Chapter

Basic Animal Breeding Methods

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Abstract

In the era of genomic selection, basic animal breeding methods are still playing a very important role in animal selection and their improvement. Animal Breeding involves the selective breeding of domestic animals with the intention to improve desirable and heritable qualities in the next generation. An animal's overall performance is mostly influenced by genetic potential acquired from its parents, as well as the environment, which includes nutrition, health, management, and other factors. This chapter covers a brief outline of traditional breeding methods for the selection of animals and their improvement.

Keywords: criteria, methods, selection, improvement, breeding value, inbreeding

1. Introduction

Selection is one of the important processes for any improvement in farm animals. The breeding merit animal is not often determined by a single character, but more often based on many characters simultaneously. The purpose of selection is to produce elite breeding stocks which act as parents of future generations. The system of selection allows the best animals to act as parents of future generations and culling of undesirable animals from the herd. The animals retained have certain acceptable traits which make them produce more. The breeding of animals is underneath human control, and the breeders decide which individuals shall produce the subsequent generation [1, 2]. The breeding of animals is based upon the fact that certain qualities are genetic; hence valuable qualities are passed on from parents to offspring's. Due to selection, the qualities of animals can be maintained or improved in the next generation [3]. The purpose of selection is to enhance the frequency of desirable alleles and reduce the frequency of unwanted alleles from the herd which in the long run consequences genetic improvement in livestock. The overall performance of an animal is mainly influenced by the genetic potential that is inherited from its parents and the environment which particularly encompass feeding, health, management and so forth.

2. Methodology

Breeding for increased productivity over the past few decades has been very successful in terms of improvement of growth, production and reproduction traits; however, it has also had negative consequences on behavior and welfare [4]. Breeding and genetics are playing an important role in the improvement of domestic animals. Therefore, a broad approach is needed that encompasses both production and welfare traits, even though welfare may not be a primary breeding goal of the selection scheme. Now, in the era of genomics, breeders have lots of opportunities to collect more precise information on the biological impact of certain breeding decisions. This might help breeders to make more accurate decisions in their selection programs. Genomic tools could also facilitate selection for complex traits, which are frequently not possible to measure on a large number of animals. Looking to this the salient features about selection criteria and methods of selection have been discussed in this chapter.

2.1 Types of selection

Figure 1 is showing the different type criteria and methods of selection that are applied for the selection of animals for a single trait or multiple traits in animal breeding [5, 6].

2.2 Selection for improvement of animals

The manmade selection with certain desirable goal plays important role in the improvement of animal. The different types of artificial selection have been discussed in this chapter along with their merits and demerits. The selection, breeding and propagation of animals by breeders are known as artificial selection. There are two approaches for artificial selection. First is the traditional "breeder's approach" in which the breeder applies "a known amount of selection to a single phenotypic trait" by examining the selected trait and selecting to breed only those that show superior values" of the trait under selection [7]. The second is called "controlled natural selection," which is actually natural selection in a controlled environment [8]. The main purpose of animal breeding is not just to improve individual animals genetically but also to improve the future generation of the animal population [9]. The technique or method used by the breeder to make long-term changes in animals is called selection. Selection is the process in which certain individuals in a population are given an opportunity to produce progeny while others are denied this opportunity [10]. It also decides about how many progenies it should produce and how long they should remain in the breeding population. Selection is an important tool for changing gene frequencies to better-fit individuals for a particular purpose. Selection is not an invention of modern man. It has been going on in nature since life existed in the world. Selection is choosing individuals

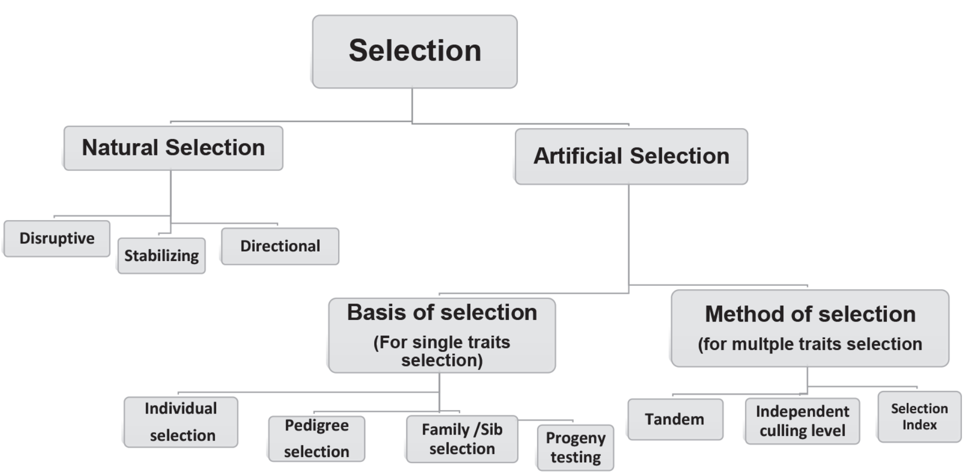

Figure 1.
Different types of selection [5, 6].

that will be parents of the next generation. The effectiveness of selection depends on the ability to recognize those animals, which possess superior inheritance [11]. Those superior animals must be mated together for the production of offspring. The aids available to estimate the breeding value of an animal is through the phenotype of an animal or its relatives.

