Chapter 58

Population, Biotic Community & Succession

- **Biotic community** is a grouping of different but interacting population of different species which live harmonious in a given locality, eg. pond, forest community etc.
- Each member of biotic community is called **species**.
- It is represented by **population**.

POPULATION

- **Population** is a group of individuals of the same species within a community occupying a particular space, has various characteristics which are unique possession of the group.
- **Population ecology** is the study of all aspects of a population and the various factors affecting it in its growth, density, size, multiplication, natality, mortality, competition etc.
- **Population density** is the number of individuals of a species per unit area or space at a given time.
- The inherent ability of a population to increase is termed **natality**. In broader sense **natality** is the production of new individuals of any organisms per unit of population per unit time through hatching, birth, germination or vegetative propagation.
- **Mortality** is the rate of death of individuals per unit time *i.e.*, number of individuals dying in a given period of time.
- **Population dispersal** is the movement of individuals or their reproductive products into and out of population area.
- Population dispersal **takes place in three forms** : **emigration** (one way outward movement), **immigration** (one way inward movement) and **migration** (periodic departure and return).
- The number of individuals added per unit population per unit time due to higher rate of births and immigrations over the rate of deaths and emigration is called **population growth**.
- Population have characteristic patterns of increase called **population growth forms** which are differentiated into two types **- J- shaped growth form** and **S-shaped growth form**.
- The **J-shaped** curve is a biopotential curve when environmental resistance is zero; it is **produced because larger populations increase more rapidly than smaller ones**.
- The **J-shaped curve** shows three stages: **lag phase**, **exponential phase** and **crash phase**.
- In **lag phase** there is a slow rise in population as the initial size of the population is very small.
- During **exponential phase**, the population size rises rapidly.
- A point is reached when population declines suddenly due to mass scale deaths. It is called **crash phase**.
- The J type of growth pattern can be **easily observed in algal blooms**, **some insects, annual plants and the lemmings of Tundra**.
- The **S-shaped curve (sigmoid curve)** is generated when a population approaches the environment's carrying capacity.
- The S-shaped curve shows three phases –
  - **Early phase** (**Lag phase**): Little or no growth takes place due to small size of population and lack of adaptation;
  - **Middle phase** (**Log phase or exponential phase**): There is geometrical increase in population size owing to abundance of food and other favourable conditions.
  - **Stationary phase** (**Zero growth or Plateau rate**): Birth and death rates are equal, the population stabilizes around the carrying capacity of the environment.

Table : Differences between J-shaped and S-shaped growth forms of population.

	J-shaped population growth form	S-shaped population growth form
1.	It occurs in erruptive type of population	It is found in stable type of population
2.	An equilibrium is never reach in population size	An equilibrium is reached when the size of population approaches the carrying capacity of the area.
3.	Exponential phase is very rapid	Exponential phase is comparatively less rapid
4.	A phase of deceleration never occurs	A phase of deceleration occurs before equilibrium is reached.
5.	Environmental resistance does not operate to slow down exponential phase	Environmental resistance begins to operate in slow down exponential phase.
6.	Population grows well beyond the carrying capacity of the area	Population seldom grows beyond the carrying capacity of the area.
7.	A crash phase occurs at the end of J-shaped growth.	A crash phase does not occur.

- S-shaped growth curve is **seen more frequently as** in **yeast cells grown in laboratory and human population**.
- The **carrying capacity** of habitat/locality/ environment is the **maximum number of individuals of a population that can be supported in a given time**.
- The number or percentage of the individuals in a population in different age groups is called **age distribution**.
- In ecology **three different type of age groups** have been recognized, these are – **pre-reproductive**, **reproductive** and **post-reproductive**.
- The **age distribution** in a population may be **graphically represented in the form of an age pyramid** showing the number of individuals in different age groups.
- Age pyramids are of **three types**. These are –
  - **Triangular** - The number of pre-reproductive individuals is very large.
  - **Bell-shaped** – The number of pre-reproductive and reproductive individuals is almost equal.
  - **Urn shaped** – The number of reproductive age group is higher than individuals of pre-reproductive age group.
- **Biotic potential** (r) of a population is the potential ability or inherent power of a population to increase in the number when the age disribution in the population is stable and all environmental conditions are optimum.
- The sum of environmental factors that limits the population size and keeps check on the realization of full biotic potential is called **environmental resistance**.
- Environmental resistance **rises with the size in population size**.

