2. The Zone of Intolerance : When the intensity of an environmental factor is either too low or too high, organisms cannot survive. This high or low intensity of an environmental factor is called the ***zone of intolerance.***

The Salient Features of the Law of Tolerance

1. Each factor has a range of intensity at which the organism survive well. This is called ***tolerance***.

2. Species vary in their limits of tolerance of the same factor. For example, the salmon can survive well at high salinities (seawater) and low salinities (freshwater). But when other marine fishes are placed in freshwater, they die.

3. The same species varies in its limits of tolerance of different factors. For example, certain freshwater fishes cannot tolerate major changes in salinity, but they can tolerate any high changes in temperature.

4. Organisms with wide ranges of tolerance for many factors have universal distribution.

5. The tolerance of any organism of the environmental factor can be represented in the form of a curve called ***tolerance curve***.

6. When the species has a narrow range of tolerance, the prefix ***'steno'*** is added to the factor. Eg. *Stenothermal* and *Stenohaline*.

7. When the species has a wide range of tolerance the prefix ***'eury'*** is added to the factor. Eg. *Eurythermal* and *Euryhaline*.

3. The Combined Concepts of Limiting Factors

Organisms are exposed to a variety of environmental factors. Almost all the factors are essential for organisms. But some factors become limiting factors. These factors are characterized by their 1. Minimum availability in the environment and 2. The changes of intensity of the factors in the environment.

The successful survival of the organism depends on its adjustments to these factors. For survival the organism must obtain the factors which are present in minimum quantity in the environment. Secondly, the organism must be tolerant of the changes of intensity of the limiting factors.

Unit - II

9. Population Ecology

Population refers to *'a group of organisms of the same species living in a particular area at a given time'*. A population has the following salient features:

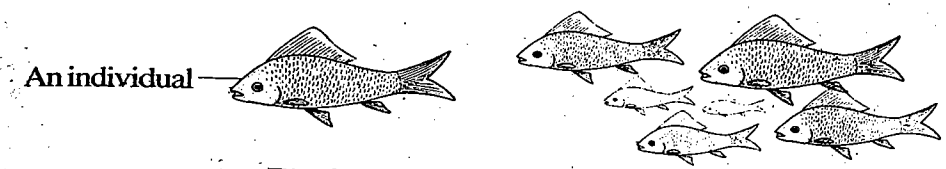


Fig.9.1: A population of fish.

1. All the individuals of a population belong to one species.

2. The individuals are morphologically and anatomically similar.

3. The individuals are genetically related.

4. There is free gene flow between the individuals of a population.

Fig.9.2: A population of teak trees.

5. The individuals are reproductively isolated from other species.

Populations are of two types. They are ***monospecific*** population and ***polyspecific*** population. A monospecific population is formed of only one species. A polyspecific population is formed of ***many related species***.

Examples : All the *Rana hexadactyla* living in a pond constitute a ***frog population***; all the human being of India constitute a ***human population.***

Each population has the following characteristics :

1. *Density*
2. *Natality*
3. *Mortality*
4. *Age distribution*
5. *Population growth*
6. *Population equilibrium*
7. *Population fluctuations*
8. *Biotic potential*
9. *Dispersal*
10. *Dispersion*
11. *Regulation of population density*
12. *Population interaction*

1. Density

Population density refers to *the total number of individuals in a unit area or unit volume at a given time*. It may be expressed in various parameters. For example, the number of bacteria in a ***litre*** of water; the number of plants per ***acre*** of land; the number of people per square ***km*** and so on. The density of any population can be expressed by the following formula:

$$D = \frac{n / a}{t}$$

Where, D = Density
n = Number of individuals
t = Time
a = Area

Measurement of Population Density

Several methods are followed to measure the population density. They are as follows:

1. Total Count

In this method, all the individuals of a population are counted one by one. It is the direct method and it gives the accurate density. But it is practically possible only in the case of trees and human beings. It is not possible to count all animals because they are not static. Again this method cannot be employed in the case of smaller organisms.

2. Sampling Method

In this method, suitable samples are selected; the organisms per sample are counted and then the density is calculated by extrapolation.

In a terrestrial habitat, the total area of the population is subdivided into sampling units. The ***sampling units*** are in the form of ***quadrates*** (squares) or ***transects*** (rectangles) or ***circlets***.

The area of the sampling unit should be based on the size of the organism. For example, if the density of trees in a forest is to be measured, then the quadrate (sampling unit) must be about 50 square metre. If the density of grass is to be measured then the quadrate must be about 5 square metre. Individuals in each sampling unit are counted and the total density is calculated by extrapolating the data.

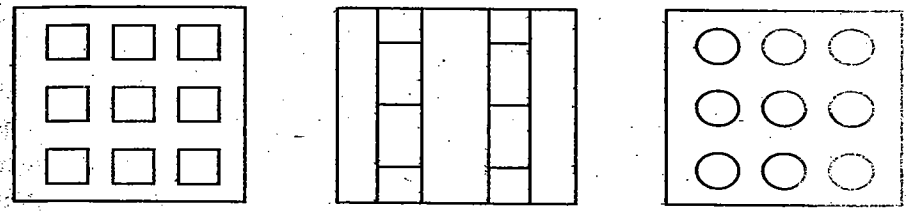


Fig.9.3 : Sampling methods.

3. Tagging Method

This method is used in counting larger animals like fishes, birds, squirrels, etc. From the population a definite number of animals, say 100, are captured, marked and released. After some days, another set of animals are captured (say 80 animals). This batch contains tagged and untagged animals. From the proportion of tagged and untagged animals the total number of individuals in the population can be calculated as follows:

Total number of tagged animals in the population (say) = 100

Total number of tagged and untagged animals captured on the second day (say) = 80

Tagged animals captured (say) = 10

$$\frac{\text{Total population size}}{\text{Number of marked animals in the population}} = \frac{\text{Total caught in the sample}}{\text{Number of marked animals in the sample}}$$

$$\frac{x}{100} = \frac{80}{10}$$

$$x = \frac{80 \times 100}{10}$$

Total population size = 800

4. Pellet Counting Method

In this method, the faecal pellets in an area are counted. The population size is calculated from this by knowing the average rate of defaecation. This method is used for mice, snowshoe hares and rabbits.

2. Natality or Birth Rate

Birth rate refers to *the average number of new individuals produced by a population in a given time.* Natality is due to birth, hatching, germination or fission. The size of population increases because of natality. Natality is of two types, namely ***potential natality*** and ***realized natality.***

$$\text{Natality or birth rate} = \frac{\text{Number of births per unit time}}{\text{Average population}}$$

1. Potential Natality or Maximum Natality : The maximum possible rate of reproduction for a population under optimal conditions is called ***potential natality***. For example, a *Salmon* (fish) produces 2,80,00,000 eggs in a season. So the potential natality of *Salmon* is 2,80,00,000 eggs in a season. But all the eggs do not hatch and reach adulthood because of environmental resistance. Hence, potential natality is not attained in nature.

2. Realized Natality or Ecological Natality : It refers to the actual number of new individuals added to the population in a given time. Realized natality is considerably lesser than the potential natality.

Carrying Capacity

The total number of individuals that can be supported in an area at a particular time is called ***carrying capacity.***

Environmental Resistance

The prevention of population increase by the environmental factors is called ***environmental resistance.*** Eg. A hen hatches about 10 chicks. But only a few chicks reach adulthood. Others die due to predation, diseases, starvation, etc. This is due to environmental resistance.

