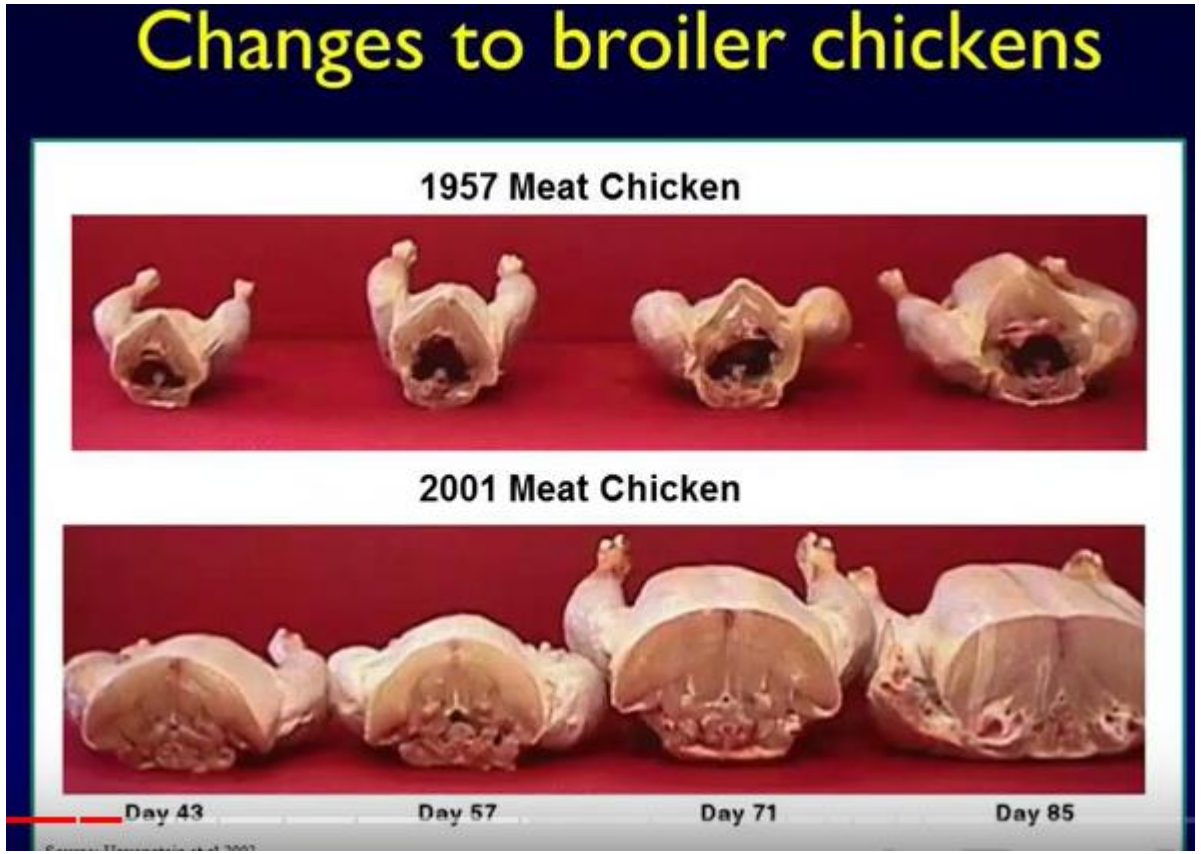
The generation interval

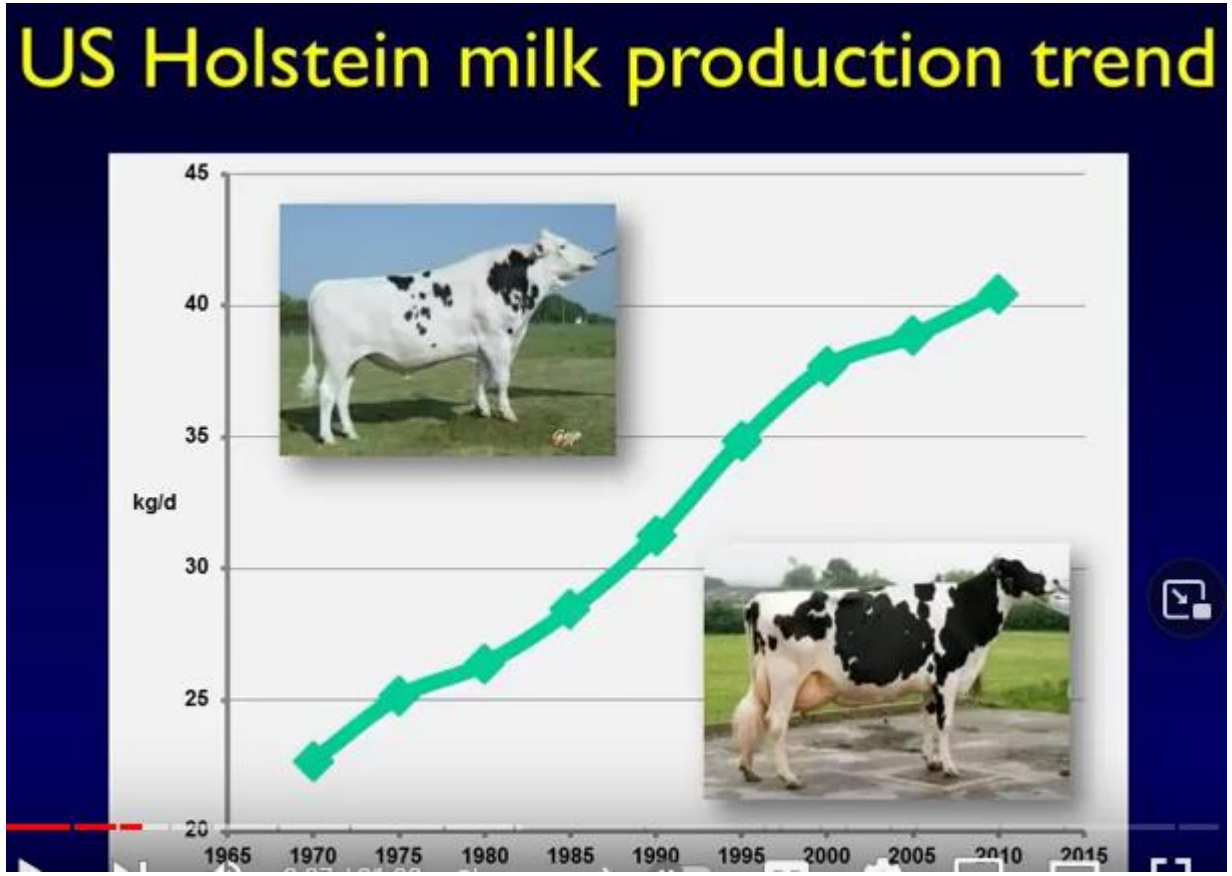
- The generation interval is the time interval between generations.
- It affects the rate of genetic progress
- Genetic progress quick for – animals having shorter generation interval
- Faster genetic progress in goats than cattle

Genetic Progress

- Genetic progress is defined as the progress that is made when the average genetic value of the offspring is higher than the average genetic value of the previous generation.

- Increasing the rate of genetic progress is about making better animals, faster.


Changes to broiler chickens
1957 Meat Chicken
2001 Meat Chicken
Day 43
Day 57
Day 71
Day 85


US Holstein milk production trend
45
40
35
30
25
20
kg/d
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015

Most genetic progress when…

- Heritability is high.
- Repeatability is high.
- Selection differential is wide.
- Generational interval is short

Traits used as a basis for selection in small ruminants.

Productivity factors	Traits
Reproduction	Age at first lambing Fertility Lambing Lambs raised to weaning
Growth	Birth weight Weaning weight Adult weight Feed conversion efficiency
Stress	Resistance to diseases
Milk yield	Milk yield Fat content Protein content Lactation length

Selection tools

1) General visual appraisal-most common
2) Breeder records
3) Performance data for sires (A male used for breeding purposes may be referred to as a sire)
4) Expected Progeny Differences (EPDs)
5) Pedigree data
6) Industry standards
7) Breed standards

- **Expected Progeny Difference**
- **"the differences in performance expected from the offspring of one individual compared to the offspring of another individual, within the same breed"**

