



# Phenotypic and Genotypic effect of inbreeding in Livestock

*Prepared  
By*

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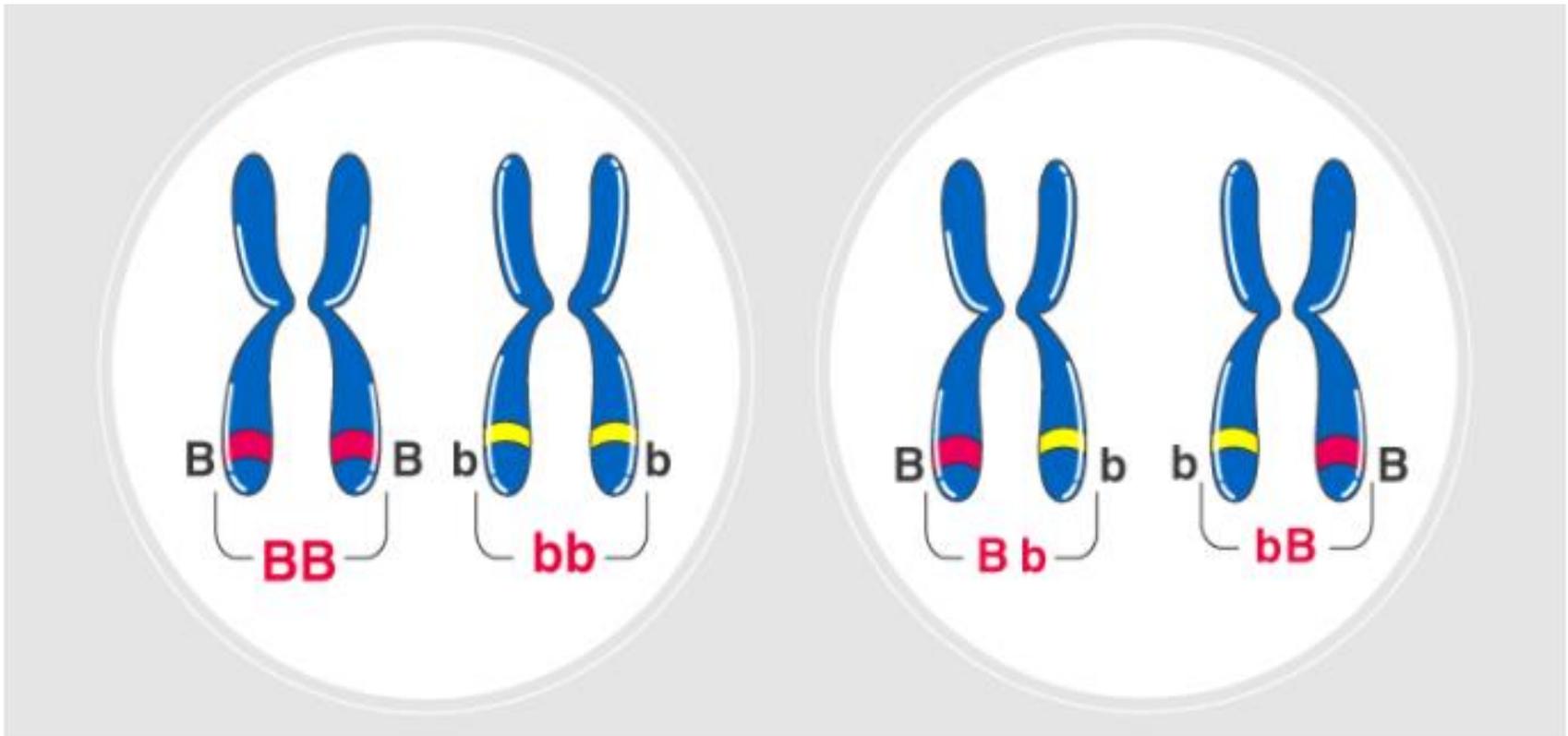
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# Biological Relationship Between Animals

- ❖ Individuals are considered to be biologically related when they have one or more common ancestors. For practical purposes, if two individuals have no common ancestor within the last five or six generations, they are considered to be unrelated.
- ❖ Biological relationship has importance in animal breeding in that the closer the relationship the higher the percentage of like genes the two individuals carry.
- ❖ Closeness of relationship is indicated by how far back in the two animals' pedigrees the common ancestor appears, the number of common ancestors and how frequently each appears. It is also influenced by any inbreeding of the common ancestor or ancestors.