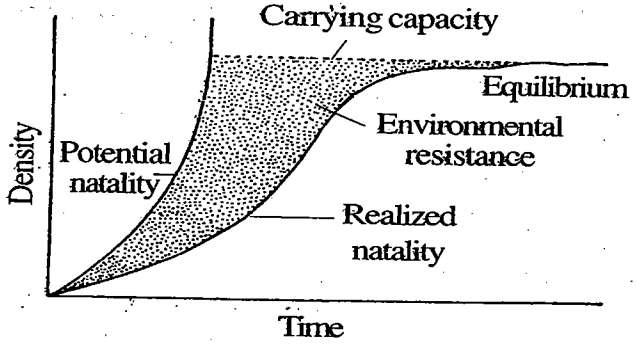


Fig.9.4: Environmental resistance.

3. Mortality or Death Rate

Mortality refers to *the number of individuals dying in a population at a given time.* The size of the population decreases because of mortality.

There are two aspects of mortality. They are ***potential mortality*** or minimum mortality and ***realized mortality*** or actual death rate.

Potential mortality refers to ***the number of deaths due to old age***.

But realized mortality is ***the number of deaths that occur at all ages from gametes to adults*** due to environmental factors like predation, diseases and other hazards. Realized mortality is higher than potential mortality.

$$\text{Mortality or death rate} = \frac{\text{Number of deaths per unit time}}{\text{Average population}}$$

Vital Index

The ratio between birth rate and death rate is called ***vital index***. It is represented by the formula:

$$\text{Vital index} = \frac{\text{Birth}}{\text{Death}} \times 100$$

Vital index helps to understand the rate of growth of a population. When birth rate is higher, the population grows progressively. When death rate is higher, the population declines. When the birth rate equals death rate, the population is stable and remains at equilibrium.

4. Age Distribution

A population is formed of individuals in different age groups. The individuals in a population can be classified into three groups according to their ages. They are:

1. The ***pre-reproductive group*** which includes immature animals.

2. The ***reproductive group*** comprising sexually mature individuals.

3. The ***post-reproductive group*** comprising old animals where the reproductive ability has been stopped.

The birth rate, death rate and the growth of a population are determined by the age groups of the population. When a population is formed predominantly of pre-reproductive age group, it is in a state of ***growth***. In growing populations, the birth rate is high. When a population is formed predominantly of post-reproductive age group, it is said to be ***declining***. When a population contains predominantly pre-reproductive and reproductive age groups, it is said to be in a ***stable condition***.

Age Pyramids

The different age groups of a population can be represented in the form of a graph called ***age pyramid***. In the age pyramid, the pre-reproductive age group is represented at the bottom, the reproductive age group in the middle and the post-reproductive age group at the top. The shape of the pyramid shows the growth or decline or equilibrium of the population. For example, when

a population contains more of pre-reproductive and reproductive age groups, the pyramid is ***bell-shaped***. The bell-shaped pyramid shows that the population is stable.

Salient Features of Age Pyramids

1. An age pyramid is a graph showing the different age groups of a population.

2. The pre-reproductive age group is represented at the base, the post-reproductive age group at the top and the reproductive age group in the middle.

3. It indicates wheather the population is growing or declining or stable.

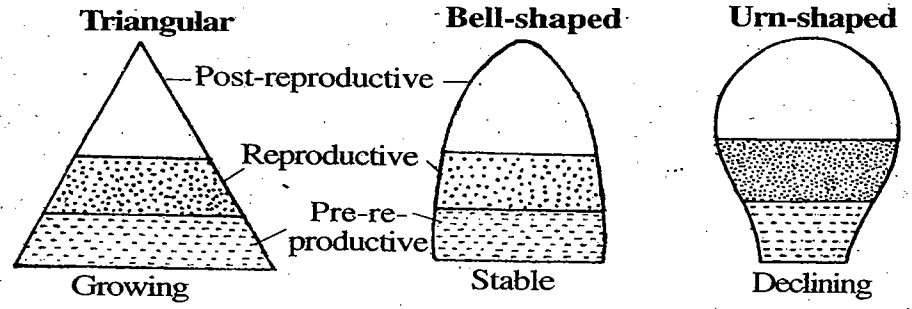


Fig.9.5: Age pyramids.

4. When the pyramid is ***triangular,*** the population is growing; when ***urn-shaped,*** the population is declining, when ***bell-shaped,*** it is stable.

5. An age pyramid represents the age distribution of a living population at a specific time. Hence, when the age distribution changes over a period of time, the shape of the pyramid also changes.

5. Population Growth

The increase in size of population is called ***population growth***. A population grows when the birth rate is high and the death rate is low. It is also aided by immigration i.e. migration of animals into the population from another similar population. When the increase in the number of animals is plotted against

time factor, a curve is obtained called the ***growth curve***. The pattern of growth curve is different for different populations. Mainly, two patterns of growth curves are significant. They are,

1. *S-shaped growth curve* or *sigmoid curve* and
2. *J-shaped growth curve.*

1. S-shaped Growth Curve

When a few organisms are introduced into an unoccupied area, the population grows gradually. In the beginning, the growth is slow and this stage of growth is called ***positive acceleration phase.***

Then, the growth is rapid and the population increases steeply. This stage of growth is called ***logarithmic phase.***

After reaching the maximum size, the growth rate slows down due to environmental resistance. This stage is called ***negative acceleration phase.***

After this the population reaches an ***equilibrium*** level in which there is neither increase nor decrease.

This pattern of growth curve is exhibited by the ***yeast*** and ***bacteria*** grown in the laboratory.

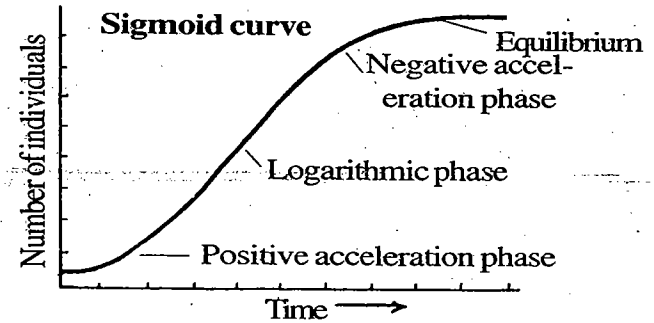


Fig.9.6: Growth curve.

Carrying Capacity : The upper level beyond which no more increase can occur in a population is called ***carrying capacity*** or ***upper asymptote***. Thus carrying capacity is defined as the maximum number of individuals of a population that can be supported in a habitat at a given time. Once a population reaches the carrying capacity, it fluctuates around it till it reaches the equilibrium.

2. J-shaped Growth Curve

In certain populations, the growth is very rapid and the number of organisms increases in compound interest fashion

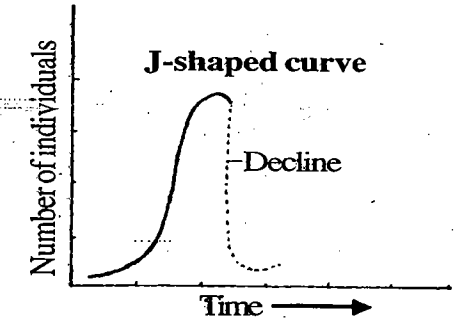


Fig.9.7: J-shaped Growth curve.

and then the growth stops abruptly and the population declines suddenly. The decline is caused by environmental factors. This type of growth-pattern gives J-shaped curve and it is exhibited by ***Lemmings,*** certain insects like thrips in roses, algal blooms, etc.

6. Population Equilibrium

When a few animals are introduced into a new habitat, they increase in number and the population grows. At the beginning, the growth is slow and later it increases in geometric ratio. After reaching the maximum number, the population remains at that level for a long period. This is called ***population equilibrium.***

At the equilibrium level, there is no net change in the size of the population and the death rate and birth rate are more or less equal. The population remains in the equilibrium as long as the biotic and abiotic factors are optimum. When there is slight change in the environment, the population adjusts itself by fluctuating above or below the equilibrium. If the changes are great, the population declines resulting in the extinction.

