B. Sc. Part III Paper VII

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Isolating mechanisms and their role in evolution

Pg-1

Mechanisms that prevent successful reproduction between members of two or more populations i.e. closely related species, that have descended from the same original populations are called Isolating mechanisms. This is also an important pre-requisite of speciation. The role of Isolating mechanism in speciation was first of all recognised by the post-Darwinian evolutionist, Dobzhansky, in 1937.

Types of Isolation or Isolating mechanisms —

Mayr (1970) and Stebbins (1971), have classified the reproductive Isolating mechanisms into two classes namely premating or prezygotic Isolating mechanisms and postmating or postzygotic isolating mechanisms.

I Premating or prezygotic Isolating mechanisms — It prevents wastage of gametes and so are highly susceptible to improvement by natural selection. It prevents interspecific crosses like fertilization and zygote formation. It is again of four types —

1. Habitate Isolation : In such kind of Isolation same region, but populations live in the so that potential mates do not occupy different habitats,

2. Seasonal or Temporal Isolation - The populations same region, but are sexually mature at different times, so that potential mates remain unable to mate.

3. Ethological Isolation - These populations are isolated by different and incompatible behaviour before mating so that only potential mate occurs.

4. Mechanical Isolation - Cross fertilization or pollination is prevented or restricted by differences in structure of reproductive organs, so that, copulation is attempted but no transfer of sperms take place.

II Post-mating Isolating mechanisms - Fertilization takes place and hybrid zygote are formed, but these are inviable, or give rise to weak or sterile hybrids.

1. Gametic mortality - sperm transfer takes place but egg is not fertilized.

2. Zygotic mortality - Egg is fertilized but zygote dies.

3. Hybrid Inviability — Zygote produces an

F_1 hybrid of reduced viability.

4. Developmental hybrid sterility — Hybrids are sterile because of abnormal aggregation to the genetic of whole chromosomes or combination of genes.

5. Segregational hybrid sterility — Hybrids are sterile as gonads develop abnormally or meiosis breaks down before it is completed.

6. F_2 breakdown - F_1 hybrids are normal, vigorous and fertile, but F_2 contains many weak or sterile individuals.

It is further recognized that for these reproductive Isolating mechanism to evolve, the separated populations of an original single group must be seperated spatially or geographically or by time. Hence, three types of Isolation has been reported —

A. Isolation by time :- The palaeontological history of animals and plant suggest that the population at one time is always the descendant of the one living earlier. In case of straight evolution one species simply get transformed gradually into a new species through accumulating genetic differences. If the

changes are great enough then a new species evolves. e.g. evolution of Horse. According to G.G. Simpson horse evolved some 16 million years ago in Eocene. It underwent successive changes produced by thousands of favourable mutations of every gene involved in the evolutionary trend of each characteristic.

2. Isolation by Distance - Sheer distance also acts as an isolating factor for a species which occupies a great range of area, which is unbroken by effective barriers. e.g. Wrens (birds) of South America. Wrens are found all over the continent but the wrens of one region differ from those of the other in colour changes, size, proportion and habits. Thus, only sheer distance can produce local races (subspecies).

3. Geographical Isolation - It is most common type of Isolation and occurs when an original population is divided into two or more groups by geographical barriers such as a river, desert, glacier, mountain or ocean, all of which prevent interbreeding between them, thus in the course of time, different mutations become incorporated in the gene

pods of the different groups. These differences are of such a great to nature that they dont interbreed, thus species have been formed by geographical Isolation. The e.g. Darwin's finches. Darwin found that there were 26 groups of finches among the Galapagos Islands. Only five of these groups are same as the finches found on the mainland. The other twenty-one were types peculiar to the groups of islands. Some of twenty one groups interbreed quite freely, while other didnot. Apparently, each of these groups become isolated by migration. Another example is provided by elephant seals. The Southern elephant seal, Mirounga leonina, occurs in the cool waters of the Southern hemisphere around Antarctica, coasts of South America, South Africa. A closely, the northern elephant seal, Mirounga angustirostris, is found in cool waters along the coast of Western North America. However, the breeding populations of the two forms are separated by 3000 miles. Thus, these forms occupy discrete geographic or ecologic ranges separated by spatial barriers, are called Allopatric populations. And such kind of Isolation is Allopatric Isolation and these species are called Allopatric Species.

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Isolation & Isolating Mechanisms (Contd.)

(Part-2)

II Prezygotic or Premating Isolating mechanisms :-

Premating or prezygotic Isolating mechanisms those that prevent contact between the species when they are reproductively active or which prevent or restrict the union of gametes after mating or cross-pollination has occurred. It may be caused by following reasons —

(i) Habitat Isolation — Often two closely related species will occupy different ecological Conditions. Since in different territory, but no within the same territory, but no hybrid between them will be found. However, members of the representative species are taken into the laboratory, hybrids between them can be obtained. Thus, their respective gene pools are isolated physically, but not physiologically. This kind of isolation is most common in plants because of their sedentary nature. In them it operates in two ways — The species may live in the same general area, but have such different habitats that their populations are rarely close enough together to cross fertilize each other frequently. If hybrids are occasionally formed, they are not viable. This type of Habitat Isolation is

Sympatric Isolation and this phenomena is called Sympatry. Thus Sympatry is the phenomena of occurrence of two or more population in the same area more precisely, the existence of a population is in breeding condition with the cruising range of individuals. Such populations which are related and share a portion of their ecologic range but remain isolated from one another not by space but through the physiologic expression of genetic difference, are called Sympatric populations or Species. This is most frequent in rivers, river fishes and certain water snakes. American plant species of Scarlet Oak and black Oak are Sympatric species.