2.3 Basis of selection for single traits

Figure 2 is showing the different basis of selection that are commonly used to estimate the probable breeding for the selection of animals for a single trait [3, 5, 6].

2.3.1 Individual selection/performance testing

Individual selection is most commonly used as a basis for selective improvement in livestock. Individual selection is based on the performance of individual or individual phenotypic value. These animals are selected based on their own phenotype. Individual selection is more effective when the heritability of traits is high, but the effect decreases with falling heritability. It is the simplest, more rapid and most commonly used basis of selection. If proper performance records are maintained then, the traits like body weight, growth rate, fleece production and other parameters of similar nature can be evaluated directly from the performance of individual animals [10, 12].

2.3.1.1 Selection for qualitative traits

The animals are kept or rejected for breeding purposes based on their phenotype for a particular trait. The progress made in selection depends on how closely genotype is correlated with the phenotype. The phenotype of the individuals is often used to estimate the breeding value for qualitative traits such as color and horned or polled conditions. Selection for such traits based on mass or phenotype is more

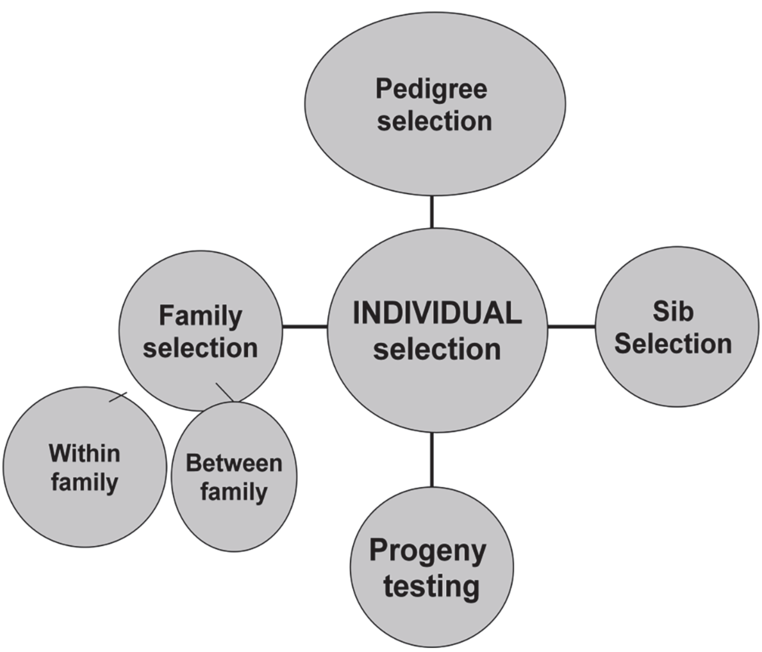

Figure 2.
Different basis of selection [5, 6].

effective than others. For example, in Angus cattle, the coat color Red (rr) is recessive to dominant black (BB) color. But it is practically difficult to distinguish and differentiate the genotype BB and Bb phenotypically. Thus, selection based on individuality will be useful but not always completely accurate [4, 13].

2.3.1.2 Selection for quantitative traits

These traits are controlled by many genes and are also affected by various environmental factors. There is no sharp distinction among the phenotypes and affected by both additive and non-additive gene action. No trait is 100 per cent heritable, because the environment always affects the phenotype to a certain extent. Therefore, the phenotype of an individual for quantitative traits is not the true indicator of genotype. The phenotypic merit of the individuals for quantitative traits is determined by comparing the individual's own phenotype with that of the average of all the individuals within a group from which it is selected and is called trait ratio [14–16].

$$\text{Trait ratio} = \frac{\text{record of individual for a trait}}{\text{Group mean for the same trait}} \times 100$$

The trait ratio depends upon the accuracy of records or available data. The individual's record is of little value unless it shows where the individual ranked relative to others under similar conditions. The environmental part of phenotypic superiority or inferiority will not be transmitted to the offspring or next generation. Therefore, in general, there is a tendency for the average phenotype of the offspring of a phenotypically superior individual will tend to regress toward the average of the population, whereas the average phenotype of the offspring of phenotypically inferior individuals will tend to rise toward the average of the population. Animals own phenotypic value of the character under selection is considered to estimate the probable breeding value (PBV) [5, 13, 14] of that character for that individual.

$$\text{Probable Breeding Value (PBV)} = \overline{P} + h^2 \left(P_i - \overline{P}\right)$$

Where, $\overline{P}$ is population mean, h^2 is heritability, P_i is individual phenotypic value.

