1.2 : Methods of Studying natural selection and Models of selection

SELECTION

- **SELECTION:**

Selection or natural selection is a process whereby one phenotype and therefore one genotype leaves relatively more offsprings than another genotype measured by both reproduction and survival. Selection is thus a matter of reproductive success. It includes three parameters—survival rate, relative fitness and selection coefficient.

- **RELATIVE FITNESS:**

It is a measure of reproductive success of a genotype. Fitness of an organism is a measure of its ability to pass its genes to the next generation. It is expressed as relative parameter, usually defined as **relative fitness** and abbreviated '**w**'.

$$\mathbf{w} = \frac{\text{Reproductive success of individual genotype}}{\text{Reproductive success of best genotype}}$$

- **SELECTION COEFFICIENT(s):**

It is a force or factor acting on each genotype to reduce its relative fitness. This force or factor is called selection coefficient. It is usually represented by '**s**'.

$$w = 1 - s$$

Thus, as the selection coefficient increases, fitness decreases.

- **STABILIZING SELECTION (CENTRIPETAL SELECTION):**

It is the action of natural selection in keeping a population constant. Here phenotypic features coincide with optimal environmental condition and competition is not severe.

Features:

(i) It operates in constant environment.

(ii) It favours average or intermediate values.

(iii) It checks accumulation of mutation in the gene pool.

(iv) It tends to arrest variance and evolutionary changes, but maintains adaptiveness.

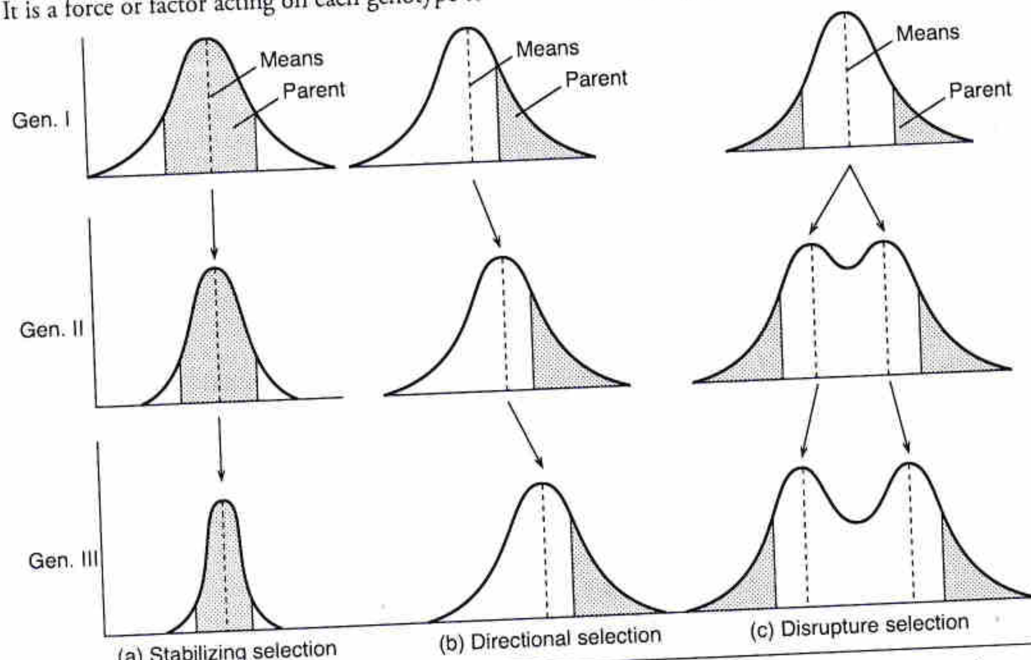

Fig. 18.1: Three basic modes of selection and their effects on the mean (dashed lines) and variation of a normally distributed quantitative character. The horizontal axis of each bell-shaped curve represents measurements of a quantitative character (e.g., from low on the left end to high on the right end), and the vertical axis represents the number of individuals found at each measurement (frequency). Shaded areas represent the individuals chosen to be parents of the next generation.

Example: Birth weight of newborns provide a good example of stabilizing selection. The optimum birth weight is 7.3 pounds and newborn infants less than 5.5 pounds have highest probability of mortality. The optimum is associated with lowest mortality.

- **DIRECTIONAL SELECTION:**

This form of selection operates in response to gradual changes in environmental condition. Here the selective force changes the frequency of alleles in a given direction either towards fixation or towards elimination.

Features:

(i) Directional selection operates when environment is changing in one direction.

(ii) It favours non-average or specialised phenotypes and eliminates the normal or average individuals.

(iii) It favours accumulation of those mutations that increase fitness of the population in the changing environment.

(iv) It brings about progressive evolution.

Example: (a) Industrial melanism, (b) Insecticides (DDT or other) resistance in mosquito.

- **DISRUPTIVE SELECTION (CENTRIFUGAL SELECTION):**

Selection that tends to favour the survival of organisms in a population that are at opposite phenotype extremes for a particular character and eliminates individual with intermediate values.

Features:

(i) It operates in heterogenous environment.

(ii) It pushes the phenotype within a population away from the mean and favour the values of the extreme.

