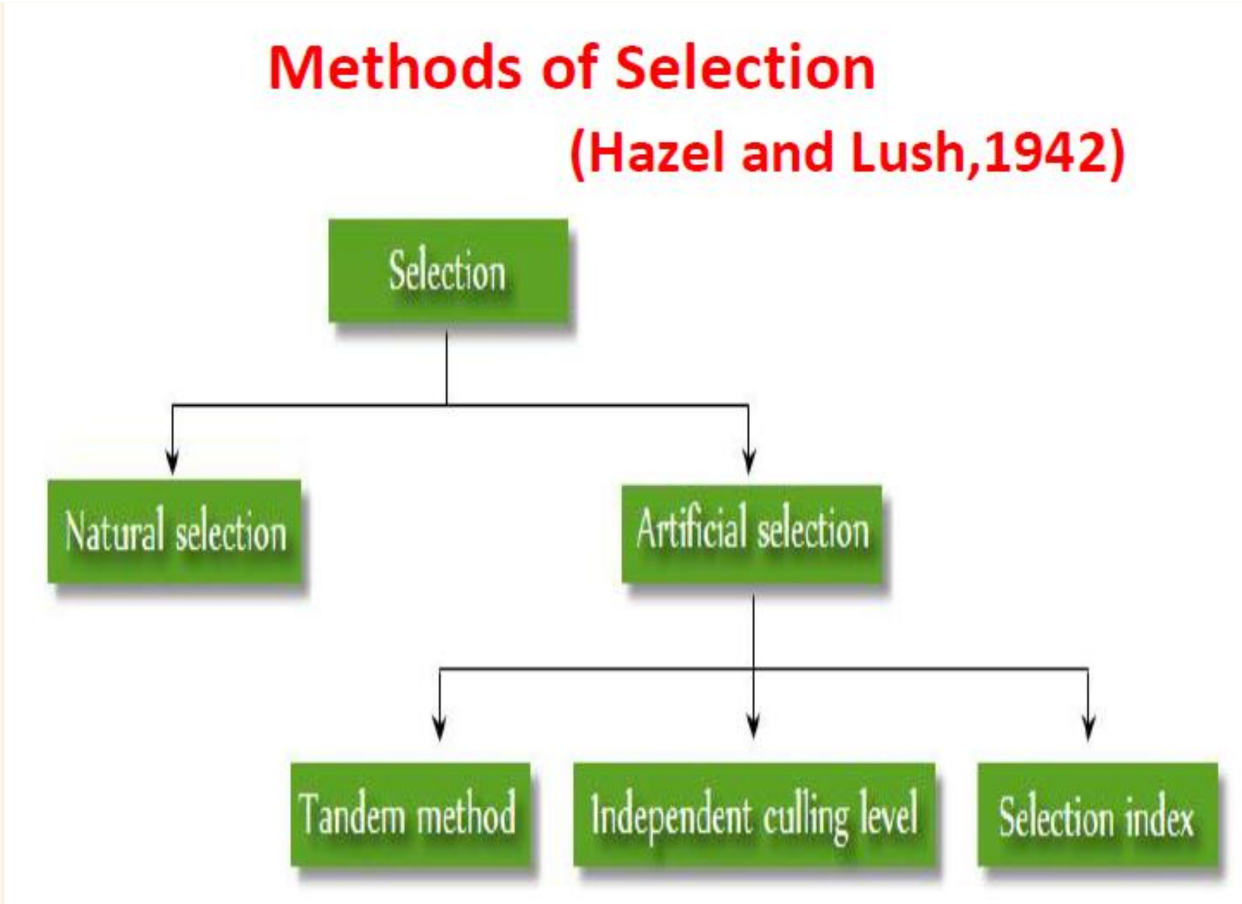


SELECTION

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:

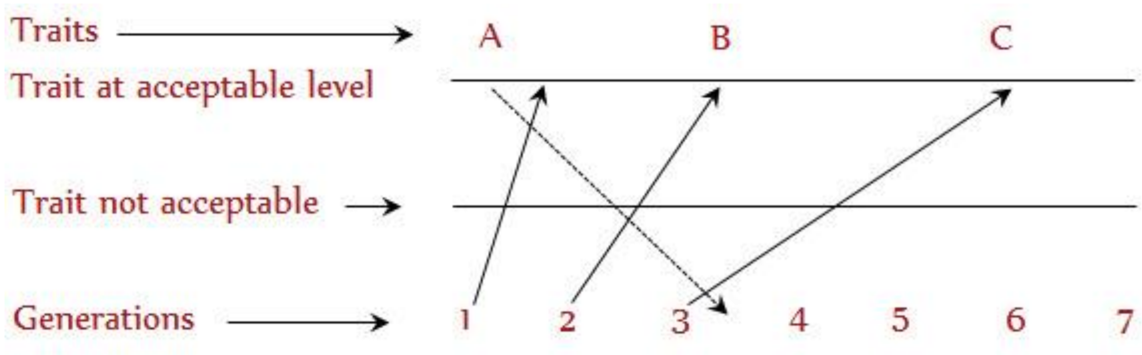
- automatic selection,
- deliberate selection and
- replacement selection and culling. Replacement selection decides which animals will become parents for the first time *i.e.*,new animals to replace parents that have been culled. These new animals are called replacements.

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.

1. TANDEM SELECTION METHOD

- Breeder selects and improves only one trait at a time until it reaches an acceptable level, and then he shift to another and so on for a third. The efficiency of this method is dependent on the genetic relationships among the traits. If the two traits are favourably or positively correlated, selection for the first trait will also automatically improve the other trait and vice versa.



- Here, the trait A was improved quickly in one generation, whereas B took more time (two generations) and C took very much longer (few generations). A remains stable when worked on B, and both A and B remained stable when worked on C. Therefore the traits are assumed to be independent. On the other hand if they are not independent, then the situation could be seen by the dotted lines A' whereas B went up, A came down i.e. **See-saw effect** caused by a genetic antagonism between them. The efficiency depends on genetic correlation between traits.
- It is easy and simplest method. It is practiced on the basis of single character expressed phenotypically at a time. This is a highly inefficient method as unless the traits selected are genetically positively related. If they are not genetically related, whatever achievement is made in the first trait is lost when attention is directed to another trait. Therefore, the rate of net improvement becomes very small. Since a very long period is involved in the selection practiced, the breeder might change his goals too often or become discouraged and not practice selection effectively.

- In general, the efficiency of this method is very low. If there is a positive correlation, then the results may be desirable in the other trait also. If there is a negative correlation, the efforts will be undesirable. Since very long time would be involved in selection practice, the breeder may change one goal to another and discourage one trait.
- **A selection method to select for one trait until the trait is at a satisfactory achievement.**
- **The efficiency of this method depends a great deal upon the genetic correlation between the traits selected so for.**
- **If the genetic correlation is positive the one trait may also improve another.**
- **Disadvantages are it takes time and effort and it the least efficient method.**

2. INDEPENDENT CULLING LEVELS

- **Method of selecting two or more traits but they both need to meet a minimum standard. It is very strict if the animal didn't meet one trait it would be rejected.**
- In this method, selection may be practiced for two or more traits at a time. But for each trait, a minimum standard (culling level) is set, so that every animal must meet the minimum standards to be selected for the breeding purposes. The failure to meet the minimum standard for any one trait makes the animal to be rejected. Therefore, in actual practice, it is possible to cull some genetically very superior animal when this method is used. The properties selected for each trait will depend up on the total number of animals screened for the breeding.
- This method reduces selection intensity of the traits to be selected. The negative correlation among the traits will make the further reduction in selection intensity. Selection based on independent culling method is easy to perform but becomes complicated when more traits are considered and if there is negative correlation between traits. Therefore, only few important traits should be considered in this method.