Comparison is made with the average of other individuals kept under similar environmental conditions of same age and same time; thus, individuals are ranked relative to others under similar conditions. It is also called as mass selection.

In individual selection, the best animals are selected from within a group of animals of the similar age group that has been reared and treated similarly at the same time, i.e., contemporaries. In individual selection, the breeder will be having a single record of each animal's performance (performance test) and hence an estimate of probable breeding value (PBV) [13] for a given trait is calculated as:

$$\text{Probable Breeding Value (PBV)} = \overline{P} + h^2 \left(P_i - \overline{P_c}\right)$$

Where, $\overline{P}$ is population mean, h^2 is heritability, P_i is individual phenotypic value, $\overline{Pc}$ is average of contemporaries.

2.3.1.3 Advantages of individual selection

- Information of individuals to be selected is easily available [3, 5].
- Used when pedigree information not available, this is the only available guide for selecting the breeding stock.

- Used when generation interval is shorter than progeny testing.
- It gives a direct estimation of BV and is more accurate when h2 is high.
- Traits such as body type, growth rate, fleece production, horn pattern, color and others of a similar nature can be evaluated if suitable records are available.
- Useful for traits expressed in both sexes and performance of the individual is above average for breeding, regardless of the merit of near relatives.
- In the absence of pedigree and progeny records, this is the only available guide for selecting the breeding stock.

2.3.1.4 Disadvantages of individual selection

- Not applied for sex-limited traits such as milk production, egg production, maternal abilities, semen production and litter size, etc. [3, 13].
- Not applied when traits are expressed in later life/after the death of individual.
- Not applied when traits have low heritability, then the individual selection is the poor indicator of breeding value such as reproductive characters.
- Not possible for traits expressed only after sexual maturity, because selection has to be delayed till maturity resulting in waste of time and money.
- The easy appraisal of appearance often tempts the breeder to overemphasis this evaluation in selection.

It is concluded that the individual selection is based on individual's phenotype (appearance) and performance. Individuals are selected solely in accordance with their own phenotypic values. This is the simplest and yields more rapid response. It is the most commonly used method for selective improvement of livestock. Undoubtedly, most of the progress in livestock improvement can be credited to individual selection. Traits such as body type, growth rate, fleece production and other of similar nature can be evaluated directly from the performance of the individual animal, if suitable performance records are being kept; such evaluations are usually available by the time initial selection of breeding stock has to be made. In contrast, only a few can be progeny tested.

2.3.2 Pedigree selection

When the genetic worth or breeding value of animals is determined based on the performance of their ancestors or pedigree information is called as pedigree selection. Pedigree may be a record of an individual's ancestors associated with it through its parents. Therefore, the selection is based on the information of the ancestors of individuals that are related to it. Performance records from ancestors can provide useful information about the potential genetic worth or the breeding value of the individuals in question. This will give useful information before the animal is old. An estimate of calf's potential milk yield could be determined based on the milk yield of its mother until such time as the calf is grown up and can be milked. When adequate information on the merit of the individual is not available, then attention is given on pedigree information for selection of individual. From the selection point of view, knowledge of the different economic traits of the ancestors is essential [17].

It's usual to expect offspring of outstanding parents to be of superior genetic value than the mean of the individuals of the herd. Each parent transmits only sample halves of its genes to every offspring and just one quarter of genes from each grandparent. So, parents never provide the maximum amount of information about the breeding value of a single individual as individual's performance itself would produce. Unless the performance of the ancestor is well known, selection based on pedigree is meaningless. Distant ancestors of an individual give even less genetic information about the individual's breeding value especially for production traits. The pedigree is often classified into two as direct and collateral [2]. Collateral means those descended from same ancestors.

Selecting a cow based on the performance of its great grandparent is as good as random selection because the relationship is $(0.5)^2 = 0.125$, i.e., only 1/8th of the superiority can be expected in the progenies. It will not do much good to go beyond three generations into pedigree due to the halving process of the chromosomes in each generation [9].

When the pedigree data provides information on the phenotypic and genotypic merit of the ancestors then it is called performance pedigrees. If the selection differential for the ancestor could be presented in the pedigree or if the performance record of the ancestor could be expressed as a percentage of the average contemporaries (Trait ratio), the ancestor's records would be of greater predictive value [9, 10].

Figure 3 is showing the different basis of selection that are commonly used to estimate the probable breeding for the selection of animals for a single trait.

2.3.2.1 Degree of relationship

If ancestors are more closely related to the individual (Parent: $\frac{1}{2}$, Grandparent: $\frac{1}{4}$ and Great grandparent: $\frac{1}{8}$) should receive most emphasis in pedigree assessment [16].