❖ **Homozygote**- A cell is said to be homologous for a particular gene when identical alleles of the gene are present on both homologous chromosome.

❖ **Heterozygote**- A diploid organism is heterozygous at a locus when its cell contains two different alleles (one wild type and one mutant allele) of a gene.

# Inbreeding depression

- ❖ Inbreeding depression refers to the decrease or loss of fitness and strength which is mainly caused due to inbreeding.
- ❖ This phenomenon occurs in all the wild animals, plants and also in humans, representing that genetic differences in fitness traits exist both within and among the normal populations.
- ❖ The biological fitness is an organism's ability to survive and conserve its genetic material. The higher the genetic variations in a breeding population, the fewer are the chances for it to suffer from inbreeding depression.
- ❖ Inbreeding depression varies across mating systems. The hermaphrodite species *C.elegans* exhibit lower degrees of inbreeding depression. The outcrossing nematode such as *C.remanei* suffers severely from inbreeding depression.

This phenomenon is observed in several other plant species that are further grouped based on the following four categories.

✓ **High inbreeding depression**

A large proportion of plants produced by self-pollination lead to severe inbreeding depression and exhibit a **lethal effect**. It is very hard to maintain the breeding line after three to four generations **due to the loss of vigour and fertility** eg. Alfalfa of the pea family and carrots.

✓ **Moderate inbreeding depression**

Along with the lethal effects, **sublethal effects** are seen in the offsprings produced by self-pollination. There is a considerable decrease in fertility, as several lines produced are very poor and lost eg. **Maize, pearl, millet, great millet**

✓ **Low inbreeding depression**

A minor proportion of plants exhibit lethal characteristics. **The loss of vigour and fertility is lesser**. Onion, squash, pumpkin, sunflower are a few examples of plants showing low inbreeding depression.

✓ **No inbreeding depression**

It is because they reproduce both by self-pollination with developed homozygous balance and cross-pollination with heterozygous balance.

➤ Increase in inbreeding leads to reduced genetic variability by reducing heterozygosity over many loci (Falconer and Mackay 1996). An immediate concern to dairy farmers is the reduction of performance of inbred animals, referred to as inbreeding depression due to inbreeding (Falconer and Mackay 1996).

➤ Inbreeding depression decreases cow survival, reproductive performance and milk production and increases rate of disposal or loss of replacement heifers before first calving, age at puberty through reduced growth (du Toit et al 2012).

➤ Every 1% increase in inbreeding leads to a 10 kg of milk to 26kg decline in milk production per lactation (Mostert, 2011) and decrease of about 13 days in productive life (CDN, 2008; Smith *et al* 1998). du Toit et al (2012) reported a similar effect of inbreeding on functional herd life in Jersey cattle. Cows with high inbreeding level have also been reported to have a high risk of being culled (Rokouei *et al* 2010).

➤ Inbreeding depression depends not only on actual level of inbreeding but also on the rate of inbreeding such that animals with the same level of inbreeding may have different inbreeding depression effects depending on the completeness of their respective pedigrees (González-Recio *et al* 2007; Gutiérrez et al 2009).

# Genetic Effects of Inbreeding

It increases homozygosity at the expense of heterozygosity without affecting gene frequency

In small population the gene frequency fluctuates more extreme and certain genes may be lost while some are fixed.

But in large size population the fluctuation in gene frequency is less extreme and few of the alleles would be lost.

The large population is differentiated into sub population which are likely to be homozygous for different alleles under continuous inbreeding without selection and mutation

There are many hidden recessive genes in outbred population. Inbreeding results expression of these recessive genes it may effects economic parameter

As a consequence of increased homozygosity the characters are fixed in an inbred population due to gene fixation. These fixed characters may be favorable or unfavorable. It requires the culling of animals in which the unfavorable character is fixed.

The inbreeding changes the genetic structure of the population by changing the genotype frequencies without changing the gene frequencies. The inbreeding reduces the genetic variability within inbred line but leads to genetic differentiation between lines

# Genetic basis of inbreeding effects

The inbreeding increases the homozygosity and affects the phenotype depending upon the kind of gene action involved in affecting a trait.

The additive gene action means that there are no dominant or recessive genes and there is no interaction between alleles or pairs of genes. The inbreeding depression does not occur when there is additive gene action. The reason is that each allele has equal and similar effects

Thereafter; when there is dominance-recessive relationship among alleles, there will be a decline in mean phenotypic value of a trait on inbreeding.