7. Population Fluctuations

The increase and decrease in the number of individuals in a population is called ***population fluctuation.***

When a population is exposed to favourable environmental ndition, it grows and establishes an equilibrium. It remains in e equilibrium level continuously if conditions are suitable. owever, from time to time the number of individuals increases decreases. As a result, the curve moves up or down from the uilibrium level. It is called ***population fluctuation***.

If these changes are small and negligible the population rve is said to be ***flat***. If the changes are larger and regular the rve is said to be ***cyclic***. If the changes are irregular, the curve said to be ***irruptive***.

The fluctuations are caused by either ***extrinsic factors*** or ***trinsic factors.***

Extrinsic factors are the factors of the environment, such temperature, light, rainfall, space, food, etc. Extrinsic fac-rs cause ***irregular*** fluctuations.

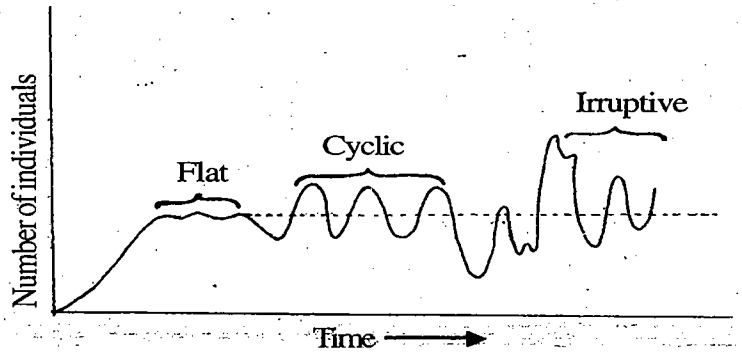


Fig.9.8: Population fluctuations.

Intrinsic factors arise inside the populations, such as den-y, interaction and so on. They cause ***cyclic*** fluctuations.

8. Biotic Potential

'Biotic potential' refers to *the inherent ability of a popu-tion to increase in number when the age ratio is stable and l environmental conditions are favourable.*

It is the reproductive ability of a population.

The biotic potential is much greater than what is realized.

Mathematically, it may be defined as the slope of the popu-tion growth curve during the logarithmic phase of growth.

It is reduced when the environmental conditions are not optimal. The factors which prevent the population from reproducing to its maximum are called ***environmental resistance***.

The environmental resistance will be low when a population is first introduced into a new territory. But as the population increases, the environmental resistance also increases in the form of competition, predation, parasitism, scarcity for food and so on.

9. Dispersal

Dispersal is a phenomenon *where the individuals (not all) of a population move into or out of the population.* There are three kinds of population dispersal. They are

1. *Migration*
2. *Emigration*
3. *Immigration.*

1. Migration

It is the periodic movement of animals from one place to another and back for breeding, feeding and shelter. Eg. *Fishes, birds, mammals, locusts, certain crabs,* etc.

Among fishes eel (*Anguilla)* exhibit ***catadromous migration***. They move from freshwater to sea thousands of miles away to lay eggs. After spawning, the parents die and the young ones after three years of larval life in the sea travel to freshwater.

The *Salmon* exhibits ***anadromous*** migration. They move from sea to freshwater for breeding.

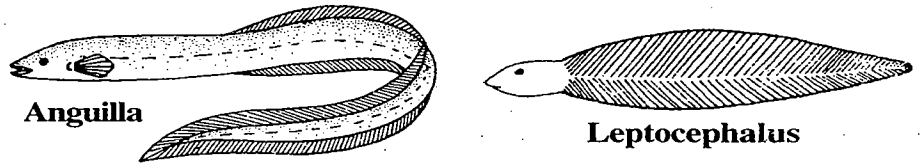


Fig.9.9: Migration of eel. It migrates from the freshwate to the sea.

Birds are regularly migrating for breeding. They generally breed in the coldest part of the World. They do northward mi gration during summer and southward migration during winter.

2. Emigration

It is the outward migration, from a population. It is a one way migration and the migrants never return to the starting place. Emigration is induced by many factors of which high density, over population and scarcity of food are significant. After some organisms move away from the population, in the remaining population age distribution, birth rate and death rate are affected.

In Scandinavia, lemming population (a small rodent) increases tremendously at an interval of four years. This leads to scarcity of food and the lemmings are forced to migrate towards the sea. Once on the move, the animals proceed readily crossing any obstacle on the way. Nothing can stop their movement. Females are found to carry young ones on their back. On reaching the sea they jump into the tides and waves and commit ***mass suicide***.

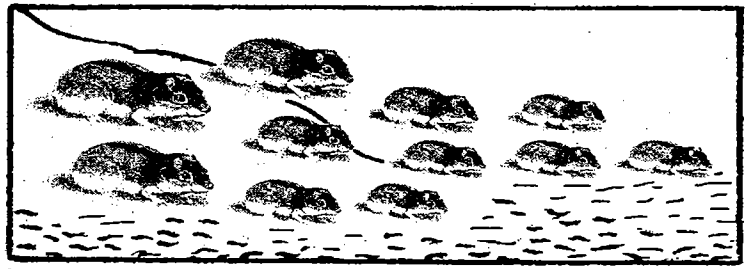


Fig.9.10: Emigration of lemmings. They migrate from the plains towards the sea and commit mass suicide.

3. Immigration

It is inward migration. It is also a one-way migration. Immigration leads to a loss of individuals from one population and the addition of individuals to another population. Hence mass immigration may change the structure of a stable population.

10. Dispersion

Dispersion refers to *the distribution of individuals within a population.* The individuals are distributed in the population in three different patterns, namely ***uniform, clumped*** and ***random***.

In uniform distribution, the individuals are uniformly distributed throughout the population.

In clumped distribution, the individuals are aggregated into groups.

In random distribution, the individuals are irregularly placed.

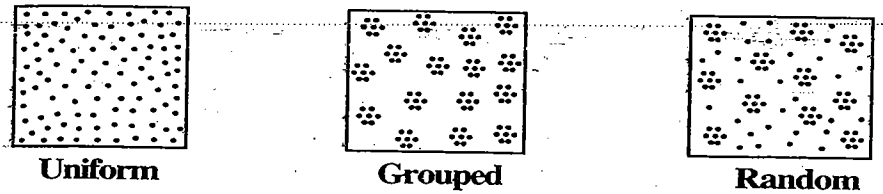


Fig.9.11: Distribution of individuals in a population.

11. Regulation of Population Density

The total number of individuals of a species living in an area is called ***population density.***

The population grows by the reproduction of the individuals. New individuals are added to the population by the birth of individuals.

The reproductive ability of animals is very very high. For example, a *Paramecium* undergoes binary fission for every 16 hours. If all the daughter *Paramecia* survive and reproduce at this rate for five years, they will produce a cytoplasmic mass, the volume of which will be equal to 10 thousand times the volume of the Earth.

An ***Oyster*** lays about ***50 million*** eggs in a season. If all these eggs hatch out and if all the young ones reproduce for 5 generations, they will form a volume about 8 times the size of the Earth.

A single neem tree produces thousands of seeds in a season. If all the seeds grow into trees one Earth is not sufficient for the neem tree alone.

Though the reproductive rate is high, the population density does not increase as expected. This is because the density is regulated.