In pedigree selection, the PBV [3] of an individual is estimated on the basis of the performance of his ancestors.

$$\text{PBV} = \overline{P_c} + b_{AP}\left(\overline{P_i} - \overline{P_c}\right)$$

Where, $\overline{P}$ is population mean, b_{AP} is regression of additive genetic value or breeding value on phenotypic value, Pi is phenotypic average of individual, $\overline{Pc}$ is average phenotypic value of individual contemporaries,

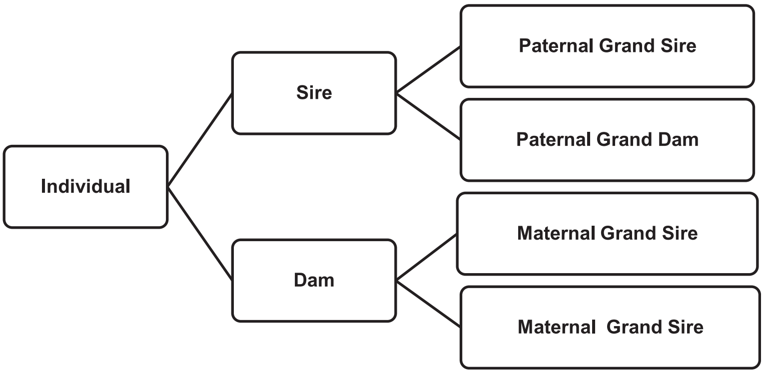

Figure 3.
Schematic of pedigree selection [5].

The selection criteria based on the ancestor's performance is called as the pedigree selection. For pedigree selection, more recent ancestors consider rather than distant.

2.3.2.2 Difficulties in pedigree selection

- Ancestral records are not always available.
- Recording may be faulty due to stray mating
- Most of the characters have low heritability.

The accuracy of pedigree selection when only single information is available for ancestor has been summarized in **Table 1**.

Table 1 summarizes the accuracy of pedigree selection when only single information is available for ancestor (n = 1) [3]. The accuracy of selection based on individuals own record increases, when ancestors' information (parents and grandparents) is combined with an individual's own records.

When information of more than one ancestor are available the accuracy of selection increases, which is described in **Table 2**.

Table 2 summarizes the accuracy of pedigree selection when information of more than one ancestor (n > 1) [3] is available. This increases the accuracy of selection. The pedigree selection is basically only useful to select the individual before its own records is available.

2.3.2.3 Merits

- It is less costly and allows selection at a younger age and provides first-hand information [3, 17].
- It helps in multistage selection and is also useful for sex-limited traits.
- It is useful when two individuals have similar performance.

Ancestor	b	Accuracy of selection (n = 1)
Dam	$0.5\ h^2_D$	$0.5\ h_D$
Sire	$0.5\ h^2_s$	$0.5\ h_s$
Mean of both parents	$1/\sqrt{2}\ h^2$	$1/\sqrt{2}\ h$
One grand parent	$0.25\ h^2$	$0.25\ h$

Table 1.
Accuracy of selection (n > 1) [3].

Ancestor	b	Accuracy of selection (n > 1)
Dam	$0.5\ h^2{}_D\ [n/1 + (n\text{-}1)r]$	$0.5\ \sqrt{}[nh2\ D/1 + (n\text{-}1)r]$
Sire	$0.5\ h^2{}_s\ [n/1 + (n\text{-}1)r]$	$0.5\ \sqrt{}\ [nh2\ s/1 + (n\text{-}1)r]$
Mean of both parents	$1/\sqrt{2}\ h^2\ [n/1 + (n\text{-}1)r]$	$1/\sqrt{2}\ \sqrt{}[nh2/1 + (n\text{-}1)r]$
One grand parent	$0.25\ h^2\ [n/1 + (n\text{-}1)r]$	$0.25\ \sqrt{}\ [nh2/1 + (n\text{-}1)r]$

Table 2.
Accuracy of selection (n = 1) [3].

- The pedigree should be used only as a minor ancestry to individual selection. It may be used to tip the balance between two individuals who are very close on individual merits.
- The selection based on pedigree is only useful than of individual selection only when heritability is moderate or low.

2.3.2.4 Demerits

- All the animals from an inferior pedigree are culled in spite of the fact that an individual may be of good merit and free from recessive alleles [3, 17].
- Some pedigrees get favored irrespective of the true merit of the individuals in the population.
- Pedigree records are from different environmental conditions.
- Pedigree selection provides no basis of selection among the descendants of the same ancestor.

2.3.3 Family selection

Family is a group of individuals that descended from the same ancestor. Family represents a group of animals having common genetic relationship. In family selection, it is presumed that the ancestor has outstanding merit. In animal breeding, generally, the family is a group of animals having a common genetic relationship. In animal population under random mating, generally half sibs (HS) and full sibs (FS) are the most common collateral relatives, whose records are often used to estimate the breeding value. When individual's performance is also included in calculating the sibs average performance, it is called family selection. Family selection is very useful in case of traits with low heritability [1, 3].

