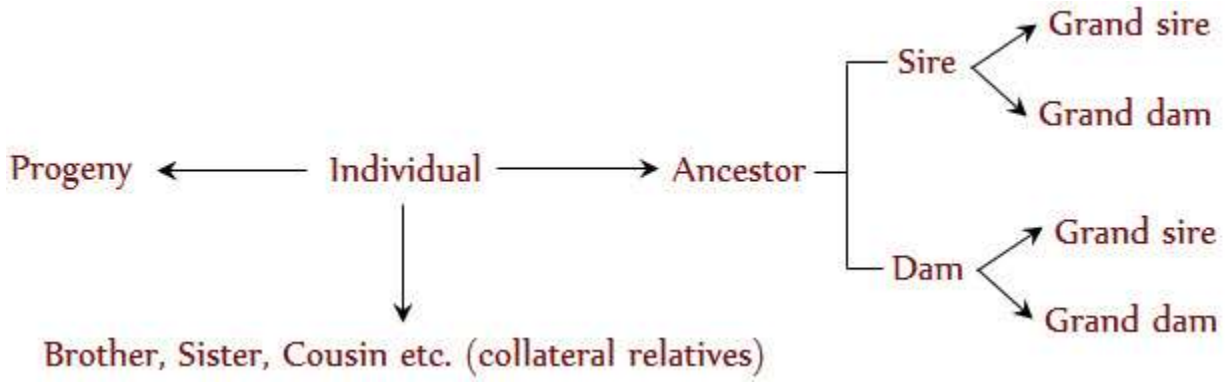
Dr. Dibyendu Chakraborty

SELECTION

- The purpose of animal breeding is not to genetically improve individual animals but to improve future generation of the animal population. The method used by the breeder to make long-term change in animals is called selection. Selection is the process in which certain individuals in a population are given an opportunity to produce offspring while others are denied this opportunity. It also decides about how many offspring 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 of individuals that will be parents of next generation.
- Effectiveness of selection depends on ability to recognize those animals, which possess superior inheritance. 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.



- Various aids available for selection are: (a) Individual selection or mass selection, (b) Pedigree selection, (c) Progeny testing and (d) Family selection and sib selection.

Breeders always tend to go for selection of several traits at a particular time. Because, the net value of an animal would depends on several traits that may not be equally economically important. The desirable trait will depend on the economic value but only of real importance may be considered. If too many traits selected for one time there will be less progress in improvement of any particular trait. There are three methods of selection *viz.,* tandem method, simultaneous but independent culling level method and selection index method.

GENETIC EFFECTS OF SELECTION

- Selection does not create new genes. It is practiced to increase the frequency of desirable genes in a population and decrease the frequency of undesirable genes. Since the selected individuals can transmit only sample halves of genes they have to their offspring, so if animals with better quality genes possessed are selected then the offspring will also posses the same. If the frequency of desirable gene is increased, the proportion of individuals homozygous for that desirable gene is also increased. The changes thus obtained in gene frequency due to selection are permanent even if selection ceases thereafter. The higher frequency obtained by initial selection can be maintained

by random mating. Hence, selection has been aptly called the keystone of the arch in animal improvement. Man's selection even in the absence of genetic knowledge has been highly effective.

COMPLICATIONS OF SELECTION

- Selection is carried out for a variety of traits in different species. For *e.g*., speed in racehorses, milk yield in dairy cattle, litter size in swine, wool yield in sheep, market weight in goats and egg production in poultry. In farm animals, selection should always be directed to greater utility. However, selection is not so simple a task to produce immediate results. Selection is also not always successful. If selection were always being effective, the animal breeders' problems would be largely resolved. But the failures of selection dampen the enthusiasm of many people engaged in animal breeding. The complications can be classified genetic and operational complications. The genetic complications are: heredity and environment, genotype and phenotype, heritability, regression to the mean, types of gene action, correlation of traits and effects of inbreeding. The operational complications are: objectives in selection, number of traits, foundation stock, level of performance, systems of selection, length of time and number of animals.