BIOTIC COMMUNITY

- Members of biotic community depends upon one another for food, reproduction, dispersal and productions, the phenomenon is called **species inter-dependence / interaction**.
- **Three types of interactions** occurs amongst different members of a biotic community - **neutral**, (no one is harmed neither benefitted), **positive** (beneficial) and **negative** (antagonistic).
- The relationship between two living individuals of different species in which one is benefitted while the other is neither harmed nor benefitted is **commensalism**.
- **Examples of commensalisms** are –
  - The colonial hydrozoan *Hydractina* attaches itself to whelk shells inhabited by hermit crab.
  - The woody stem of lianas is closely associated with supporting tree.
  - Orchids, bromeliads, *Usnea, Alectoria* (**epiphytes**) grow on another plant for shelter only but are nutritionally independent. The large plant is neither benefitted nor harmed by the growth of epiphytes.
  - Some plants grow on the surface of animals (**epizoans**). *Basicladia* grows on the back of fresh water turtle.

- The pilot fish (*Remora*) always accompanies shark.
- Sucker fish (*Echeneis*) attaches itself to under surface of shark.

- Some animals are called **ectocommensals** or **epizoite**. They are associated with other animal for anchorage and protection. Examples are, *Kerona* on *Hydra*, annelids on cray fish, barnacles which attach themselves to the backs of whales.
- Commensalism may also be **internal** such as *Escherichia coli* found in human colon.
- **Mutualism** is the interaction in which growth and survival of both populations is benefitted and neither can survive under natural conditions without the other.
- Mutualism is also termed as **symbiosis** and is generally **obligatory**.
- **Examples of mutualisms** are –
  - The sea anemone *Calliactis* attaches itself to a shell used by hermit crab.
  - Herbivorous ruminants contain a vast number of cellulose digesting bacteria and ciliates.
  - Formation of root nodule of leguminous plants by *Rhizobium*, a bacterium.
  - *Anabaena* (a nitrogen fixing blue green alga) is associated with water fern *Azolla.*
  - **Mycorrhiza** is a mutualistic interaction in which a fungus (e.g. *Boletus*) and a root (e.g. *Pinus*) are involved.
  - **Termites** harbour cellulose digesting **flagellates** in their alimentary canal.
  - Swollen thorn of acacias give shelter to ants.
  - The body of lichen is made up of a matrix formed by a fungus, within the cells of which an alga is embedded.
  - Some unicellular photosynthetic plants, known as **zoochlorellae**, live symbiotically in the outer tissue of certain sponges and coelenterates. *Chlorella vulgaris* lives within the gastrodermal cells of *Hydra.*
- **Proto-cooperation** is **non-obligatory mutually beneficial relationship in which both the populations benefit**, e.g., crocodile bird rids crocodile of leeches sticking inside its mouth.
- **Amensalism** is an **interaction between two living organisms in which one population is inhibited (not allowed to grow) and the other is not affected**. E.g., penicillin does not allow *Staphylococcus* bacterium to grow and *Trichoderma* inhabits the growth of fungus *Aspergillus* and *Convolvulus arvensis* inhibits the germination and growth of wheat.
- Amensalism is of **two types** –
  - **Antibiosis –** Some micro-organisms secrete certain chemical substances which kill or inhibit other micro-organisms. These substances are called antibiotics and phenomenon is called antibiosis.
  - **Allelopathy –** Some higher plants also secrete certain chemical substances which inhibit the growth of other plants. This phenomenon is called allelopathy, eg, roots of carrot grass or

Table : Interaction of species.

	Interaction	Effect on Species I	Effect on Species II	Result
I.	Neutral Interactions	Zero	Zero	Neither benefitted nor harmed
II.	Negative Interactions			
	1. Competition	(–)	(–)	Mutual inhibition
	2. Predation	(+)	(–)	One is benefitted, other is harmed.
	3. Parasitism	(+)	(–)	Parasite benefitted, host harmed
	4. Amensalim	(–)	Zero	One harmed, other uneffected
III.	Positive Interactions			
	5. Scavenging	(+)	Zero	Useful to scavenger, no effect on other
	6. Commensalism	(+)	Zero	Commensal benefitted, no effect on other
	7. Protocooperation	(+)	(+)	Both benefitted but association not obligatory
	8. Mutualism	(+)	(+)	Both benefitted, association obligatory.