2.3.3.1 Sib selection

The selection of individual based on the sibs performance not including individuals own performance.

Based on its sib performance it is of 3 types:

- Full sibs, Maternal half sibs, Parental half sib - cousins, uncle/aunt, nephew/niece.
- Sib selection is performed when the measurements on the individual are not available. For example, Slaughter traits; Sex limited traits; Threshold traits like disease resistance.

HS selection is preferred over FS selection:

- HS are easily available in more number
- The rate of inbreeding can be kept low in HS mating as compared to FS
- FS selection is more likely to be increased by c-effects

Breeding value of sib selection:

$$PBV = \overline{P_c} + rh^2 \frac{n}{1 + (n-1)t} \left(\overline{P_s} - \overline{P_c}\right)$$

Where, $\overline{P}$ - Average of contemporaries, $\overline{P_s}$ - average of sibs, n- number of sibs, r- coefficient of relationship (½ for FS and ¼ for HS), t- intra-class correlation (rh^2) among sibs (½ for FS and ¼ for HS), h^2- heritability of the traits, h^2s heritability of sibs = $\frac{nh^2}{1+(n-1)t.}$ [18]

Breeding value of Family selection:

$$PBV = \overline{P_s} + h^2 \left| \frac{1-r}{1-t} \left(P_1 - \overline{P_s}\right) \frac{1+(n-1)r}{1+(n-1)t} \left(\overline{P_s} - \overline{P_{cs}}\right) \right|$$

Heritability of the trait:

- Accuracy of family selection is more for the traits of low heritability [5, 19]
- Accuracy of sib selection based on one FS is 0.5 h and based on one HS is 0.25

2.3.3.2 Advantages of family selection

- Improve the character of low heritability in species with high reproductive rates
- It does not allow generation interval to increase.
- It supports individual selection because it is better to select an individual from a superior family.

2.3.3.3 Disadvantages of family selection

- It is costly
- It requires a large family size depending on the genetic relationship which is only possible in prolific breeder.
- It results in inbreeding and limits the genetic diversity.
- Its accuracy depends upon the genetic relationship among the family members.

2.3.4 Progeny selection

The selection criteria for evaluating an individual based on his progeny performance is known as Progeny selection or progeny testing. Progeny testing is the most important and one of the best criteria of selection. It is regarded as a form of family selection since progenies are the family members of each other. Progeny selection is very useful in the case of sex-limited traits. Such traits are milk yield and fat percentage in cattle and goat, litter size and litter weight at weaning in pigs and egg production in poultry etc. [20]. Progeny selection is also useful for the evaluation of an individual for carcass quality traits which could only be recorded after slaughter. The various functions or equations (sire indices) are used for the estimation of breeding value of individual. The accuracy of progeny testing is depending on number of progenies tested, heritability of traits and the environmental correlation between the records of different progeny [5].

2.3.4.1 Genetic principle of progeny testing

Each progeny of an individual inherits half of the genes. Hence, the breeding value of the parent is twice the mean deviation of the progenies from population mean.

Points to be considered in Progeny testing:

- Test as many as sires as possible (5 to 10 would be minimal) [5, 13]
- Make sure that dams are mated to sires at random, within age group as possible.
- Produce as many progenies per sire as possible (10 to 15 progenies of either sex for growth traits but up to 300 to 400 progeny is required for traits like calving difficulty and fertility).
- No progeny should be culled until the end of the test.
- Offspring that are being tested are not a select group.
- The performance of an adequate sample of an animal's progeny under normal environmental conditions will give a true indication of its genotype than any knowledge of individuality or pedigree.
- To involve a large number of individuals, Progeny testing should be followed in associated herds.
- Five males should be tested to select one Progeny testing breeding bull
- Ten female progenies of each bull should be performance tested.
- One set of bulls should be completed in two years
- Facility for recording performance of progenies

Constraints in Progeny testing:

- Small Population Size
- Unplanned Mating

Breeding value of Progeny testing

$$PBV = \overline{P_c} + \frac{2nh^2}{4 + (n-1)h^2} \left(\overline{P_i} - \overline{P_c}\right)$$

Accuracy of Progeny testing

$$r_{G\overline{P}=}r_{A\overline{P}} = 0.5\sqrt{\frac{nh^2}{1 + (n-1)t}}$$

Restriction on Records		Heritability	
		Low ($h^2 < 0.20$)	High ($h^2 > 0.40$)
For selection of Males:			
1	None	Progeny	Own
2.	Females only (i.e., MY)	Progeny	Progeny, maternal relative
3	Relative only (i.e., carcass traits)	Progeny	Sibs, progeny
For selection of Females:			
1	None	Own, Pedigree	Own
2.	Males only (i.e., Semen Production)	Sibs, Pedigree	Sibs, Pedigree
3	Relative only (i.e., carcass traits)	Sibs, Pedigree	Sibs

Table 3.
Choice of records for the optimum breeding program [4, 9].