GENETIC COMPLICATIONS

Heredity and environment

- Most traits of economic importance are controlled by many genes and are greatly influenced by environment also. The environment may alter the traits and mask the real genetic worth of the individuals. For example, an animal with a faster growth rate rose in a faulty environment (deficient diet) and an animal with poor genetic constitution for growth rate but raised in a good environment can be responsible for mistakes in selection. This effect of environment can be responsible for mistakes in selection. However, this effect could be overcome by keeping the stock under selection in a standard and suitable environment wherein the better genotype will be able to express itself fully. Under such conditions, the breeder will have a chance to recognise the differences that are hereditary and thus increase the accuracy of selection.

Genotype and phenotype

- Genotype is animal's genetic constitution. The genotype remains constant for an animal throughout its life. But phenotype is the result of interaction between the genotype and environment in which the animal is developing. The phenotype, unlike the genotype, changes with time. Hence it affects selection. Selection is done for the genotype, but seldom, it could be assessed correctly. So the genotype is assessed based on phenotype of the individual though it is not accurate. So, for selection to be effective, phenotypic selection should be done at the age when the economic traits are expressed, for e.g., meat animals like sheep, swine and poultry, phenotypic selection should be done at market age. Cows should be selected at the end of first lactation.

Heritability

- Most selection processes are based on phenotypic differences. Though we are selecting on phenotypic basis, our aim is to effect selection on genotypic basis. If the phenotype accurately reflects the genotype, the selection will be quite accurate. But phenotype is not a true indicator of genotype. Heritability of a trait may be defined as that portion of the phenotypic variation that is due to additive gene action. If most of the phenotypic variation is due to environment, progress from selection will be slow. On the other hand, if the additive genetic variation is larger, then the heritability estimate will more accurately predict the genotype. The heritability values are not constant and vary from herd to herd and in the same herd from time to time. Inbreeding for instance increases homozygosity of genes and reduces the hereditary variation. Therefore, heritability will decrease with inbreeding and increase without crossing. In other words, phenotype or individual selection will be more effective in herds and for traits where the heritability is high. Hence, knowledge of heritability of economic traits in livestock is therefore essential for a breeder.

Regression to mean

- The offspring of outstanding parents often have a tendency to regress towards the average of the breed from which they were selected. This is referred to as Galton's law of filial regression. This is because (i) due to combination of genes; when they reproduce due to segregation and independent assortment of genes, the suitable combination is broken up and the average results and (ii) due to environment; the offspring are brought up in an environment which is much different from that of the parent. If the superiority of the parents is due to lucky combination of genes, little could be done to interfere with the laws of segregation and independent assortment. If the superiority of the parents is due to high percentage of homozygosity of favourable genes, by adopting inbreeding the gene pool could be maintained in the offspring. If the superiority of the parents is due to heterosis *i.e.*, Aa (heterozygous) better than AA or aa (homozygous), it is not possible to control the segregation of genes. So, heterozygous individuals that are superior could be used for market but not for breeding. The environmental part of regression can be levelled out a great deal by keeping the same environment as far as possible from year to year. This is another reason why animals should be tested and selection should be made under conditions similar to one in which their offspring are to perform.

Type of gene action

- Genes act differently in different combinations. This makes accurate selection more difficult. For instance, when "A" is dominant to "a", AA and Aa individuals who have the same phenotype will be selected with equal preference. But AA will breed true whereas Aa will segregate. But in case of over dominance, Aa will produce larger effect than AA / aa. So in heterozygous condition, selection will not produce desired results. Only crossing of appropriate inbred lines will produce the desired effect. Hence the job of the breeder is to increase the frequency of favourable alleles and to discard the less favourable ones.

Correlation of traits

- Some characteristics are positively correlated, for example, rate of gain in weight and efficiency of gain in swine. Whereas some others are negatively correlated, for example, milk yield and butter fat percentage in dairy cattle. If the desirable traits are positively correlated selection becomes somewhat easier. If you select for one trait it automatically

improves the other trait also. When the traits are negatively correlated, selection for one trait will affect the other trait. Hence, knowledge of correlation of different traits will be of great help in avoiding mistakes in selection.