13. Animal Relationships

For any organism, living alone is impossible.Organisms are ciated with one another. Successful survival depends on the nacy of associations. The associations may be between *ts* and ***plants*** or between ***plants*** and ***animals*** or between *nals* and ***animals***. All associations are broadly classified two groups, namely ***intraspecific relationship*** and ***inter-ific relationship***. When the members of the same species interrelated, the relationship is called ***intraspecific rela-ship***. When the members of different species are related, relationship is called ***interspecific relationship.***

The interspecific relationship is broadly classified into groups. They are as follows:

1. *Neutralism*
2. *Symbiosis - Commensalism* and *Mutualism*
3. *Antagonism - Antibiosis, Parasitism, Predation* and *Competitions.*

eutralism (0, 0) (0 = No effect)

It is an interspecific relationship. In this association, no ies is affected. Eg. *Robin birds* and *squirrels* living in the tree and same forest; a *cow* and a *dog* living in the same e, etc.

ymbiosis (o, + or +, +) (+ = Beneficial effect)

It is an animal association where *no partner is harmed. or both the partners are benefited.* On this basis, symbio-

sis is divided into two groups. They are ***commensalism*** and ***mutualism.*** In commensalism, only one partner is benefited. In mutualism, both partners are benefited.

Table.13.1: Interspecific relationships (+ .= Beneficial effects; − = Harmful effects; O = No effect).

Sl. No.	Type of relationships	Effects		General results
		SpA	SpB	
1.	Neutralism	0	0	Neither sp affects the other
2.	Commensalism	+	0	Favourable to A
3.	Mutualism	+	+	Favourable to both
4.	Antibiosis	-	0	A is affected
5.	Parasitism	+	-	Favourable to A
6.	Predation	+	-	Favourable to A
7.	Competition	-	-	Harmful to one or the other

1. Commensalism (+, 0)

It is a symbiotic interspecific relationship where *one partner is benefited and the other partner is not harmed.* The partners are called ***commensals***. The term ***commensalism*** was coined by ***Van Beneden***. It literally means *eating at the same table as guest, messmates.*

Commensalism is classified into four groups. They are as follows:

1. *Temporary commensalism*
2. *Permanent commensalism*
3. *Ectocommensals* and
4. *Endocommensals.*

1. Temporary Commensalism

Here the association is temporary. Sometimes the partners may separate and go away. Eg. *The crab living in the tube of Chaetopterus; sucker fish* and *shark.*

2. Permanent Commensalism

Here the association is permanent. The partners remain together permanently. Eg. *Lichen.*

3. Ectocommensals

Ectocommensal lives on the outer surface of the other partner. Eg. *Sucker fish* and *shark; Hermit crab* and *Sea anemone*, etc.

4. Endocommensals

Endocommensal lives inside the body of the other partner. Eg. *Flagellates living inside the body of the termites.*

The following are the examples for commensalism:

1. Sucker fish and Shark : The sucker fish *Echeneis* has a sucker on the dorsal side. It is the modified first dorsal fin. It is used for attachment. Commonly it is found attached to sharks. The sucker fish gets two benefits. a. It is transported by shark, b. It feeds on the left overs of the shark.

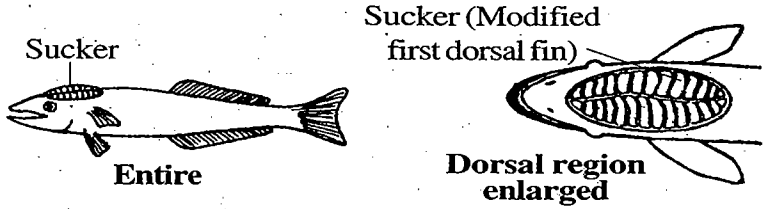


Fig.13.1: Commensalism. The sucker fish is transported by a shark. It also feeds on left overs of shark.

2. Chaetopterus and Crab: The crab *Polyonx* lives in the posterior end of the tube of the polychaete worm *Chaetopterus*. The crab gets three benefits. a. It is protected from enemies, b. It gets food from the outgoing water and c. It gets oxygen from the water current.

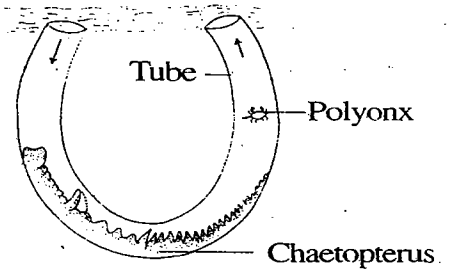


Fig.13.2: Commensalism;The crab Polyonx lives in the tube of Chaetopterus. The crab gets shelter food and oxygen.

3. Pinnotheres and Mussels : The pea crab *Pinnotheres* lives in the mantle cavity of mussels. The crab obtains protection and food from the mussels.

4. Echiuroid worm, Polynoe, Crab and Fish : The echiuroid worm, *Urechis caupo* lives in a U-shaped tube. In this tube, three animals live as ***commensals***. They are the scale worm *Polynoe,* the *Pea crab* and the fish *goby.* All the commensals obtain food and oxygen.

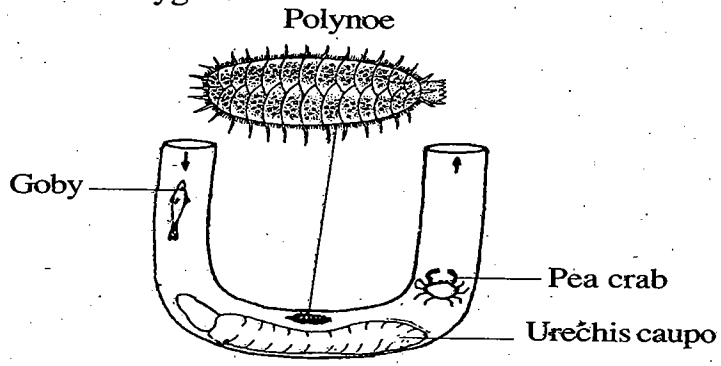


Fig.13.3. : Echiuroid worm and its commensals.

5. Portuguese man-of-war and fish : *Physalia,* the ***Portuguese man-of-war*** is a deadly poisonous jelly fish. It can kill almost all fishes with the help of the tentacles. But the small fish *Nomeus* lives among the tentacles freely as a commensal. The fish gets shelter, protection and food from the jelly fish.

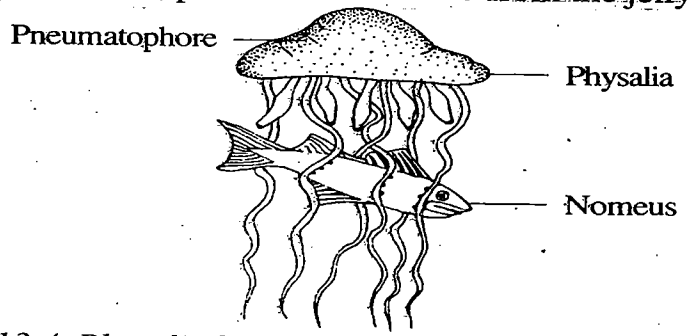


Fig. 13.4. Physalia had deadly poisonous tentacles which can kill almost all fishes. But Nomeus lives peacefully among these tentacle.

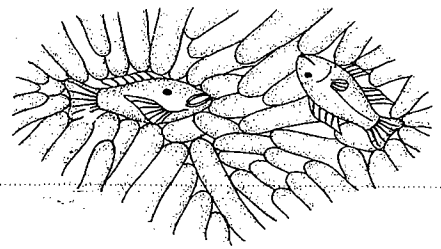


Fig.13.5: The clown fish lives among the poisonous tentacles of Sea-anemone. The fish is protected by a mucous coat. The Sea-anemone does not get any benefit. But the fish gets food and protection.