The different types of parasites		
Ectoparasite	:	live on the body of the host (e.g., sucking lice)
Endoparasite	:	live inside the host body (e.g., *Ascaris*, malarial parasite)
Partial/temporary parasite	:	spend only a part of their life cycle on the host (e.g., leech, female mosquito)
Permanent parasite	:	spend their entire life as parasite (e.g., *Ascaris*, lice)
Holoparasite	:	completely dependent on their host for all requirement (e.g., *Rafflesia*)
Hemiparasite / semiparasite	:	obtain a part of their nourishment from host and the rest is prepared by them own (e.g., *Viscum, Loranthus*)
Stem parasite	:	live on the host stem to obtain food (e.g., *Cuscuta, Loranthus*)
Root parasite	:	parasitic on host root (e.g., *Rafflesia*)
Pathogenic parasite	:	parasite causes diseases in the host (e.g., *Corynebacterium diptheriae* causes diptheria)
Non-pathogenic parasite	:	parasite do not harm the host (e.g., *Entamoeba coli*)
Hyperparasite	:	parasite that lives on another parasite (e.g., *Nosema notabilis* is the hyperparasite on myxosporidian)

congress grass (*Parthenium argentatum*) which is most troublesome terrestrial weed in India secrete trans – cinnamic acid which checks the growth of other plants.

- **Competition** is the relationship in which **each population adversely affects the other in the struggle** for resources in short supply.
- Competition is of **two types** as - **intraspecific** (between individuals of same species) and **interspecific** (between individuals of different species).
- **Predation** is an **interaction between members in which one population adversely affects the other by direct attack** (capture, kill and eat) but is nevertheless dependent on the other. The former is called **predators** and the latter is called **prey**.
- The carnivorous animals eat the other animals and the herbivorous animals eat the plants and so are predators.
- **Parasitism** is the relationsip between two living organisms in which **one organism resides on the body of the other living organism (host) and derives nourishment from its tissues**. It is always an one side relationship for the parasite which is always benefitted from the host.

Biotic community organization

- The number of species of plants, animals and other organisms that occur in a biotic community is called **species composition**.
- Species composition (type of species) differs from one ecosystem to another depending upon geography, topography and climate.
- Maximum species composition occurs in tropical rain forests and coral reef and minimum occurs in deserts and arctic regions.
- The total number of species and their relative abundance in a biotic community is **species diversity**.
- **Keystone species** is a species which has significantly large influence on the community structure and characteristics.
- Removal and decrease in the number of key stone species causes serious disruption in the community.
- **Critical link species** are species which play an imporant role in **supporting network species** by functioning **as pollinators, nutrient - circulators or absorbers**.
- **Ecotone** is defined as the place or area, where **two major communities meet & blend together**. It consists of species of both the communities.
- The tendency of ecotone to contain a greater number of species and a higher population density is called **edge effect**.
- The species which are found most abundantly in ecotone boundary are known as **edge species**.

Analysis of plant community

- **Communities are analysed for** –
  - Knowing the constituent species.
  - Relative abundance, cover and importance of species.
  - Study of variations within and between communities.
  - Recording of various types of communities.
  - Naming and classifying communities.
- Community characteristics are of **two types– analytical characters** and **synthetic characters**.

- **Analytical characters** are structural characteristics which can be directly observed or measured.
- Analytical characteristics, if measurable, are called **quantitative characters**, eg frequency, abundance, diversity, biomass, leaf size.
- Non–measurable analytical characters which can be observed are known as **qualitative characters**. eg, species composition stratification, periodicity, growth forms, dispersion, life forms.
- **Synthetic characters** are generalisations or abstractions which are derived from analytical characters, eg, constancy, fidelity, pattern, dominance, physiognomy.

BIOTIC OR ECOLOGICAL SUCCESSION

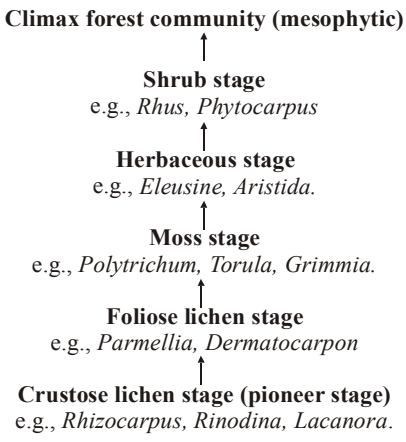
- **Biotic** or **ecological succession** (Hult, 1885) is the natural development of a series of biotic communities at the same site, one after the other till a climaxot community develops which does not evolve further because it is in perfect harmony with the environment of the area.
- A biotic community is influenced by **biotic factors**, **physico-chemical factors** and **geographical factors**.
- The **first biotic community** which develops in a base area is called **pioneer community**.
- **Climax community** is the stable, self perpetuating and final biotic community that **develops at the end of biotic succession** and is in perfect harmony with the physical environment.
- Climax community is also termed as **climatic climax community**.
- Climax community has **maximum diversity** and **niche specialization**.
- The various biotic communities that develop during biotic succession or the intermediate communities between the pioneer and climax communities are termed as **seral** or **transitional communties**.
- The entire sequence of development stages of biotic succession from pioneer to a climax community is known as **sere**.