Effect of inbreeding

- It is generally known that a decline in all attributes of vigour usually accompanies inbreeding. Breeders therefore hesitate to practice inbreeding. However, it is necessary to practice inbreeding in order to induce gene segregation and to fix desirable gene combinations. Inbreeding increases prepotency. Regularity of transmission is increased with increased homozygosity, which is obtained only through inbreeding and selection. To avoid depressing effects of inbreeding: choose foundation stock that is superior in production, rigid selection from beginning to offset the possible bad effects of inbreeding on performance and flexible system of mating that permits besides close breeding, mating of best individuals that is controlled breeding.

OPERATIONAL COMPLICATIONS

Objectives in selection

- Many failures in selection of livestock may be attributed to lack of definite objectives as a result of which selection has changed its direction frequently. Selection will be more effective when the breeder has definite objectives for which to strive. The objectives should be defined by measurements. Judgement should be used along with measurements, but should never replace measurements.

Number of traits

- When a single trait is subjected to selection, it is very simple to rank the individuals in order of their merit for the trait. This becomes increasingly difficult as the number of traits is increased. An animal may be good in one trait and deficient in another. Only a few individuals will be good in all the characters that are under selection. To simplify this problem, the number of traits must be kept as small as possible and must be those with greatest value from the stand point of utility.

Foundation stock

- Selection will be ineffective if the foundation animals are genetically poor and also where there is no genetic variability. Selection merely sorts genes and permits the better ones to be saved and poorer ones to be discarded. Therefore, it is important to start with good foundation stock.

Level of performance

- In available stock, selection will be effective for the first few generations and then it becomes ineffective for further progress. When the level of performance rises after a few years, due to increased homozygosity and frequency of desirable genes, further progress is slow, unless it is accompanied by a system of mating that will bring about new gene combinations. For example, by artificial insemination is used as a tool, for increase in milk production. The improvement will be achieved in few generations and afterwards

the progress is slow. Then it does not mean that the sire used is inferior, but the level of performance of the herd has become higher.

System of selection

- Too much rigidity in the systems of selection may be a handicap to progress in animal breeding programme. For example, a breeder may specify that no cows should be selected with the lactation yield less than 2000 kg. But only few cows will be available and after few years very few animals will reach the standard. A selection index giving relative importance to each trait is good. But the importance of the trait at that particular time should be taken into consideration for selecting the trait.

Number of animals

- Where there are few animals in the herd, selection is very much restricted. Selection pressure will be applied effectively since it will cull most of the animals leaving few that will not be able to replace the stock. Also there will be little opportunity for genetic segregation.

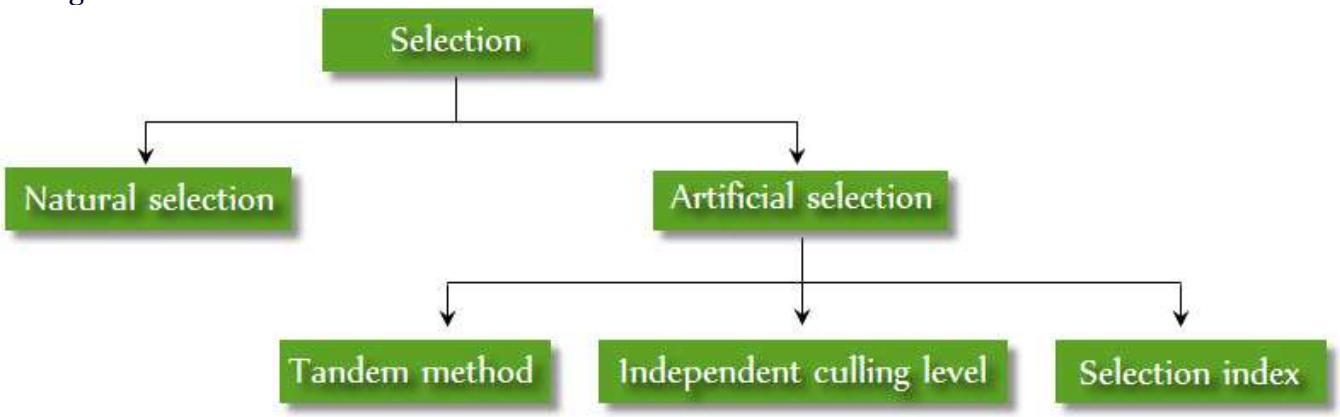
Length of time

- The turnover in livestock is slow in number of animals and in number of generations because small herds or flocks offer so little opportunity for genetic segregation. So the breeder must be prepared to continue his project for a relatively longer period of time. Progress in a single generation is apt to be masked by environmental effect and it takes many years to turn over several generations in large animals. Although progress per year is small, real improvement can be effected over a long period of time.