2. Mutualism (+,+)

Mutualism is an *interspecific symbiotic relationship where both partners are benefited.* This term literally means ***'living together'*** and was coined by ***De Bary*** (1877). The following are the examples:

1. Hermit Crab and Sea anemone

The hermit crab *Eupagurus* lives inside the empty gastropod shell. The outer surface of the shell is inhabited by Sea anemone *Adamsia.* The hermit crab is protected from enemies by the stinging cells of Sea anemone. The Sea anemone gets

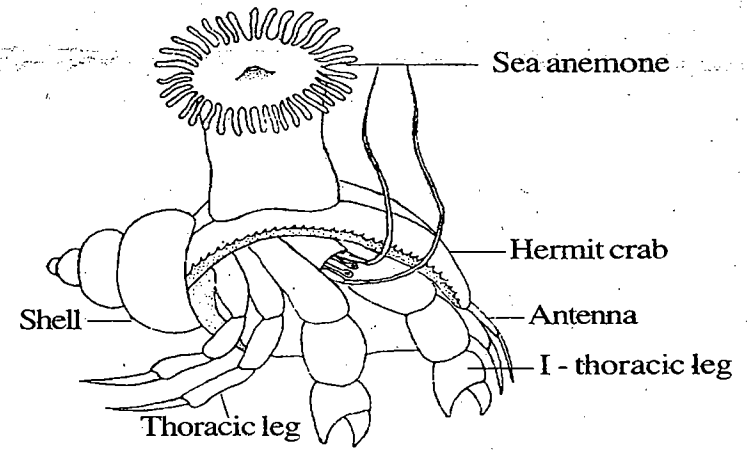


Fig.13.6: Hermit crab and Sea anemone maintain mutualism where both partners are benefited.

two benefits. a. It is transported from place to place and b. It shares the food captured by the crab.

2. Giant Clam and Zooxanthellae

The mantle of the giant clam *Tridacna* (lamellibranch) is thickly populated by the brown-coloured flagellates *Zooxanthellae.* As the shells of the molluscs are thick, they cannot be closed completely and this helps *Zooxanthellae* receive Sun light. Again the mantle contains numerous ***lens***-like structures which focus light into the deep-seated *Zooxanthellae.* Thus the *Zooxanthellae* obtain plenty of light for photosynthesis. The older senescent *Zooxanthellae* are selectively called by the amoebocytes of the giant clam and are digested as food. ***Yonge*** (1944) stated that the giant clam ***'farms'*** *Zooxanthellae* and derives considerable portion of its nutrition.

3. Rhizobium and Leguminous Plants

The bacterium *Rhizobium* produces nodules on the roots of leguminous plants. The bacteria fix up atmospheric free N_2 in the nodules in the form of nitrates. The plants utilize these nitrates. The bacteria, in turn, obtain carbohydrate and other substances from the plants.

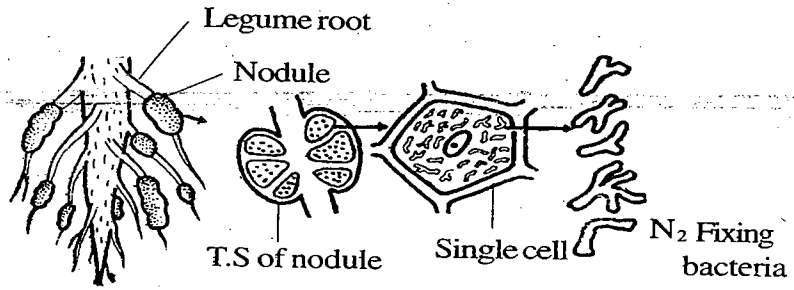


Fig.13.7. Mutualism; Leguminous plants and bacteria. Bacteria fix N_2 in the nodules of leguminous plants.

4. Lichens

Lichens are formed of algal cells and fungus. The fungus provides protection, moisture and minerals for the algal cells. The algal cells prepare carbohydrate for both partners by photosynthesis.

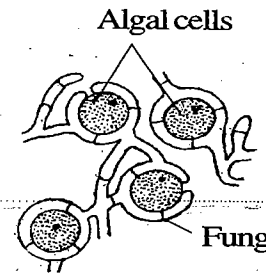


Fig.13.8: Lichen with algal and fungal cells.

5. Termites and Flagellates

Termites cannot digest wood particles (cellulose). But the intestine of termites contain numerous flagellates like *Trichonympha*. These flagellates produce ***cellulase*** which digests cellulose. By this both partners are benefited.

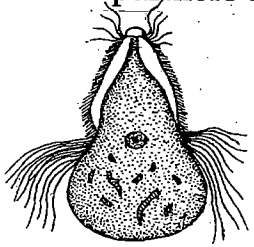


Fig.13.9: Trichonympha, a flagellate protozoan, digests cellulose for termites.

6. Ants and Aphids

The little brown ants *Lassius orunneus* rear aphids in their colony. Everyday the aphids are transported to the roots of growing corn where they are looked after just as a shepherd watches his sheep. The ants obtain honey from the honey-tubes present in the abdomen of aphids. Hence it is said that ants ***'keep cows'*** and ***milk them***.

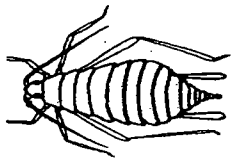


Fig.13.10: Aphid. Ants rear aphids in their nests as cows.

7. Birds and Grazing animals

The cow bird *Oxpecker* and *white heron* are found alighting on the back of grazing animals. The birds pick off the ticks and the other external parasites. These form food for the birds. The grazing animals get two benefits. 1. They get rid off external parasites. 2. They get early warning about the approaching enemies by the activity of birds as ***'watchmen'***.

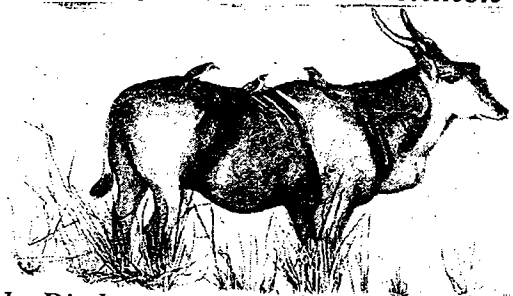


Fig.13.11: Birds on a grazing animal. The birds remove the ticks and mites and also give early warning of the enemy.

8. Crocodile-bird and Crocodile

The crocodile allows the crocodile-birds go deep into the mouth making them remove the leeches found in between the teeth. Thus the crocodile gets rid of leeches and the birds obtain food.

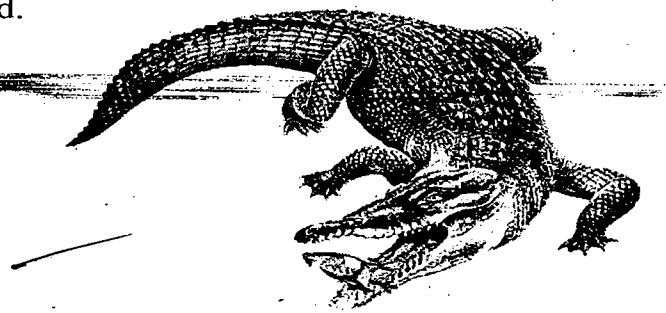


Fig.13.12: Crocodile-bird and Crocodile. The birds remove the leeches.

3. Antagonism

It is an interspecific relationship where one or both partners are harmed. It is of four types, namely

1. *Antibiosis*
2. *Parasitism*
3. *Predation* and
4. *Competition*

1. Antibiosis (-,0) (- = Harmful effect)

Antibiosis is an interspecific relationship where one partner inhibits or kills the other partner. The inhibition is brought about by the secretion of a toxin called ***antibiotic.*** Antibiotic does not affect the organism which is secreting it. But it kills other organisms. The following are the examples for antibiosis:

1. Fungi produce harmful substances like ***penicillin, streptomycin, aureomycin,*** etc. They kill bacteria and virus. This principle is used in medical field to treat bacterial and viral infections.

2. The blue-green alga *Microcystis* produces a toxic substance called ***hydroxylamine***. It kills the freshwater fishes and the cattle which drink this water.