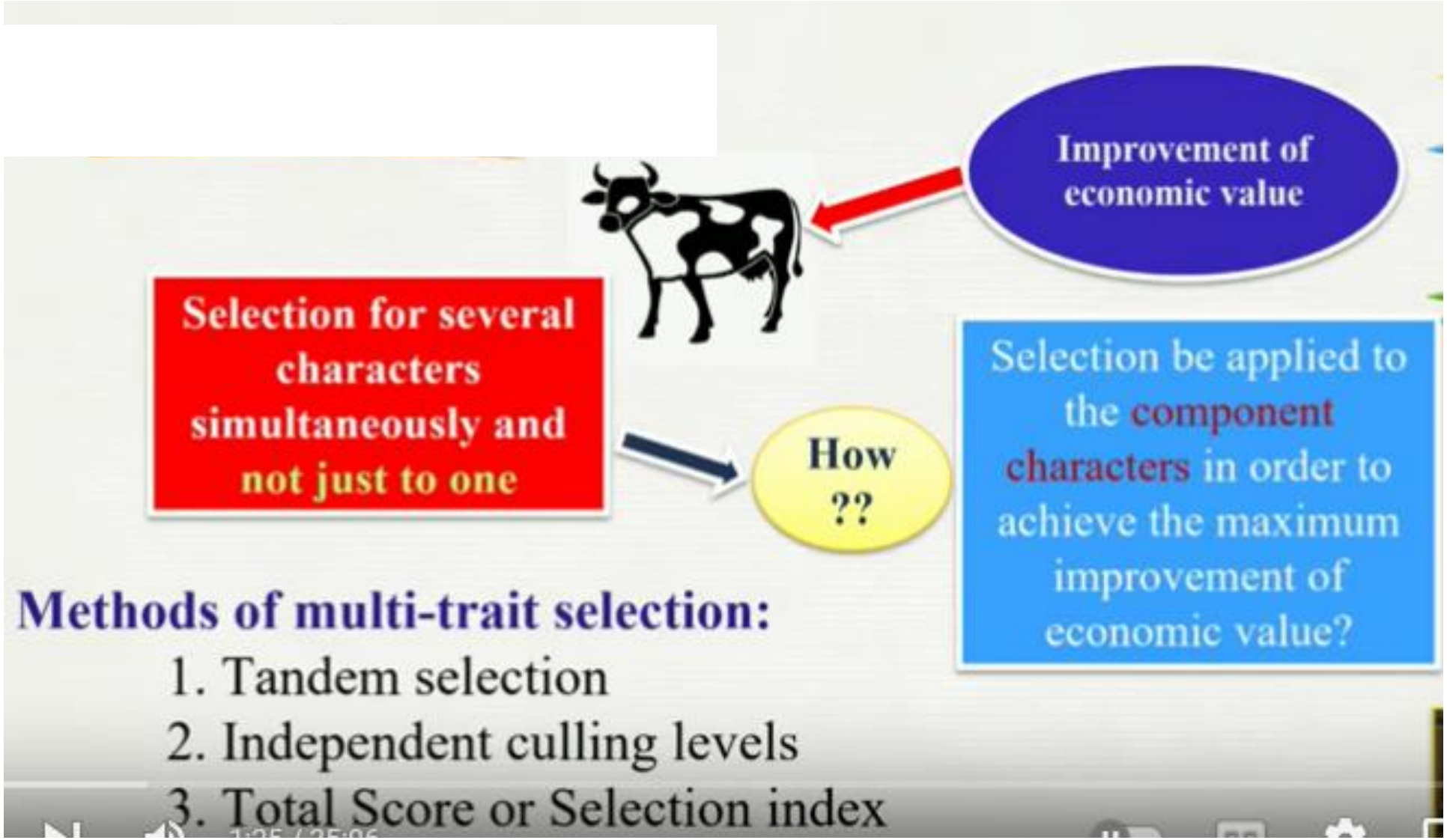
Breed standards are devised by **breed** associations, and are written to reflect the use or purpose of the **breed** of the animal.

Methods of selection

1. Single trait
2. Multiple trait

- Methods of Selection for Single Traits
  Progeny Test- observing the performance of the offspring.
  – Must be mated several times and then look at the offspring.
  – Best when looking at carcass traits

Multiple trait



Methods of Selection for Multiple Traits

Tandem Selection-

- focuses on multiple traits, one at a time. After the performance of one is achieved, then move to the next trait
- Selection may result in changes (positive or negative) to correlated traits.
    - Milk yield vs. fat percentage (antagonistic)

Independent Culling

- Set minimum standards for more than one trait at a time for the individual
- Cull any that does not meet the minimum standards for any trait
  Examples: Keep only twin-births. Don’t keep any kids that require deworming more than once