Dr. Dibyendu Chakraborty

CLASSIFICATION OF SELECTION

- Selection is of two kinds namely, natural and artificial selection. Again the artificial selection is divided into different methods, they are Tandem method, independent culling level and selection index or index selections.



NATURAL SELECTION

- The main force of natural selection is the survival of fittest in a particular environment. The survival is for the particular environment in which the population lives *e.g.*, wild animals. In nature, the animals best adapted to their environment survived and produced the largest number of offspring. This natural selection acts through the variations produced by mutations and recombination of genetic factors and eliminates unsuccessful genetic combination and allows nature's successful experiments to multiply.
- Natural selection is a very complicated process and many factors determine the proportion of individuals that will reproduce. Those factors are:
    - differences in mortality in the population especially early in life,
    - differences in the duration of sexual activity,
    - degree of sexual activity and
    - differences in the degree of fertility of individuals in that population. Natural selection operates through differences of fertility among the parents or of viability among the progeny. Therefore, in natural selection by means of survival of the fittest, there is a tendency towards elimination of the defective or detrimental genes that have arisen through mutation.

ARTIFICIAL SELECTION

It is the selection practised by man. This can also be defined as the efforts of man to increase the frequency of desirable genes or combination of genes in his herd or flock by locating or saving those individuals with superior performance or that have the ability to produce superior performing offspring when mated with individuals from other lines or breeds. This can be classified as:

- automatic selection,
- deliberate selection and

- replacement selection and culling. Replacement selection decides which animals will become parents for the first time *i.e.,* new animals to replace parents that have been culled. These new animals are called replacements.

CULLING

- Culling decides which parents will no longer remain parents. It is the removal of inferior animals rather than the more positive selection of good ones. While doing culling, decision should be firm that culling has been made for genetic or environmental reasons. It is easy to cull poor looking stock but genetically this achieves little if they are poor because of environmental reasons. Thus, selection and culling go together. The risks of this type of error are higher when animals examined after a period of high production such as lactation. *E.g*. In ewes, twin born will be thin and poor looking and barren ewes will be fatty. Similar observations can be seen in sows. Therefore, replacement selection and culling are really just different sides of the same coin. They involve different sets of animals, but their purposes are the same *i.e*., to determine which animals reproduce. Hence, both are integral parts of selection as a whole.

Individual selection

An animal may be selected for breeding based on the basis of its own performance one or more traits. This selection based on its own performance is called mass selection or individual selection. Here the selection is based on type (appearance) of the animal and its performance (production). This comparison of performance based on its own individual performance is called performance test. Selection based on individuality is strictly phenotypic and phenotype is taken as the sole estimate of the genotype.

It is the outward confirmation of individuals i.e. the relative proportion, length, breadth and size of different parts of the body that include colour, size and shape of horns, ears etc.

Selection depend on type is inevitable when

- Reliable records of production are not available.
- Selection is to be made early in life before the availability of production records in order to reduce the cost of culling.
- When records are available in only one sex as milk yield, males have to be selected only as type.
- When production records come after the death of the individual e.g. Meat animals.
- Where productivity is not easily and completely measured as in works and speed.
- When market demands a particular type that is more profitable.
- Where beauty is the main consideration as in pet and fancy stock.

PROBABLE BREEDING VALUE (PBV)

PBV of an individual for a particular trait may be determined by

$PBV = P_1 + b (P_i - P_1)$

Where,

P1 – phenotypic average of individual contemporaries

Pi - phenotypic value of individuals selected

b – regression coefficient

The PBV of an individual is the estimated genetic superiority of the individual over the average of the group from which it is selected. PBV is always near the group average than its phenotypic value because environmental effects which are not transmitted to the individual's offspring.