Independent culling levels

Traits	Standard set	Cows Number	
		Cow 1	Cow 2
AFC (months)	40	**38**	**41**
Milk Yield (Kg)	1900	**1960**	2325
Fat (%)	4.60	**4.97**	**4.50**

On the basis of standard set in above, Cow1 will be selected in spite of low milk yield. Cow2 will be culled as it does not meet out all the standard set by breeder.

3. SELECTION INDEX OR INDEX SELECTION OR TOTAL SCORE METHOD

The first application of the selection index to plant breeding was by Smith (1936) using the Discriminant Function of Fisher (1936), and the first to animals by Hazel (1943).

Selection index is also known as Discriminant function, since it is in discriminating individuals with high and low scores.

- In this method, selection is made for all the traits simultaneously by using some kind of a total score or index of the net merit of an individual constructed by combining together the scores for each component character.
- It is the most effective method of selection. Selection index is a single numerical value within the total scores given for each trait considered in the selection. Each trait is weighted, by giving score and an individual trait score is summed up to the total score for the each animal within the selection criteria. The individual specification for a number of traits can vary greatly and is combined into one value for the animal called a **Total score or an Index.** The high merit in one trait can certainly be used to compensate the deficiencies in other traits. An index is simply a means of putting a whole lot of different information into one value. The information and the score should be fixed based on:-
  - Variation seen in each trait – the phenotypic standard deviation
  - Heritability of the traits
  - Phenotypic and genetic relationships (correlation) between the traits

- Relative economic value of the traits

- The aim in computing an index is to derive an estimate in which the various traits are approximately weighted to give the best prediction of the animal's breeding value i.e. what it will produce when the animal breeds. An advantage of this index is suppose if one component is missing then benefit can be obtained by predicting the missing one from the others that are present.
- Index selection is predicted to be be $\sqrt{n}$ times as efficient as independent culling levels where **n** is the number of traits involved. The greater the number of traits involved, the index becomes more reliable than the independent culling method.
- In dairy cattle, milk production is the most important economic trait, whereas the reproductive efficiency that is also important may not be as important in magnitude as milk production. Hence, higher economic value should be given to milk production and correspondingly lower economic value to the reproductive efficiency.

$$I = b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots.. + b_nX_n$$

Where,

I – Index value or genetic prediction

n – Number of traits of information

b_1 to b_n – coefficients obtained based on the relative importance of heritability of each trait and genetic relationships of the traits concerned.

X_1 to X_n – Measurement of each of the traits incorporated (phenotypic values)

- The animals are arranged based on index values and those with the highest scores are kept for breeding purposes and the animals with lower index values are eliminated from the breeding population. The net value of an animal is dependent upon several traits that may not be of equal economic value or that may be independent of each other. Hence, it is necessary to select more than one trait at a time. The desired traits will depend upon their economic value.
- This method of selection leads to most efficient improvement in livestock breeding. Selection indices are constructed with a view to making maximum

improvement in the total performance. All the characters selected are combined into one figure.

- Index selection has been more widely used with sheep and swine than in beef and dairy cattle. Large volume of accurate data of population is necessary to provide information to compute the selection index. Indices computed from inadequate or erroneous information can be ineffective in selection. A trait that is highly heritable can be given adequate weightage than one with low heritability.
- In conclusion, the selection index is a total score that includes all the advantages and disadvantages of an animal for those traits considered for selection. The amount of weightage given to each trait depends on their relative economic value, heritability of the character and genetic correlation between characters. A trait, which is highly heritable, can be given greater score than a trait, which has a low heritability. The selection index method is the most efficient (best method) among the three (Tandem, Independent culling and Selection Index) methods because it results in better genetic improvement. The index is the best estimate of an animal's breeding value. The only disadvantage is that the traits vary in importance from time to time and the index built at one time will not be applicable for all times. Hence, it has to be constructed and modified from time to time.