(iii) It splits homogenous population into two or more adaptive forms.

(iv) It occurs when population is subjected to divergent selection pressure.

Example:

(a) On the basis of bristle number of *Drosophila*. When individuals with highest and lowest bristle number were selected, the population showed a non-overlapping divergence in only 12 generation.

(b) British lands nail (*Cepaea nemoralis*)

(i) They are found in grass field and forest. Predator bird (song bird) in low vegetation dark shell without light coloured bad snail are preyed by bird (thrushes) and in forest dark shelled light coloured snails are eaten up.

(ii) The populations as is divided into light coloured light bands in grassland and dark snails without band in forest.

- **CYCLIC SELECTION:**

Stabilizing and directional selection is constant, when selective environment is stable.

When environment is not stable between seasons or generations the optimum phenotype and also optimum genotype may show fluctuation because of the selection operating in one direction and in opposite direction for the next. This type of selection is called cyclic selection.

Features:

(i) It occurs when selective environment is unstable.

(ii) It helps in maintaining genetic differences in a population and fixes all the alleles of the gene pool.

- **COMPONENTS OF SELECTION:**

(1) Gametic selection, (2) Zygotic selection, (3) Sexual selection, (4) Fecundity selection.

- **GENERAL METHOD OF DETERMINING CHANGE IN ALLELIC FREQUENCY DUE TO NATURAL SELECTION:**

Solution:

Let there are two alleles viz. (A) and (a) for a gene in population. (A) is dominant over (a); p is the initial gene frequency of dominant allele (A) and q is the initial gene frequency of recessive allele (a).

If the population is at equilibrium, the gene frequencies will remain unaltered, but if the population exhibit differential reproduction due to selection against recessive allele (a), the selection coefficient(s) represent(s) the force of natural selection operating against recessive alleles. It means that genotypes AA and Aa produce cent percent (1) offsprings and aa produces 1–s.

The genetic contribution from them will be

$AA = p^2 \times 1$ $Aa = 2pq \times 1$ $aa = q^2(1-s)$.

Allele frequency changes after one generation of selection against recessive homozygotes.

	Genotypes			
	A_1A_1	A_1A_2	A_2A_2	Total
1. Initial genotypic (zygote) frequency	p^2	$2pq$	q^2	1
2. Fitness (w)	1	1	$1-s$	
3. Frequency after selection	$p^2 \cdot 1$	$2pq \cdot 1$	$(1-s)q^2$	$1-sq^2$
4. Relative genotypic frequency after selection	$\frac{p^2}{1-sq^2}$	$\frac{2pq}{1-sq^2}$	$\frac{(1-s)q^2}{1-sq^2}$	

Allelic frequency after selection:

$$p^1 = p + \frac{1}{2}2pq = \frac{p^2}{1-sq^2} + \frac{1}{2} \times \frac{2pq}{1-sq^2} = \frac{p^2+pq}{1-sq^2} = \frac{p(p+q)}{1-sq^2}$$

$$q^1 = \frac{(1-s)q^2}{1-sq^2} + \frac{1}{2} = \frac{2pq}{1-sq^2} = \frac{(1-s)q^2+pq}{1-sq^2} = \frac{q^2-sq^2+pq}{1-sq^2} = \frac{q(q-sq+p)}{1-sq^2} = \frac{q\{(p+q)-sq\}}{1-sq^2} = \frac{q(1-sq)}{1-sq^2}$$

Change in allelic frequency due to selection, i.e.

$$\Delta q = q^1 - q = \frac{q(1-sq)}{1-sq^2} - q = \frac{q(1-sq)-q(1-sq^2)}{1-sq^2} = \frac{q-sq^2-q+sq^3}{1-sq^2} = \frac{sq^2(q-1)}{1-sq^2} = \frac{-sq^2(1-q)}{1-sq^2}$$

As $p = 1 - q$, so $\Delta q = -\frac{sq^2 \cdot p}{1-sq^2}$

(when $\Delta q = 0$, no further change occurs in allelic frequencies).

There is negative sign in the equation to the left side of $\frac{sq^2 \cdot p}{1-sq^2}$, because the values of s, p and q are always positive or zero, Δq is negative or zero. Thus, the values of q will decrease with selection.

- **Genetic load:**
  (i) A reduction in the average fitness of individuals in population is due to the deleterious genes or gene combinations in the population.
  (ii) It has many forms such as "mutational load", "segregational load" and "recombinational load".
- **Genetic polymorphism:**
  (i) The stable coexistence of two or more discontinuous genotypes in a population over a succession of generation.
  (ii) When the frequencies of two alleles are carried to an equilibrium, the condition is called balanced polymorphism.
- **Genetic identity (I)** $= \frac{\text{Arithmetic mean of the products of allele frequency}}{\text{Reproductive success of best genotype}}$
- **Genetic distance:** It is a quantitative measure of divergence between the phenetic appearance of two populations (or species) based on their difference in gene frequencies.
  Nei's D index = –In I = –In 0.9899 = 0.0101.
  (Nei's D index is that the rate of evolutionary change is equal for all loci being evaluated.)