In individual selection, best animals are selected from within a group of animals of similar age group that have 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 breeding value (BV) for a given trait is calculated as:

BV = h^2 x (Individual average – Average of contemporaries)

= h^2 x Individual deviation

Hence selection based on individual selection is strictly phenotypic and the phenotype is taken as the sole estimate of individual's genotype and thus the PBV.

Advantages

- Used for traits of high heritability.
- Traits such as body type, growth rate, fleece production, horn pattern, colour 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.

Demerits

- Not useful for sex limited traits such as milk production, egg production, maternal abilities, semen production and litter size etc.
- If heritability is low, then 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 on the basis of 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.

BASES OF SELECTION

FAMILY SELECTION

- Family names are used in at least two senses in animal breeding. The family name has been traced through the dam and sires. Family, in animal breeding, includes full-sib and half-sib families. In a random mating population, half-sibs have a relationship coefficient of 0.25 and full-sibs have a relationship coefficient of 0.5. Such family members are collaterally related not directly related. They are neither ancestors nor descendants. Because of their common ancestry, they would have some genes in common and thereby some performance in common.
- If the records of the individual are included in the family average and used as a criterion for selection, it is known as family selection. If the individuals' records are not included in arriving at the average, then it is known as sib selection. When selection is carried out for market weight in swine, the market weights of all males and females in the family are considered in the calculation of family average (family selection). But when selection is carried out for fertility traits and milk yield, the performance of males cannot be included but they are selected on the basis of sibs' average (sib selection).
- The family selection can be represented as a part of pedigree selection. The families are ranked and based on this, the entire family is selected or rejected. Family/sib selection is used more frequently in swine and poultry where the number of progenies produced by females is high. The family selection does not increase generation interval. The information from family/sib is combined with individual information in the form of index and selection is based on the index.
- Collateral relatives are those not directly related to an individual as ancestors or progeny. The relatives are neither direct ancestors nor direct descendants of an individual. They may individual's brothers, sisters, cousins, uncles, aunts, nieces, nephews, etc. The more closely they are related to the individual in question, the more valuable information they can supply for selection purposes.
- If information on collateral relatives is complete, then it will give an idea of the kinds of genes and combination of genes the individual is likely to possess. It will be of much useful in selecting traits that can be measured only after the sacrifice of the individual e.g. carcass traits. Similarly it is also useful in selecting dairy bulls, since milk production can be measured only in cows though bull possesses and transmits genes for milk production to his progeny. It is also used in selection of poultry for egg and meat production and also for all or none traits such as mortality, disease resistance and fertility. Selection on the basis of sib tests (Half sibs or Full sibs) means that an individual id kept for breeding or is rejected on the basis of the phenotype of its brothers and sisters. They may be maternal half sibs or paternal half sibs or full sibs.

PROBABLE BREEDING VALUE

- The accuracy of selection on the basis of collateral relatives depends upon the degree of heritability, closeness of the relationship ® of the sibs and individual being selected,

number of sibs used to determine the sib average, degree of correlation (t) between the phenotypes of sibs.

$$\textbf{Accuracy of selection} = Rh \sqrt{n / 1 + (n-1)\, t}$$

- If environmental correlation among the phenotypes of the sibs are zero, then $t = Rh^2$
- The accuracy of selection increases as the records on a large number of half sibs are considered and as the heritability increases. The accuracy of selection never exceeds 0.5, regardless of the number of half-sibs tested and the degree of heritability of that trait.
- Nearly 30 half sibs are required to give the same accuracy as information on the individual's own record when heritability is as low as 0.10 and 100 or more when heritability is higher than 0.10. The addition of the record of another half sib is affected by the law of diminishing returns. However in instances where information cannot be obtained from the individual, such as sex limited traits can be used effectively in selection.
- Full sibs may be used in selection, but they have a similar maternal environment from conception to weaning lowers the accuracy of their use for such a trait. The selection on the basis of individuality is relatively more accurate than selection on the basis of full sib records when the trait is highly heritable. However, when heritability is low, and records on six or more full sibs are available then selection on the basis of full sibs is more accurate.
- The combination of records on the individual and its sibs for selection is more advantageous than records on the individual's own performance when R and t are greatly different. It is more useful when difference between families are mainly due to environment possibly because different families have been treated differently.