INFORMATION REQUIRED FOR CONSTRUCTION OF SELECTION INDEX ARE:

i. Genetic and phenotypic variances for each trait (or heritability of each traits)

$V_A = 4\ \sigma^2_{s}$, $V_P = \sigma^2_{s} + \sigma^2_{d} + \sigma^2_{w}$

ii. Genetic and phenotypic co-variances between each trait (or genetic and phenotypic correlations among each traits)

$Cov_A = 4\ CovS_{(xy)}$

$Cov_P = CovS_{(xy)} + CovD_{(xy)} + CovW_{(xy)}$

iii. Relative economic value of the traits.

$a_1, a_2, a_3, \ldots\ldots\ldots, a_k$

Genetic basis of selection Index

- The overall net genetic improvement (H) for several traits should be the sum of the genetic gain made for several traits. ($H=\sum G_i$)

$$H=a_1G_1+a_2G_2+a_3G_3 \ldots\ldots\ldots +a_nG_n$$

$=\sum a_iG_i$=genetic worth of animal=aggregate genotypic value

Where, a_i—relative economic values

G_i---expected values of Xi due to additive gene effects

Since Gi's are unknown, H can not be used as a criterion of selection. Under the circumferences selection has to be based on some function of the observed values of the various characters. Clearly, it is the simplest to have the linear function I given by-

$$I=b_1X_1+b_2X_2+b_3X_3+\ldots\ldots\ldots+b_nX_n$$

rHI—max (bi)

Method 1. Construction of Selection Index by using Matrix

- **Calculation of economic weights:** The procedure is based on the actual phenotypic standard deviation of each traits. Primary trait is given unit weight i.e. 1.0 and for economic weight secondary traits is calculated by using formula:

$$\text{Economic Weight for Secondary traits} = \frac{\sigma_P(\text{primary trait})}{\sigma_P(\text{secondary trait})}$$

- **Calculation of Unknown vectors of weight (i.e., b values..)**
  - Write equation in matrix form
  - Replace values in above matrix
  - P-matrix is transferred to right
- **Calculate determinant of P-matrix**
- **Obtain adjoint of P-matrix**

  Cofactors ……..Transpose it
- **Get inverse of P-matrix**
- **Multiplication of matrix …..**

Index value of animal: $I = b_1X_1 + b_2X_2$

For example if one considers two traits, two simultaneous equations will be as follows:

$$V_P(x_1)\, b_1 + Cov_P(x_1x_2)\, b_2 = V_G(x_1)\, a_1 + Cov_G(x_1x_2)\, a_2 \text{ ---------(I)}$$

$$Cov_P(x_2x_1) b_1 + V_P(x_2)\, b_2 = Cov_G(x_2x_1)\, a_1 + V_G(x_1)\, a_2 \text{ ---------------(II)}$$

In matrix form the above equation can be written as:

$$\begin{pmatrix} P11 & P12 \\ P21 & P22 \end{pmatrix} \begin{pmatrix} b1 \\ b2 \end{pmatrix} \qquad \begin{pmatrix} G11 & G12 \\ G21 & G22 \end{pmatrix} \begin{pmatrix} a1 \\ a2 \end{pmatrix}$$

$$[P] \qquad [b] \qquad [G] \qquad [a]$$

- Phenotypic variances: $V_P(x_1)=\sigma^2_s+\sigma^2_e=\sigma^2_{P;}$ $V_P(x_2)=\sigma^2_s+\sigma^2_e=\sigma^2_P$
- Phenotypic covariance's: $Cov_P(x_1x_2) = Cov_P(x_2x_1)= Cov_s+ Cov_e= Cov_P$
- Genotypic variances: $V_G(x_1)= \sigma^2_s$, $V_G(x_2)= \sigma^2_s$
- Genotypic covariance's: $Cov_G(x_1x_2) = Cov_G(x_2x_1)= Cov_S$
- Relative economic weights: a_1, a_2
- Partial regression coefficients: b_1, b_2