Pioneer community (the first biotic community on base area) → **seral community** (the various biotic community that develop during successsion → **climax community** (the stable, self perpetuating and final biotic community)

- **Changes that occur during biotic succession** are –
  - Small short lived plants to large long-lived plants.
  - Unstable biotic community to stable biotic community.
  - Little diversity to high degree of diversity.
  - Greater niche specialization.
  - Increase in biomass.
  - Increase in soil differentiation.
  - Increase in human content of soil.
  - Aquatic or dry conditions to mesic conditions.
  - Simple food chains to complex food webs.
- Ecological succession is of **two types** – **primary** and **secondary succession**.
- **Primary succession** is a biotic succession which occurs on a **previously bare or unoccupied area**, e.g., new exposed rock area, sand dunes, igneous rocks, deltas etc.
- **Secondary succession** is a biotic succession that occurs in an area from **which a community has been removed and where nutrients and conditions for existence are present**, e.g., cut over forest, abandoned crop land, ploughed field.
- Successions are variously designated as - **xerosere/lithosere** (succession on bare rock), **hydrosere** (succession in water), **psammosere** (succession on sand).
- Structure of hydrosere is depicted in the following flowchart :

Climax forest community (mesophytic)
e.g., Temperate mixed, Tropical rain, Tropical deciduous.
↑
Woodland stage
e.g., *Salix, Poplus, Almus, Cornus.*
↑
Sedge meadow stage
e.g., *Juncus, Cyperus, Eleocharis, Carex.*
↑
Reed swamp stage
e.g., *Sagittaria, Phragmites, Typha, Scirpus.*
↑
Floating stage
e.g., *Nymphaea, Trapa, Azolla, Lemna, Wolffia, Pistia.*
↑
Submerged stage
e.g., *Elodea, Hydrilla, Vallisneria, Utricularia, Potamogeton.*
↑
Pioneer stage
e.g., *Diatoms, Bacteria, Cyanobacteria, Green algae.*

- The **structure of lithosere or xerosere** is shown by the following flow chart.



Importance of biotic succession

- Sequence of biotic succession is usually fixed. Ecologists can immediately recognize the seral stage of a biotic community found in an area.
- It tells us how a biotic seral stage like grasses and herbs of a pasture can be maintained by net allowing the biotic succession to proceed further through interference like grazing and fire.
- Information gained through biotic succession is used in having controlled growth of one or more species by preventing their superiors to invade the area, eg., maintainance of teak forest.
- Dams are protected by preventing situation and biotic succession to occur.
- It gives information about the techniques to be used during reforestation and afforestation.

Some other types of succession

- **Autogenic succession** - After the succession has begun, in most of the cases, it is the community itself which, as a result of its reactions with the environment, modifies its own environment and, thus causing its own replacement by new communities. This course of succession is known as autogenic succession.
- **Allogenic succession** - In some cases replacement of one community by another is largely due to forces other than the effects of communities on the environment. This is called allogenic succession and it may occur in a highly disturbed or eroded area or in ponds where nutrients and pollutants enter from outside and modify the environment and in turn the communities.
- **Autotrophic succession** - It is characterized by early and continued dominance of autotrophic organisms like green plants. It begins in a predominantly inorganic environment and the energy flow is maintained indefinitely. There is a gradual increase in the organic matter content supported by energy flow.
- **Heterotrophic succession** - It is characterized by early dominance of heterotrophs, such as bacteria, actinomycetes, fungi and animals. It begins in a predominantly organic environment and there is a progressive decline in the energy content.
- **Induced succession** - Activities such as overgrazing, frequent scraping, shifting cultivation or industrial pollution may cause deterioration of an ecosystem. Agricultural practices are retrogression of a stable state to a young state by man's deliberate action.
- **Retrogressive succession** - It means a return to simpler and less dense or even impoverished form of community from an advanced or climax community. In most cases, the causes are allogenic, *i.e.,* forces from outside the ecosystem become severe and demanding. *For example*, most of our natural forest stands are degrading into shrubs, savanna or impoverished desert-like stands by the severely grazing animals brought from surrounding villages. Excessive removal of wood, leaf and twig litter also leads to retrogressive succession.
- **Cyclic succession** - It is of local occurrence within a large community. Here cyclic refers to repeated occurrence of certain stages of succession whenever there is an open condition created within a large community.

End of the Chapter