Families can be broadly classified into three types:

- Sire families: These are progeny of one sire.
  - Out of different dams – born in the same year (contemporaries)
  - Out of different dams – born over a number of years
- Dam families
  - By different sire – born in the same year i.e. by super ovulation before artificial insemination with mixed semen from number of sires and identification of sires by blood typing
  - By different sires – born over a number of years
- Sire and dam families: These are progeny by one sire out of one dam.
  - Family selection is more effective when the genetic relationship between members of the same family is large, and the phenotypic relationship between members is small. When heritability is low, the use of family data is most valuable as it reduces the chances of making wring decisions.

Indications

- For sex-limited traits,
- For carcass traits and
- For traits of low heritability.

Limitations

- If selection intensity is more, then there may be an increase in inbreeding and
- Increase in cost and space in raising larger population.

Precautions

- Number of progeny in each family should be large and
- There should not be common environment between sibs.

PEDIGREE SELECTION

SELECTION BASED ON PEDIGREE

- Pedigree is a record of an individual's ancestors related to it through its parents or selection 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 assessed based on milk yield of its mother until such time as the calf is grown up and can be milked. Much attention is to be paid to pedigree when no adequate information on the merit of the individual is available.
- It is usual to expect offspring of outstanding parents to be of higher genetic value than the average of the individuals of the herd. Each parent transmits only sample halves of its genes to each offspring and only one quarter of genes from each grand parent. So parents never provide as much information about the breeding value of an individual than individual's performance itself would provide. Unless the performance of ancestor is known, selection based on pedigree is meaningless. Even when the performance is known the relationship between the individual and ancestor is very important. Distant ancestors of an individual provide even less genetic information about the individual's breeding value especially for production traits. This pedigree can be classified into two as direct and collateral. Collateral means those descended from same ancestors.
- Selecting a cow based on the performance of its great grand parent is as good as random selection because the relationship is $(1/2)^3 = 1/8$ i.e. only $1/8^{th}$ of the superiority can be expected in the progenies. It will not do much good to go beyond three generations into pedigree due to halving process of the chromosomes in each generation.
- Pedigree selection can be made more useful by giving all information good and bad about ancestors, including the collateral relatives. Pedigree selection is particularly useful for initial selection for traits that are expressed in only one sex. Such selections can be made early and inexpensively. However the accuracy of ancestor's performance may not be highly reliable because they have been recorded under different environmental conditions. Rarely the pedigree records possess the presence of recessive genes or defective animals. So when the ancestors are relatives for traits that are linked with lethal genes then chances of getting offspring with such lethal defects is more and use of such animals should be avoided.
- For traits of high heritability little is gained from considering ancestors and the most progress could be made by evaluating the individual itself e.g. horned condition. The main danger in pedigree selection is that the harm done by lowering the intensity of individual selection is greater than the good made by making the selection more accurate. Hence 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. The average relationship between one parent and offspring is 0.5. Therefore when pedigree information on both the parents are available, that gives more reliable estimate of the genotype of the offspring. 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 ancestor could be expressed as a percentage of the average contemporaries (Trait ratio), the ancestor's records would be of greater predictive value.
    - Degree of relationship
        - If ancestors are more closely related to the individual (Parent – 0.5, grand parent – 0.25 and great grand parent – 0.125) should receive most emphasis in pedigree appraisal.
    - Degree of heritability
        - When heritability of the trait is low, the more remote ancestors should receive relatively more emphasis, but when it is high they provide almost no new information.
    - Environment correlation
        - Pedigree selection is accurate when heritability is high. The correlation between pedigree information and individual's breeding value approaches the theoretical 0.71 as heritability approaches 1.0.
    - How completely the merit of ancestors used in the prediction is known.

Dangers of pedigree selection

- Undue emphasis on remote relatives.
- Unwarranted favouritism toward the progeny of favoured individual.