(ii) Seasonal Isolation → Two groups may exist in exactly the same ecological area, but almost disturbed because they became sexually mature at different time of the year or under different conditions. Further, seasonal barriers are particularly frequent among aquatic animals because water temperatures are more stable than air temperatures and embryonic development is more closely

harmonised to definite temperature. These two factors combined and permit a close regulation of the breeding seasons. It is common in plants and occurs frequently among insects and other invertebrates and some vertebrates. In animals, it is the time or condition for mating, which varies and prevent interbreeding. e.g. In North eastern United states, three species of frog, Rana pipiens, R. sylvatica and R. clamitans, all mate in the same pond, but at different times. R. sylvatica begins breeding when the water is 44° F and, while R. pipiens breed at 55°c. R. clamitans breed at temperature of at least 60°F.

3) Ethological or Behavioural Isolation → It refers for those behaviour patterns which prevent mating due to incompatibilities in behaviours. Ethological isolating mechanisms are barriers to mating due to incompatibilities in behaviour. It is based on the production and reception of stimuli by the sex partners. The male of every species have specific courtship behaviour and females of the same species are receptive. Courtship involves an exchange of stimuli, between male and female with a state of physiological readiness in which successful copulation can occur. This species

specific stimuli which help the sexes for the simultaneous recognition of each other for courtship forms the ethological isolation. For example, birds and insects embark on mating after highly standardized ritual dances. In some species of birds, plumage of the male stimulates the female sexual interest. Thus, the different colour patterns of insects, different colour patterns of plumage of birds, light signals sent out by male fire flies (beetles of family Lampyridae)

4 Mechanical Isolation - Mechanical Isolation is provided due to differences in the structure of flower of flowering plants or in the genital organs of different species in animals. So that cross-pollination or copulation doesn't occur. Dufour (1844) asserted that these genital armatures like act like lock and key, preventing hybridization between individuals of different species. According to Mayr (1970), the genitalic apparatus of animal is a highly complicated structure and is the pleiotropic byeproduct of very many genes of the species.

B Postmating or Postzygotic Isolating mechanisms — These mechanisms prevent the growth of hybrid individuals after fertilization has occurred or which reduce

the fertility of F_1 hybrids or the viability of their descendents. They are caused by following methods —

1. Gametic Mortality - The male gamete i.e. sperm can tolerate only narrow ranges of physiological conditions (pH, temperature etc.) and these conditions are not in female of same species. Deviation from any of these physiological compatibility would prove lethal to sperm and if few would survive, the offsprings produced will not survive.

2. Zygotic Mortality - The development of the fertilized hybrid egg is often irregular and development may cease at any stage between fertilization and adult level, zygotic mortality can be caused due to cyto-logical, genetical, embryological, molecular biological and physiological reasons in most animals. For example, certain hybrid zygotes of Amblystoma lack nucleolus, but they die without undergoing cleavage.

3. Hybrid Inviability - Many naturally occurring animal hybrids, though have somatic hybrid vigour and fertility, but leave no offspring.

the reason for reproductive failure of fully fertile species hybrids is perhaps that they are less well adjusted to available ecological niches than individuals of the parental species. Thus ecological and ethological inferiority, reduces their chances of leaving offsprings.

4) Developmental hybrid sterility — This type of hybrid sterility involves the abnormal development of gonads or abnormal micro or abnormality in gamete formation. For example, viable F_2 hybrids between different species of Drosophila and flies, abnormality occurs due to poor growth and a low rate of mitosis in the cells of seminiferous tubules. Further, developmental abnormality also occurs at the time of meiosis of spermatocyte.

5) F_2 break down → In this case, hybrids produced are either weak, abnormal or of sterile progeny in the second (F_2) generation. This phenomenon is called hybrid breakdown. example - F_2 hybrids of Grossypium arboreum X G. herbaceum.

Role of Isolating Mechanisms

- One of the most important role of I.Ms. is to increase the efficiency of mating, when other closely related species can not mate due to non-specificity of mating signals. Under these circumstances there will be a selective premium on precision and distinctiveness of signals. This is exemplified by Parus bird of Tenerife island and Regulo song bird of Azores.
- Moreover, each species is a delicately integrated genetic system that has been selected through many generations to fit into a definite niche in its environment. Hybridization breaks this system. It is the function of I.Ms. to prevent such a breakdown and to protect the integrity of the genetic system of species.
- Any attribute of a species that would favour the production of inferior hybrids is selected against, since it results in the wastage of gametes. Such selection by I.Ms. maintains the efficiency and serve as one of the most important biological tool in evolution.

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