3. The alga *Chlorella vulgarus* produces a toxin called ***chlorellin***. It is toxic to other species of algae.

4. **Red Tide:** The marine dinoflagellate *Gymnodinium* appears in huge populations on certain seasons. This organism is bioluminescent and hence the water is glowing with red light. Hence this is called ***red tide***. These organisms produce a toxin. It causes the death of fishes and other marine animals. In 1946-47, this red tide caused the whole sale death of fish throughout an area of several thousand square miles in the west coast of Florida.

2. Parasitism (+, -)

Parasitism is a one-sided relationship where one partner is benefited at the expense of the other. The other partner is harmed. The partner which is benefited is called ***parasite***. The other partner is called ***host***.

Parasite

The parasite lives inside or on the body of the host. Hence the parasite is usually smaller than the host. The parasite exploits the resources of the host. But it does not kill the host. The death of the host, if any, is due to the after effects of the parasitism.

Host

The host is the animal which provides shelter and food for the parasite. It is usually larger than the parasite. Certain parasites require more than one host to complete their life cycle. When there are two hosts, they are named ***primary hosts*** (definitive hosts) and ***secondary hosts*** (intermediate hosts). In the primary host, the parasite completes its sexual cycle. In the secondary host, the asexual cycle of the parasite is completed.

Types of Parasites

Parasites are of the following types:

1. Temporary Parasites: When an animal spends only a part of its cycle as parasite, it is called ***temporary parasite***. Eg. *Glochidium larva of freshwater mussel.*

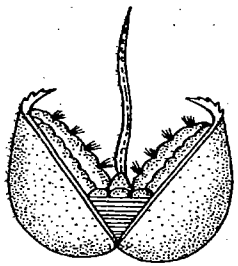
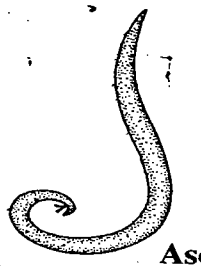
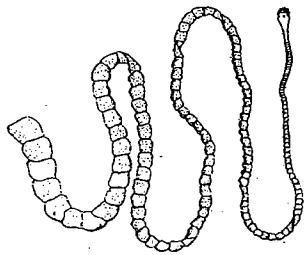


Fig:13.13 : Temporary parasite; Glochidium larva of freshwater mussel.

2. Permanent Parasites: The animals which spend their entire life as parasites are called ***permanent parasites***. Eg. *Ascaris, Taenia,* etc.



Ascaris



Taenia

Fig.13.14: Permanent, intercellular endoparasites.

3. Ectoparasites: The parasites which are living on the outer surface of the hosts are called ***ectoparasites***. Eg. *Ticks, mites, leeches,* etc.

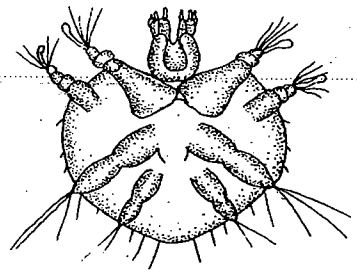


Fig.13.15 : Mite, an ectoparasite.

4. Endoparasites: The parasites which live inside the body of hosts are called ***endoparasites***. Eg. *Ascaris, Taenia,* etc.

5. Intracellular Parasites : The parasites which live inside the cells of the hosts are called ***intracellular parasites***. Eg. *Trypanosoma, Plasmodium, Monocystis,* etc.

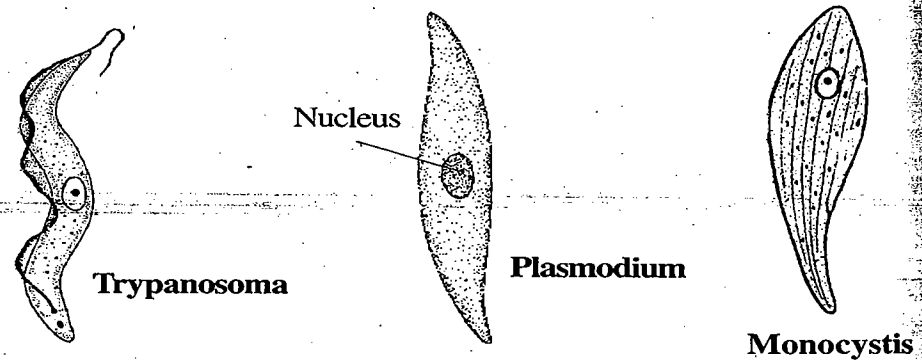


Fig.13.16 : Intracellular parasites.

6. Intercellular Parasites: The parasites which live in between the cells of hosts are called ***intercellular parasites***. Eg. *Ascaris.*

7. Phytoparasites : The parasites living in plants are called ***phytoparasites***. Eg. *Rhinoceros beetle on coconut.*

8. Zooparasites : The parasites living in animals are called ***zooparasites***. Eg. *Ascaris.*

9. Facultative Parasites: Some parasites are parasitic only when there is opportunity for parasitic life. When there is no opportunity for parasitism, they lead an independent life. Such parasites are called ***facultative parasites***. Eg. *Pinnotheres* (crab).

10. Obligatory Parasites : Some parasites must lead a parasitic life. Otherwise they will die. These are called ***obligatory parasites.*** Eg. *Ascaris lumbricoides.*

11. Hyperparasites : When a parasite lives in other parasites it is called ***hyperparasite***. *Nosema notabilis* is a hyperparasite on a Myxosporidium, *Sphaerospora polymorpha* inhabiting the urinary bladder of the toad fish.

Parasitic Adaptations

Adaptation is the fitness or adjustment of an organism to its environment. Parasitic adaptation refers to the fitness of a parasite to its environment. The following are the parasitic adaptations:

1. Thick Cuticle: All parasites are covered by a thick cuticle. It is formed of insoluble protein. This protein can resist the digestive enzymes of the host. Thus the parasite is protected from the enzymes of the host.

2. Antienzymes: Intestinal parasites secrete certain enzymes called ***antienzymes.*** These enzymes neutralize the digestive enzymes of the host.

3. Organs of Attachment : Most of the parasites are provided with organs of attachment. These organs include hooks, suckers, rostellum, claws, adhesive secretions, etc.

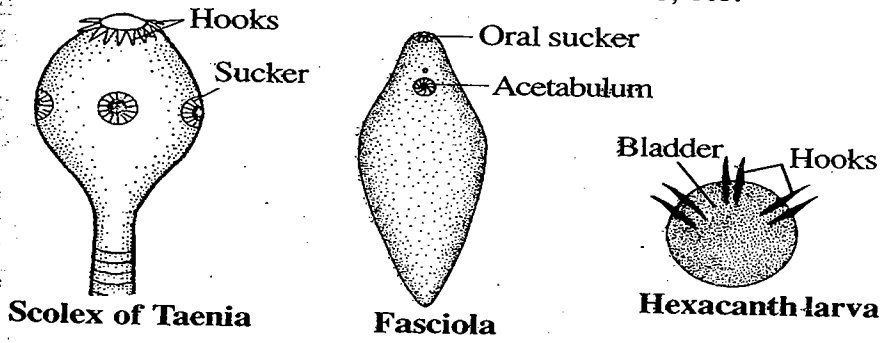


Fig.13.17 : Organs of attachment in parasites.

Eg. *Taenia solium, Fasciola* - Suckers.
Taenia, Hexacanth larva - Hooks
Lice and fleas - Claws

4. Loss of Sense Organs : Sense organs are helpful in understanding the environmental changes. The parasite lives inside the host. In the host, the environment is uniform. Hence the sense organs are not necessary for the parasite. So the sense organs are lost in the parasites.

5. Loss of Locomotory Organs : Parasites need not move a longer distance. Hence the locomotory organs are reduced or degenerated.

6. Poor Nervous System : As the sense organs and locomotory organs are reduced, the nervous system is also poorly developed.