ADVANTAGE AND DISADVANTAGES OF PEDIGREE SELECTION

Advantages

- Pedigrees do have the advantage that they are cheap to use.
- Used to select traits not expressed early in life or still immature and have not had their production records e.g. cancer, tumour, longevity etc.
- Used to select traits expressed in only one sex (sex limited) such as milk production, egg production, semen production, etc.,
- Useful when selection based on individuality is not accurate i.e. to supplement selection based on individuality.
- When production performances of the individuals are not available,
- For making preliminary selection of sires in progeny testing
- When the characters are expressed late in life
- For traits with low heritability pedigree information can be combined with individual's record.

Disadvantage

- A disadvantage of the use of the pedigree in selection against a recessive gene is that there are often unintentional and unknown mistakes in pedigrees that may result in condemnation of the entire family from breeding even when actually it may be free of such a defect.

LIMITATIONS OF PEDIGREE SELECTION

- Since phenotype is not surely the true indicator of genotype due to complications by dominance, epistasis and environment prediction of genotype is difficult. When the phenotypic value of an individual is known not much is gained by the use of pedigree,
- The sampling nature of inheritance, the genetic makeup of the parents cannot be known definitely of genes that are heterozygous makes it impossible what the individual offspring has got from its parents (Better half or poor half).
- Usually pedigree contains ancestors that are selected and hence contains only selected information to show them in a favourable light and tells very little about the collateral relatives.
- The pedigree records are made in different environment and hence the accuracy of the ancestry may not be reliable and
- Unwanted favouritism towards the progeny of the favoured individual.

An unusually good animal in poor parentage always suggest that it is the result of lucky combinations of genes each manifesting the desirable effects. Mostly the animals will be heterozygous for many genes and its regularity of inheritance is questionable due to sampling nature of inheritance. On the other hand a poor animal from good parentage does not have the good stock of genes. The offspring may not able to express itself fully probably due to lack of few genes necessary for a successful combination. Therefore, it will be able to inherit the good genes and most probably its mate will supplement the few genes it lacks. So it may be preferred to a good individual of poor parentage.

In nutshell, pedigree is a record of an individual's ancestors related to it through its parents. Knowledge of the productivity of the ancestors is necessary if pedigree is said to be useful. Such pedigrees are known as **performance pedigrees**. Ancestors more closely related to the individual should receive most emphasis in pedigree appraisal. The basis of pedigree selection is the fact that an individual gets half of its inheritance from each of the parents and it is usual to expect offspring of outstanding parents to be of higher genetic value than the average of the individual in the herd. Pedigree should be used only as additional information to individual selection.

SIB SELECTION AND PROGENY TESTING

SELECTION BASED ON PROGENY TESTING

- The idea of progeny testing is not new, having been advocated 2000 years ago by Roman Varro. Robert Bakewell is reported to have used in the eighteenth century by letting out bulls and rams on an annual basis. Then he could later use those which proved to be outstanding transmitters.
    - **Individuality** tells us what an animal **seems to be**,
    - his **pedigree** tells us what he **ought to be**,
    - but the performance of his **progeny** tells us what **he is**."

- This progeny testing is used to rate a sire or dam's breeding value. It attempts to evaluate the genotype of an individual on the basis of its progeny's performance.
- It is the best way of determining the genetic make up of an individual. Each parent contributes sample halves of genes to each offspring. Thus an effort to evaluate an individual (usually a male) on the basis of one or a few offspring can be misleading.
- Chance at segregation may result in any one or a few offspring receiving a better or poorer than average sample of genes from the parents. Progeny testing is a technique generally used for males because they are responsible for more progenies in their lifetime than any one female.
- Use of progeny test is not a very practical preposition to establish the breeding value of females, since the number of offspring per female is small. When the individual produces sufficiently large number of offspring, the individual has already completed its productive life and the need for selection will be already over.
- It is very important that all of the progeny and not just a selected sample of the progeny be included in the progeny test appraisal. Omitting the poor progeny is unfair and misleading because, similar poor progenies are just as likely to be produced among the next group of progeny.
- Progeny testing may be used in selection of traits expressed in both traits. When heritability is low, fewer progenies are required to make the progeny test.
- However the accuracy of progeny test is reduced when there is an environmental correlation among progenies due to non-genetic factors. This situation arises when several progeny tested sires are being compared, but their progeny had been tested at different locations.
- Feeding and management also influences the progeny group differences. These will reduce the accuracy of progeny testing. Progeny testing are conducted to compare the performance of progeny of two or more parents.
- Usually sires rather than dams are progeny tested because generally sires produce more progeny in a given season or year.