Where, r is Coefficient of relationship between sire and his progeny, n is Number of progenies, P_i is Mean performance of progenies of i^{th} sire, P_c is Mean performance of contemporaries of progenies of i^{th} sire, h^2 is Heritability of the trait

The choice of records for the optimum breeding program for low and high heritable traits has been summarized in [5, 14, 21] (**Table 3**).

Table 3 [4, 9] summarizes the appropriate criteria for selection male and female for optimum breeding program under different restrictions of records for low and high heritable traits.

Advantages of Progeny testing:

- It is the better method for sex-limited traits, the traits with low heritability and slaughter traits.
- The bulls carrier of recessive gene can be identified by mating with its progenies.
- It evaluates carcass traits that demands sacrifice of animal.
- Progeny testing increases selection intensity.
- Its accuracy increases with an increase in the number of progenies.

Limitations/disadvantages of progeny testing:

- High cost and time are required.
- It increases the generation interval and due to longer generation interval genetic gain per year is low.
- It requires an adequate number of progenies to be tested on a bull.

3. Systems of breeding

Systems of breeding can be classified into two major groups: Inbreeding and Out breeding [5, 22].

3.1 Inbreeding

Inbreeding is the mating of animals more closely related to each other than the average relationship with in the population concerned. The mated individual should have one or more common ancestors in their pedigree up to 4–6 generations. Inbreeding includes mating like parent-offspring, brother–sister. Inbreeding is classified into two types: close Inbreeding and line breeding [22].

Close inbreeding is mating between sibs or between parents and progeny to achieve inbred lines with a relatively high degree of homogeneity. Most of the time, we use the full sib mating method. The same effect can be achieved by consistently back crossing the progeny to the younger parents. Line breeding is a milder form of close inbreeding is in which the relationships of mated individual is kept as close as possible to some ancestor. As a general rule sire is not mated to its daughters but half sib mating is made among the offspring of the particular sire. Line breeding was used extensively in the past in development of British breeds of cattle such as Angus, Hereford and Shorthorn [3]. Line breeding should be practiced in purebred populations of the high degree of excellence, after identifying outstanding individuals and it can be advocated to form a new breeds.

Inbreeding is that it makes more pairs of genes in the population homozygous irrespective of the type of gene action involved. Inbreeding does not increase the number of recessive alleles in a population but merely brings to light through increased homozygosity. When the animals are homozygous for several traits, the regularity of inheritance is assured (i.e., it fixes the characteristics). Inbreeding reduces vigor or it results an inbreeding depression.

Despite certain obvious disadvantages of inbreeding, there are certain instances where it may be used as the advantage of livestock production. It is used to maintain genetic purity and thereby to increase prepotency. It is also used to develop inbred lines and also to eliminate undesirable recessives from the population. When a sire is mated to at least twenty of its daughters and does not produce any recessive characters in the offspring, it may conclude that the sire is not heterozygous for recessive characters.

Inbreeding is to be practised only when the herd is better than the average, i.e., when the frequency of desirable genes is more, herd has an outstanding sire, the breeder knows the merits and demerits of inbreeding and the herd is not maintained for commercial purpose.

3.2 Out breeding

Out breeding is the mating of animals that are less closely related to each other than the average of the population. Its general, effects are the opposite of those of inbreeding. Out breeding increases the heterozygosity of the individual. The maximum practical usefulness of out breeding systems is the production of animals for market. Out breeding is a form breeding where the mates are chosen based on not being related. The following type of out breeding is used in animal breeding [3, 6].

3.2.1 Selective breeding

The selective breeding is used to maintain the purity of the breed along with their improvement. **Figure 4** describes the brief information for genetic improvement of indigenous cattle breeds by selective breeding is shown below:

Figure 3 is showing the different basis of selection which are commonly used to estimate the probable breeding for selection of animals for single trait.