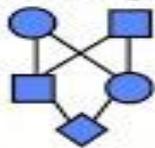
# Mechanism

- Inbreeding results in **more recessive traits** manifesting themselves, as the genomes of pair-mates are more similar.
- Recessive traits can only occur in an offspring if present in both parents' genomes.
- The more genetically similar the parents are, the more often recessive traits appear in their offspring.

## How inbred Line Form

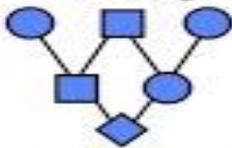
- ✓ Separation of the Population into Distinct Lines
- ✓ The population rapidly separates into phenotypically distinct lines.
- ✓ This is because of an increase in homozygosity due to which there is random fixation of various alleles of different lines.
- ✓ Therefore, the lines differ in their genotype and consequently in phenotype.
- ✓ Each line becomes increasingly homozygous following inbreeding.
- ✓ Consequently, the variation within a line decreases rapidly.

Full siblings



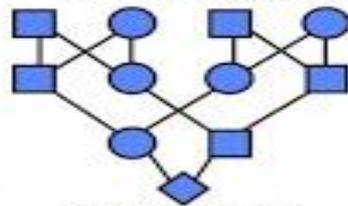
COI = 1/4 (0.25)  
25%

Half siblings



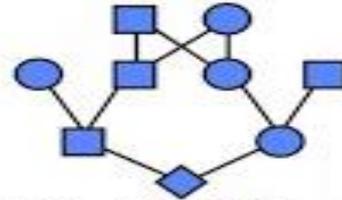
COI = 1/8 (0.125)  
12.5%

Double first cousins



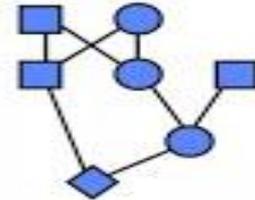
COI = 1/8 (0.125)  
12.5%

First cousins



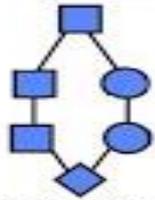
COI = 1/16 (0.0625)  
6.25%

Uncle-niece



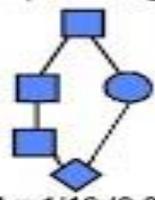
COI = 1/8 (0.125)  
12.5%

Half first cousins



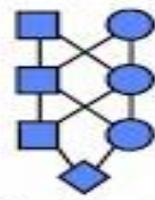
COI = 1/32 (0.03125)  
3.125%

Grandparent to grandchild



COI = 1/16 (0.0625)  
6.25%

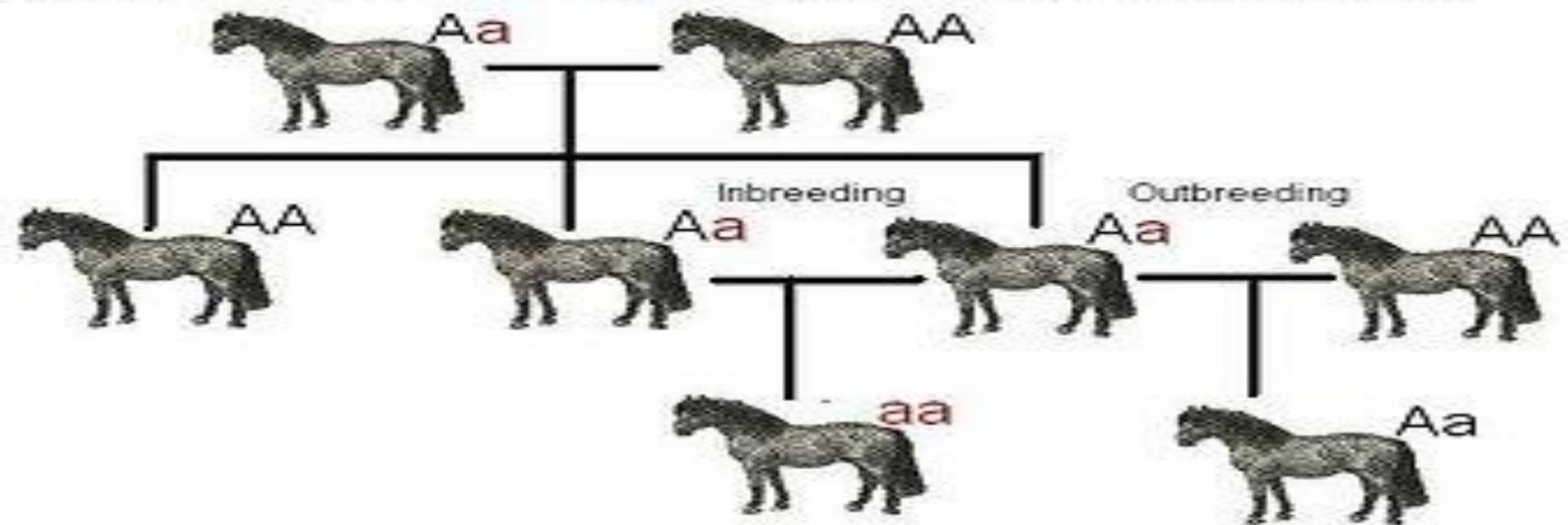
Two generation sibling to sibling



COI = 3/8 = 0.375  
(37.5%)

COMMON INBREEDINGS  
AND THEIR COEFFICIENT  
OF INBREEDING  
COI

A= Dominant allele      a= Recessive deleterious allele



# Phenotypic Effects of inbreeding

It affects particularly on fitness traits like reproduction, vigor (vitality ) and growth traits.

It depresses growth rate in farm animal

It reduces reproductive efficiency in farm animals

It results into an increases in death and hence **loss in vigor**.

## For Example

- ✓ Spider Leg condition in Sheep,
- ✓ Dwarfism in cattle,
- ✓ or Diaphragmatic Hernia in Dogs etc

All these defects decreases the overall performance of the animals. And this decline in their performance is known as Inbreeding depression.

✓ Ultimately, after 7 to 8 generations of selfing, the lines become almost uniform. Since they approach complete homozygosity (> 99 percent homozygosity).

✓ The lines, which are almost homozygous due to continued inbreeding and are maintained through close inbreeding, are known as inbred lines or inbreds.

## **Prepotency**

- ❖ The ability of an individual to produce progeny whose performance is especially like its own
- ❖ One of the consequences of inbreeding is the greater prepotency in the animals, means the performance of the offspring is similar to their parents. And that is why the inbreeding is performed.