USE OF PROGENY TESTING

Use of progeny test depends upon

  - Accuracy of the test.
  - The number of sires to be tested during specified period of time.
- For greater accuracy greater numbers of offspring are needed. If more number of offspring has to be produced, then large numbers of females have to be mated, thereby reducing the number of bulls tested.
- Progeny testing is carried out based on the assumption that most of the inheritance in the livestock is due to additive genetic effects. If there are sizeable dominant and epistatic effects, then the following to be accounted i.e. whether the offspring's performance is due to additive genetic effects alone or is due to dominant and epistatic effects.
- If some offspring of a male mated to certain set of females, perform better than offspring of the same male mated to another set of females. Then a male and female that produce better averages in the offspring will be chosen to exploit dominant and epistatic effects over and above additive effects.
- In livestock breeding, progeny test based on more than five unselected offspring usually reduces the chances of error considerably. With traits having very low heritability, large number of offspring (10 or more) has to be used to get a reliable progeny test. The rapid acceptance of artificial insemination and the advancement of techniques for the freezing

and storage of bovine semen have greatly extended the use of outstanding progeny tested sires.

Points to be considered

- Test as many as sires possible (5 to 10 would be minimal)
- Make sure that dams are mated to sires at random, within age group is possible.
- Produce as many progeny 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.
- 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.

PRECAUTIONS FOR PROGENY TESTING

Precautions to be taken to make progeny tests more accurate

- Dams mated to all sires on a given progeny test should be selected randomly.
- Feed all animals the same ration and in same manner to avoid bias.
- Compare different parental groups raised in as nearly the same environment as possible.
- Compare the parent groups born during the same year or same season of the year when possible.
- Include all healthy progeny of a particular parent in the test, if possible whether they are inferior or superior. This tends to average the Mendelian and environmental errors for each sire group.
- Pens should be rotated among progeny groups to reduce the pen effects.
- Larger the number of progeny tested per parent, within limits, the more accurate the estimate of that parent's probable breeding value.
- Errors like effects of year, season and location should be eliminated as far as possible.

The accuracy of selection that is the correlation of the genotype of the parent with the average genotype of its progeny may be calculated as:

$$PBV = h / 2 \sqrt{n} / 1 + (n-1) t$$

Where,

h – square root of heritability

n – number of progeny per parent used in the average

t – ¼ h^2 if progeny group is composed of half sibs and there is no environmental correlations between sibs.

- Testing of progeny at several locations using artificial insemination and adoption of comparison of performance with contemporary animals can increase the accuracy.

Dr. Dibyendu Chakraborty

ADVANTAGE AND LIMITATIONS OF PROGENY TESTING

Advantages

- For selecting sex limited traits.
- For selecting traits require sacrifice of the animal (carcass traits)
- For selecting traits expressed late in life
- For traits having low heritability value.
- For selection of animals that nick or combine well.
- For testing animals for recessive traits.

Limitations

- More number of animals must be progeny tested.
- It prolongs the generation interval. Hence it is time consuming and expensive
- Use of superior animals extensively once they have been located and errors due to environment that are not standard for the progeny are more serious limitations.
- Sires can be selected only when the progenies come for production and by the time the sire may become old and useless. Therefore, the annual rate of genetic gain is lowered.
- Hence it is time consuming and expensive

In conclusion, Progeny testing is estimating the breeding value of a sire based on the average performance of its offspring. Each offspring receives a sample half of genes from the sire. Therefore, the performance of large number of daughters will indicate the breeding value of sire on progeny testing. Progeny testing is usually conducted for males as more number of progenies can be produced for males and also proven bulls can be extensively used for production of more number of progenies. The primary selection of the bulls is based on the sibs' average. The bulls with highest averages are selected and included in the progeny testing. Then the bulls are used on many females to produce many progenies. The performances of progenies are then studied to estimate the breeding value of each bull. It is the best way of determining the genetic makeup of an individual. The genetic principle behind progeny testing is that the more the number of progeny are tested the greater the accuracy of assessment of the parents, since the errors in sampling are reduced.