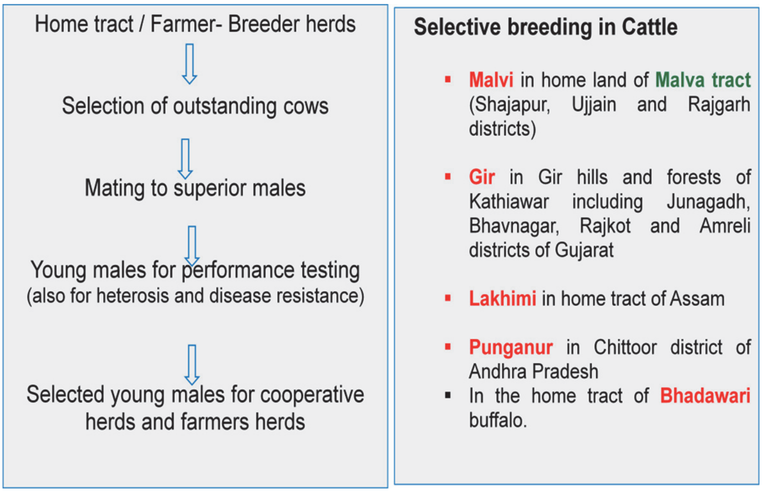

Figure 4.
Schematic of selective breeding [3, 5].

3.2.2 Out crossing

It is usually applies only to mating within a pure well-defined breed. If two lines within the same breed are separated for 4 or 5 generations and the sire from one herd is used in another herd that accounts to out crossing. It is used when the genetic variability and there is lack of selection response [3]. It introduces new genes in the population with reference - color, horn type, etc.

3.2.3 Top crossing

It refers to the use of highly inbred sires to the dams of the base population or non-inbred population within the same breed. It usually refers to the best sire in a pedigree. It also refers to the continued use of sires to different families within a pure bred, same breed or different breed [3, 5].

3.2.4 Up-grading

Grading up or upgrading is the repeated use of pure breed sire (or sires) over females of non-descript population. There is a noticed improvement in crosses if sires from a particular breed (A) are repeatedly back crossed to another breed/non-descript animals (B). Five generations are sufficient to raise the level of inheritance of breed A to 96.9% (0.969) in the fifth generation. After five generations of repeated back crossing to a particular breed, the animals after the end of fifth generation become eligible to be registered as purebred. After 7 to 8 generations of continuous grading up the non descript population will be transferred into well defined purebreed [3, 4].

The level of inheritance (%) of pure-bred male and non-descript in different generation under upgradation program is summarizes below in the [4, 5] (**Table 4**).

Table 4 [4, 5] summarizes the change in the per cent level of inheritance of pure-bred male and non-descript female in different generation under upgradation program. By the successive backcrossing from one population into another population over generation after generation (7–8 generations), the non-descript population can be substituted by pure bred population.

The representative model for upgrading the local cattle by frozen semen and nucleus breeding unit is summarized in [4, 5] (**Figure 5**).

Generation	Level of inheritance (%)	
	Pure breed male (A)	Non-descript females (B)
First generation	50.00	50.00
Second generation	75.00	25.00
Third generation	87.50	12.50
Fourth generation	93.75	6.25
Fifth generation	96.87	3.13
Sixth generation	98.44	1.56
Seventh generation	99.24	0.76
Eighth generation	99.62	0.38

Table 4.
Up-gradation of non-descript population [4, 5].

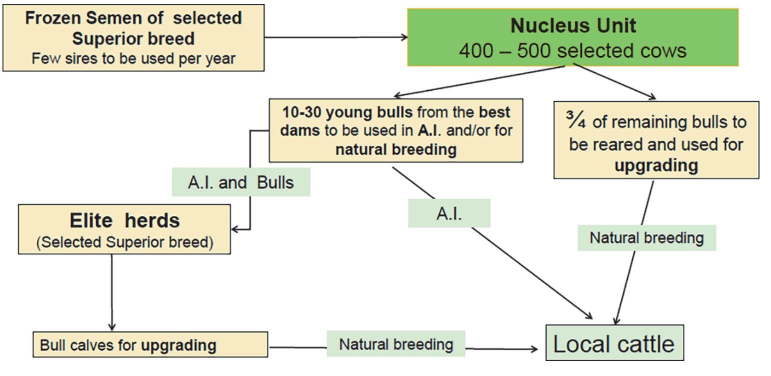

Figure 5.
Representative model for upgrading the local cattle by frozen semen and nucleus breeding unit [5].

3.2.5 Cross breeding

Cross breeding is mating of two individuals from different distinct breeds. In recent years, crossbreeding has been used for development of new breeds or synthetics strain. For example: Santa Gertrudis, Jamaica Hope, Norwegian Red and White, Australian Milking Zebu, Hissardale, Karan Swiss, Sunandini, Taylor breed