Method 2. Construction of Selection Index by algebraic equations

- Set up normal simultaneous equations to obtain partial regression coefficients (b) to get the index. For example, if two traits are considered for selection,

  $I = b_1X_1 + b_2X_2$

  where,

  X_1 and X_2 are phenotypic values of the traits

  b_1 and b_2 are the regression coefficient for each trait

The normal simultaneous equation for two traits is,

$$V_{P\,(X1)}\, b_1 + Cov_{P\,(X1X2)}\, b_2 = V_{A\,(X1)}\, a_1 + Cov_{A\,(X1X2)}\, a_2 \qquad \text{- Equation (I)}$$

$$Cov_{P\,(X2X1)}\, b_1 + V_{P(X2)}\, b_2 = Cov_{A\,(X2X1)}\, a_1 + V_{A(X2)}\, a_2 \qquad \text{- Equation (II)}$$

where,

$V_{P(Xi)}$ = phenotypic variance of i^{th} trait

$V_{A(Xi)}$ = additive variance of i^{th} trait

$Cov_{P(XiXj)}$ = phenotypic covariance of i^{th} and j^{th} traits

$Cov_{A(XiXj)}$ = additive covariance of i^{th} and j^{th} traits

a_i = economic value for i^{th} trait

b_i = partial regression coefficient for i^{th} trait

- **Multiply the genetic parameters with their corresponding "a_s" and add.**
- **Divide equation (I) by $Cov_{P(X1X2)}$ and obtain equation (III).**
- **Divide equation (II) by $V_{P(X2)}$ and obtain equation (IV).**
- **Subtract equation (III) from equation (IV) to get equation (V).**
- **Solve for b_1.**
- **Substitute b_1 in equation (III) and (IV) and solve for b_2.**
- **Construct the selection index $I = b_1X_1 + b_2X_2$**

EXAMPLE

Two traits in swine, *viz*., feed conversion and eye muscle area are considered for selection.

Economic weights: **a_1= -50 and a_2= 12**

Biological parameters: Feed conversion (X_1): $V_{A(X1)}$ = 0.03125, $V_{P(X1)}$ = 0.06250

Eye muscle area (X_2): $V_{A(X2)}$ = 4.05, $V_{P(X2)}$ = 9.0

Covariance (X_1X_2): $Cov_{A\ (X1X2)}$ = -0.1125, $Cov_{P\ (X1X2)}$ = -0.4810

Normal simultaneous equations:

Equation (I): $(0.0625)\ b_1 + (-0.481)\ b_2 = (0.03125)\ (-50) + (-0.1125)\ (12)$

Equation (II): $(-0.481)\ b_1 + (9.0)\ b_2 = (-0.1125)\ (-50) + (4.05)\ (12)$

On multiplication:

Equation (I): $0.0625\ b_1 - 0.481\ b_2 = -2.9125$

Equation (II): $-0.481\ b_1 + 9.0\ b_2 = 54.225000$

Divide Equation (I) by (-0.481) to get Equation (III): $-0.129938\ b_1 = 6.5055093$

Divide Equation (II) by (9.0) to get Equation (IV): $-0.053444\ b1 + 0\ b_2 = 6.025000$

Subtract Equation (III) from Equation (IV) to get Equation (V): $-0.076494\ b_1 = 0.030093$

Use equation (V) to Solve for b_1: we get $b_1 = -0.393403$

Substitute b_1 in Equation (III) or (IV) and solve for b2:

$(-0.053444)\ (-0.393403) + b_2 = 6.025000$

Therefore, $b_2 = 6.003974$

Construct selection index

$$\mathbf{I = -0.393403\ X_1 + 6.003974\ X_2}$$

Simplify $\mathbf{I = -X_1 + 15.261240\ X_2}$