7. Loss of Alimentary Canal : Parasites feed on the digested food of the host. Hence the alimentary canal is reduced or absent completely. Eg. *Taenia.*

8. Loss of Digestive Glands: As parasites feed on the predigested food, there is no need for digestion. Hence digestive glands are completely absent from parasites.

9. Anaerobic Respiration: Parasites live in an environment which is free from oxygen. Hence they have the ability to respire without oxygen. This kind of respiration is called ***anaerobic respiration.***

10. Complicated Reproductive System: There are many risks and hurdles for a parasite to reach the adult stage. Hence parasites have tremendous adaptations for producing a large number of eggs and young ones.

11. Prodigality of Production : Parasites produce a large number of eggs and young ones. For this they possess the following adaptations:

1. Most of the parasites are hermaphrodites.

2. The parasites have more than one set of reproductive system. Eg. In *Taenia solium,* there are about eight hundred proglottids. Each proglottid has a set of male and female reproductive systems.

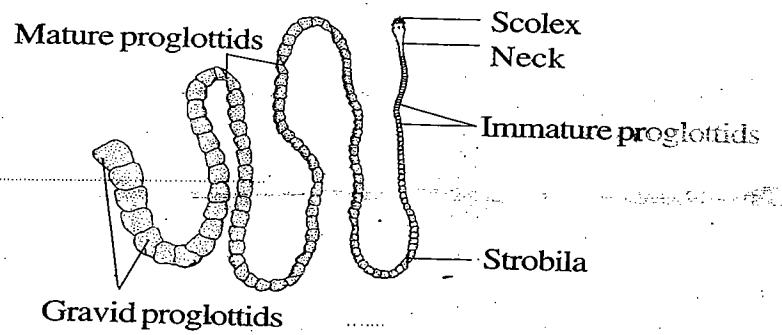


Fig.13.18: Taenia solium showing many proglottids.

3. In parasites, uterus is large and highly branched to enclose a large number of eggs.

4. Parasites have an inherent ability to produce thousands of eggs. Eg. *Ascaris* produces 20,000 eggs at a time. Each proglottids of *Taenia* contains 30,000 to 50,000 eggs and each *Taenia* has about 800 proglottids.

5. In some parasites the females are permanently attached to the males. Eg. *Schistosoma.*

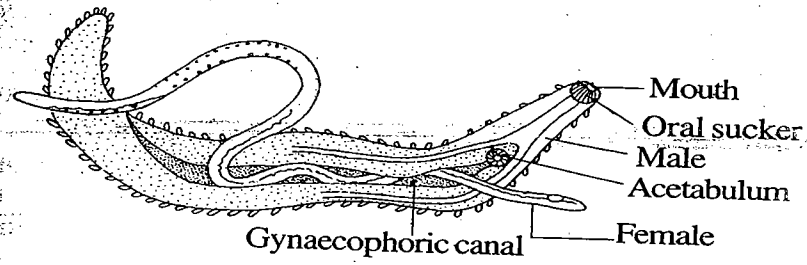


Fig.13.19 : Schistosoma, the female is permanently attached on the male.

12. Parthenogenesis : Some parasites exhibit parthenogenesis for rapid multiplication. Eg. The germ cells of *Miracidium* larva develop into *Redia* by parthenogenesis.

13. Polyembryony: The production of many embryos from a single germ-cell is called ***polyembryony***. Eg. *Taenia.* A single cysticercus larva produces many *Taenia.*

smaller in size. The other partner is called ***host.*** It is larger in size.

Parasites are of following types:

1. Ectoparasites: The parasites which are living on the outer surface of the host are called ***ectoparasites.*** Eg. *Ticks, mites, leeches,* etc.

2. Endoparasites: The parasites which are living inside the body of host are called ***endoparasites***. Eg. *Ascaris, Taenia,* etc.

3. Temporary parasites: The parasites which spends only a part of its life cycle in a host are called ***temporary parasites.*** Eg. *Glochidium larva of freshwater mussel.*

4. Permanent parasites: The parasites which spend their entire life in a host are called ***permanent parasites***. Eg. *Ascaris, Taenia,* etc.

Parasites evolve from ***free living forms.*** They form an ***interspecific relationship*** with other species.

During their relationship they inhabit a constant environment over a long period for ***food, shelter*** and ***protection.*** Evolution proceeds in these organisms slowly under constant environment. They develop ***new structure*** or ***adaptive trait*** to live comfortably. They develop ***protective covering, organs for penetration, antienzymes*** and ***cystogenous glands.***

The organism provided with ***favourable character*** succeed in the struggle for existence. These organisms are the ***fittest for survival.*** The fitness is decided by the ***environment, the nature.*** So the environment acts as the ***selecting force.*** It selects those organisms which are provided with favourable characters. This process of selection of organism with favourable variations is called ***natural selection.*** They pass these favourable characters onto their offspring.

The organisms use these adaptive traits to live on or in other species. They get their nutritional requirements from other species. They lose ***locomotor, sense*** and ***digestive organs,*** essential for living a free life.

These morphological and physiological changes make free living organism as parasite.

During their interspecific relationship, the host evolves some way to avoid parasite. Then the parasite evolves a counter acting character. It allows the parasite to parasitise the host.

When parasite changes, the host also changes. This process is called ***co-evolution.*** Parasite is antagonistic one. Hence, co-evolution is also called ***antagonistic co-evolution.***

This close evolutionary relationship between two species(parasite and host) is called ***one-on-one co-evolution*** or ***pairwise co-evolution.***

The two species, host and parasite, evolve a better method of ***attack*** and ***defence*** step by step. This retaliatory relationship is called ***arms*** and ***races.***

In their evolutionary relationship, internal parasites(endoparasites) evolve slowly because they inhabit a constant environment. External parasites (ectoparasites) evolve faster because they inhabit a changing external environment

The existence of evolutionary relationship is evidenced. It is observed in the closely related parasites and their respective hosts. The affinities between different hosts may be elucidated from the affinities existing between their parasites.

Eg. 1. *Pigeons* have feather lice. It is similar to that of parrots.

2. *Herpes simplex* virus is present only in man and monkey.

3. Lice of the genus *Pediculus* is found only in man and chimpanzee.

3. Predation (+,-)

Predation is an animal relationship where one animal kills and devours other animals for food. The animal which kills other animals is called a ***predator*** and the animal which is killed is called a ***prey***.

All animals and insectivorous plants are predatory. The predators are of two types. They are ***herbivores*** and ***carnivores.*** The predators which eat plants are called ***herbivores***. Eg.*Rabbit.* The predators which kill and eat animals are called ***carnivores***. Eg. *Fox, lion, tiger,* etc.

Characteristics of Predation

A successful predator has the following characteristics:

1. The predator has high hunting ability.
2. Searching image of the predator must be high.
3. In the case of scarcity of the desired prey, the predator should choose an alternative prey.
4. Predators hunt only when it is necessary for them to procure food.
5. Predators select food on the basis of size.
6. The predator-prey interaction causes a reduction in the population. But the co-evolution of species has led to a dynamic balance between the populations in a community; ie, the sizes of the populations of predator and prey species are inter-regulated by feedback mechanisms which effectively control the populations of both.

Evolution of Predator and Prey Strategies

- ***Predator*** kills and devours other animals for food. The animal, which is killed, is called a ***prey.*** This relationship of predator and prey is called ***predation.***
- All animals and insectivorous plants are ***predators.*** Man is also a predator. The predators are of two types. They are ***herbivores*** and ***carnivores.***
- The predators which eat plants are called ***herbivores.*** Eg. *Rabbit.*
- The predators which kill and eat animals are called ***carnivores.*** Eg. *Fox, lion, tiger,* etc.
- Predator and prey relationship is an ***interspecific relationship.***
- The interspecific relationship is an ***evolutionary relationship.*** It occurs ***over a long period***. During this period predator can change. When predator changes, the prey also changes. This process is called ***co-evolution***. The co-evolution of predator and prey is ***antagonistic co-evolution.***

The term co-evolution is first introduced by ***Erlich*** and ***Raven*** in 1964. Co-evolution occurs in a community. So it is also known as ***community evolution.*** It is explained under the following examples:

Eg. 1. In a community, there are carnivores and herbivores. Carnivore is a predator. Predator kills herbivores for food. Hence herbivore is a prey. The predator becomes ***more efficient in hunting prey.*** It hunts herbivores with a ***high speed chases***. In response to the high speed chase of predator, the prey increases its ***running ability.*** Prey uses this kind of adaptive trait to escape.