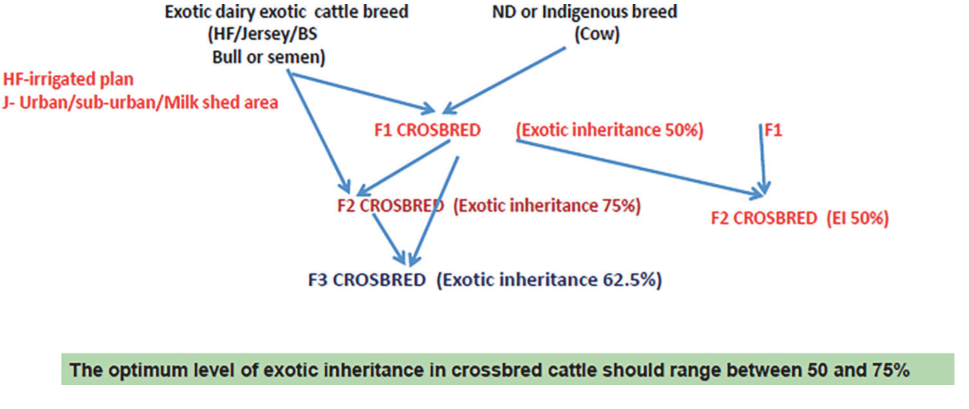

Figure 6.
Representative cross for genetic improvement of non-descript zebu cattle by crossbreeding unit [5].

etc. [4, 5]. The representative diagram for genetic improvement of non-descript zebu cattle by crossbreeding is shown in **Figure 6**.

Crosses of animals from different breeds result in offspring whose level of production is above that of the average of the parents. The increased production may be due to increased fertility, increased pre and post-natal viability, faster and more efficient growth, improved mothering ability, etc. The increased level of performance as compared to the average of the parents is known as heterosis or hybrid vigor. Heterosis is due to non-additive gene action. The breeds or lines with good nicking ability or combining ability are crossed to exploit heterosis.

4. Conclusions

In any species of livestock, the primary aim of breeder is to improve the production traits. In these traditional methods of selection along with intervention of recent molecular techniques has paved the way to exploit the genetic potential of animals upto certain limit. However, in this rapid race of genomics ethical and environmental issues should be taken into consideration.

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References

[1] Lasley JF. Genetics of Livestock Improvement. New Delhi: Prentice hall of India Pvt. Ltd.; 1965

[2] Nicholas FW. Introduction to Veterinary Genetics. Morgan City, LA, United States: Wiley-Blackwell; 2010

[3] Parekh HKB, Srivastava PN. Genetic Concepts in Animal Breeding. Pusa, New Delhi: Directorate of information and Publication of Agriculture, ICAR, Krishi Anusandhan Bhavan; 2002

[4] Marleen FM, Beerling M, Buchanan DS, Theunissen B, Koolmees PA, Lenstra JA. On the history of cattle genetic resources. Diversity. 2014;**6**(4): 705-750. DOI: 10.3390/d6040705

[5] Tomar SS. Textbook of Animal Breeding. New Delhi: Kalyani Publisher; 2010

[6] Warwick EJ, Legates JE. Breeding and Improvement of Farm Animals. Avenue of the Americas New York City, United States: TMH Edition; 1979

[7] Flint AP, Woolliams JA. Precision animal breeding, philosophical transactions of the Royal Society B biological. Science. 2008;**263**:273-390

[8] Hansen TF. Stabilizing selection and the comparative analysis of adaptation. Evolution. 1997;**51**(5):1341-1351

[9] Rodenburg TB, Turner SP. The role of breeding and genetics in the welfare of farm animals. Animal Frontiers. 2012; **2**(3):16-21

[10] Brah GS. Animal Breeding: Principles and Applications. New Delhi: Kalyani Publishers; 2016

[11] Johansson I, Rendel J. Genetics and Animal Breeding. San Francisco: W.H. Freeman and Company; 1968

[12] Tomar SS. Text Book of Population Genetics Vol. I-Qualitative Inheritance. Karnal, India: Universal Publication Centre; 1996

[13] Tomar SS. Text Book of Population Genetics Vol. II-Quantitative Inheritance. India: Kalyani Publishers; 1998

[14] Becker WA. Manual of Quantitative Genetics. 5th ed. USA: Academic Enterprises; 1992

[15] Crew FA. Animal Genetics: The Science of Animal Breeding. Redditch, United Kingdom: Read Books Ltd.; 2013

[16] Rendel J, Johansson I. Genetics and Animal Breeding. San Francisco: W. Freeman; 1968

[17] Van Vleck LD, Pollak EJ, Bltenacu EAB. Genetics for Animal Sciences. New York, NY, United States: WH Freeman; 1987

[18] Jain JP. Statistical Techniques in Quantitative Genetics. Delhi: Tata McGraw-Hill; 1982

[19] Henderson CR. Application of Linear Models in Animal Breeding. Guelph, Ontario, Canada: University of Guelph; 1984

[20] Singh RP, Kumar J. Biometrical Methods in Poultry Breeding. Daryaganj, New Delhi: Kalyani; 1994

[21] Hammond GD. Advances in Statistical Methods for Genetic Improvement of Livestock. Berlin, Heidelberg, Germany: Springer; 1990

[22] Falconer DS, Mackay TFC. An Introduction to Quantitative Genetics. NY, United States: Longman; 1996