## **Deleterious Alleles**

- ❖ It is defected genes produced after certain spontaneous mutation in the genotype.
- ❖ These alleles are often recessive and a heterozygous individual carrying a single recessive deleterious allele will not be affected.
- ❖ But if it is homozygous carrying both recessive deleterious allele will be affected by any particular defect.
- ❖ As inbreeding causes the increase in the homozygosity it causes the expression of deleterious genes.

Natural Selection:- It cannot effectively remove **all deleterious recessive genes** from a population for several reasons.

First, deleterious genes arise constantly through mutation within a population.

Second, in a population where inbreeding occurs frequently, most offspring will have some deleterious traits, so few will be more fit for survival than the others.

## **Advantageous heterozygosity**

In heterozygous form, with no adverse influence on the individual who carries them, recessive alleles retain the potential of causing future deaths from inherited disease.

❖ **Inbreeding**, the mating of individuals or organisms that are **closely related through common ancestry, as opposed to outbreeding**, which is the mating of unrelated organisms.

❖ Inbreeding is useful in the **retention of desirable characteristics or the elimination of undesirable ones**, but it often results in decreased vigour, size, and fertility of the offspring because of the combined effect of harmful genes that were recessive in both parents.

❖ Inbreeding is often described as “narrowing the genetic base” because the mating of related animals results in offspring that have more genes in common.

❖ **Mild inbreeding has been used in some breeds of dogs and has been extensively used in laboratory mice and rats.**

# Application of inbreeding

- ✓ Inbreeding is used to test for recessive alleles
- ✓ Inbreeding is used to produce distinct families within a breed
- ✓ The inbreeding is used to **develop inbred lines** as a seed stock which can be crossed according to their combining ability.
- ✓ Inbreeding also helps to know the type of **gene action** affecting a trait. The traits governed by additive gene action do not show inbreeding depression.
- ✓ Inbreeding increases the **prepotency** which is the ability of an individual to stamp its characteristics on the progeny

The inbred lines are developed mainly for crossing them **to take advantage of hybrid vigor.**

The best combining lines based on the performance of their line bred progeny

are selected.

# How to minimize inbreeding

- ❖ The mating should be among the unrelated animals
- ❖ Population size should be large
- ❖ Purchase or exchange of sire

Thank you