Both predator and prey pass this adaptive traits to their offspring. When one species evolves, the other species also evolve to some extent.

Eg.2.An animal eating plants is a herbivore. A herbivore is also a predator. It eats plants. To avoid being eaten, the plant produces ***hard parts, toxin***, etc. as protective mechanisms. In response to these hard parts and toxin of plants, herbivores produce ***strong, grinding teeth*** and ***powerful jaws.***

The predator and prey pass these adaptive traits to their offspring. When one species evolves, the other species also evolves to some extent.

- The evolutionary relationship of predator and prey may occur between two species. Such ***a close evolutionary relationship*** is called ***pairwise*** or ***one-on-one co-evolution.***
- The evolutionary relationship of predator and prey may occur between groups of species. It is called ***diffuse co-evolution.***

The diffuse co-evolution has ***less specific evolutionary relationship.***

Diffuse co-evolution can be explained under the following examples:

Eg. 1. ***Evolution of tolerance in predators.***

In a community, most plant species are eaten by a variety of herbivores. In response to the activity of these various herbivores most plants produce a variety of protective mechanism such as thorns, tough leaves, toxins and distasteful chemicals.

The single predator has to evolve tolerance to a number of different food sources or different species of plants.

Eg.2. ***Evolution of predator avoidance mechanism***

In a community, different species of herbivores are eaten by different species of carnivores. In response to predators, most herbivores evolve predator avoidance mechanism such as ***speed*** and ***camouflage.*** These behavioural adaptive mechanisms are corresponding to speed and behavioural traits of their predators.

● Both predator and prey, provided with favourable characters, succeed in the struggle for existence.

The predator has high ***running ability*** and ***searching image*** for food. This ***predation pressure*** has favoured the evolution in prey. In response to predation pressure, preys increase their running ability.

Eg. *A tiger chases a deer. The deer runs faster.*

Fig.13.22: Tiger checks the deer.

The predators i.e, carnivores hunt the herbivores by performing ***high speed chases***. In response to predator's high speed chases, the herbivores develop new adaptive traits in order to escape from their predators. They increase their ***running ability.*** They become ***fast runners.*** Several changes occur in their legs in order to improve their running ability. They are,

1. Limbs become larger and thinner.
2. The bones of toes become shortened.
3. Outside toes are lost.
4. Length of metatarsals increase.

Many of these changes are identical to prey and predator populations.

● The plants produce ***hard parts, thorns, toxins***, etc. to avoid being eaten by the herbivores, the predators .

Certain animals are provided with warning colouration, mimicry, camouflage, etc. in order to escape from their predators.

● The organisms provided with ***favourable characters*** can ***succeed*** in the ***struggle for existence***. These organisms are the ***fittest*** for ***survival.*** The fitness is decided by the ***environment,*** the ***nature.*** So the environment acts as the ***selecting force.*** It selects those organisms which are provided with favourable characters.

● The predators and prey pass on these favourable characters to their offspring.

● During predator and prey interaction, they exert selection pressure on each other. When one species evolves particular characteristics or adaptive traits, the other species also evolves in response to this.

● The first species then evolves in response to the response of the second and so on.

● The predator - prey relationship causes a reduction in the prey population. But co-evolution of species has led to a dynamic balance between the populations in the community, i.e, the sizes of the population of predator and prey species are interregulated by feedback mechanisms.

For example, *Gambusia* fishes eat mosquito larvae in reservoirs. But when the population of larvae is reduced in a significant level, the *Gambusia* fishes turn to other foods. Thus they allow the mosquito population to recover.

4. Competition (-, -)

Competition is *the rivalry between two animals for a common resource.* It is an ***animal interaction.***

It is an ***animal relationship.***

Here two individuals are involved. They are called ***partners.*** The two partners may be harmed or only one partner will be harmed as a result of competition.

The idea of competition was proposed by ***Darwin*** in the form of struggle for existence.

Eg.1. A deer competes with a tiger. A tiger needs food. It chases a deer. The deer wants to live. It runs away. It is a competition in animals.

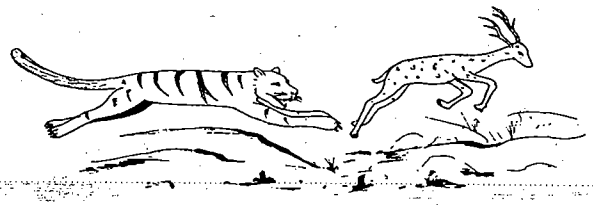


Fig.13.23: Tiger checks the deer.

2. Man stores food grains. Rats steal them. Thus there is a competition between man and rats.

3. A hen guard its chicks. But a crow chases the chicks. There is competition between hen and crow.

The competition is of two types, namely

1. Intraspecific competition

2. Interspecific competition

1. Intraspecific competition

The competition between members of the same species is called ***intraspecific competition.*** The members of the same species are similar in all respects. They have the same type of requirements such as food, shelter, mate, etc. Eg. 1. Many male dogs compete among themselves to mate with a female dog.

2. Lichens compete with each other for space on a dry ledge.

3. Barnacles *(Balanus)* a crustacean, compete for space on a submerged rock.

4. Many sperms compete among themselves to fertilize an egg.

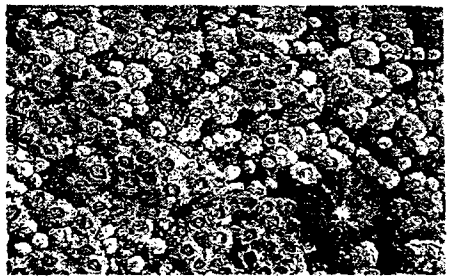


Fig.13.24: Intraspecific competition for space. Balanus on a rock.

2. Interspecific competition

The competition between members of different species is called ***interspecific competition.***

Eg. 1. A tiger and a deer compete with each other. The tiger chases the deer for food. The deer tries to escape.

Fig.13.25: Interspecific competition for food. Tiger chases deer.

2. A snake captures and swallows a rat. The rat tries to escape.

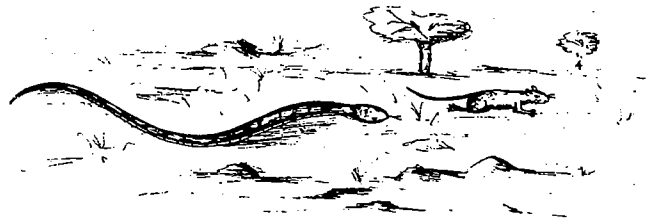


Fig.13.26: Interspecific competition for food. Snake chases rat.

3. A snake and fish have competition.

4. There is competition between man and mosquito. A mosquito bites a man. Man kills the mosquito.

5. A very good example for competition is *Paramecium. P. caudatum* and *P. aurelia* can be cultured independently in separate cultures for any number of days by supplying bacteria as food.

But, when the two species are cultured in the same culture, *P.caudatum* is eliminated from the culture due to competition. This is because *P.aurelia* has faster growth rate.

Competitive Exclusion Principle (Gause's Principle)

Competitive exclusion principle states that two species with identical requirements cannot co-exist together. Of the two species, one will be eliminated.