CHAPTER

4

COMMUNITY ECOLOGY

The group of organisms that live together in a particular ecosystem are known as a **community**. With due course of time different species have made many complex adaptations for community living, evolving together and forging relationships that give the community its features and stability.

What is a Community?

- It is an assemblage of individuals of different species living close enough together for prospective interaction.
- A community differ in its species richness, the number of species it have, and in evenness of different species.

Communities differ from each other

- In species diversity
- In species richness
- In relative abundance of different species.

The factors which shape community structure

The structure of a community is because of many interacting factors, both in abiotic and in biotic world. There are many important factors that influence community structure:

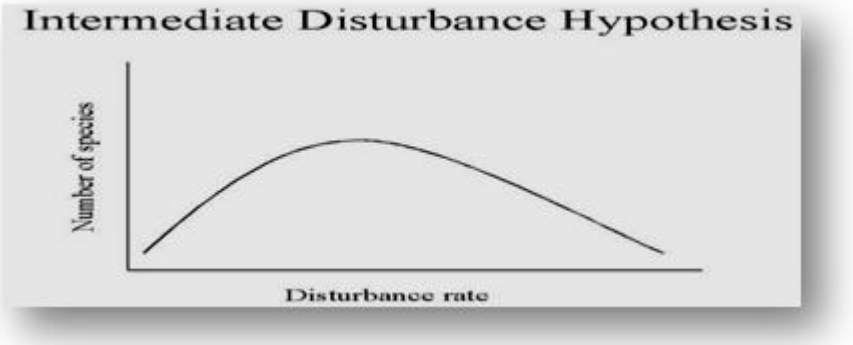
- **The climate of community's location.**
- **Geography of the community's location.**
- **The heterogeneity or patchiness of the environment**

  Each part of environment varies in its resources composition
- **Rate of disturbances, or disruptive events.**
- **Relationship between organisms.**
- **Opportunities for migration of pioneer communities**

  Far and smaller island have lower biodiversity
- **Behaviour of predators**

  A predator helps in reduction of competition by eating competitive dominants
- **Level of disturbance**

According to intermediate **disturbance hypothesis (IDH)** species diversity is maximum when ecological disturbance is neither too high nor too low.



The chance events during the history of community can also influence community's composition. Let's suppose a single seed immigrate into the soil of a particular area. If this seed is going to take root there, then this species may establish itself. Then after some time this species will become a dominant species by excluding other species. But if this seed is going unsuccessful in sprouting, than many other potential species can establish their self and can become dominant species of that area.

Ecological Characteristics of a community:

Species diversity

The species composition of a community is dependent on its locality. The complexity of a community is majored by its species composition. It is majored by its **species richness** and by **species evenness.** Greater the numbers of species it have and more even abundances of these species leads to a greater species diversity.

Species diversity has two components:

(i) **Species richness**: it refers to the number of species in a community.

(ii) **Species evenness**: it refers to the abundance of different species in a community. Evenness is highest when species are present in almost equal proportion.

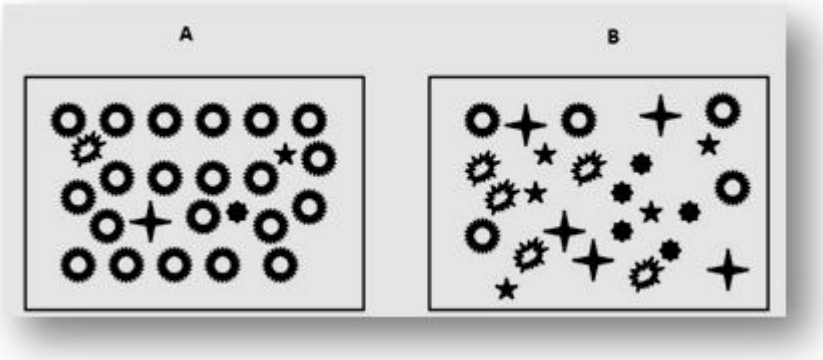


Fig. : Both communities A and B contain 5 species each. That means both have the samedegree of species richness. But in community A, one species is present in large number andthe others are few in number. Whereas, in community B, all the five species are present in thesame proportion. As a result, species evenness of community B is higher than that ofcommunity A. Communities which have higher evenness have higher species diversity.

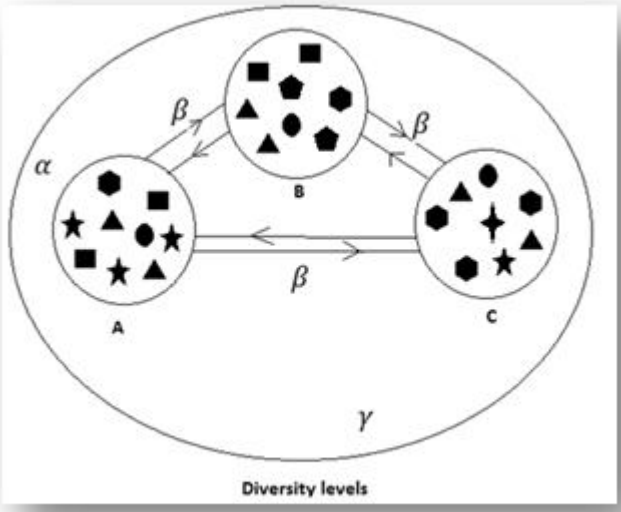
Species diversity can be studied at 3 levels:

(i) **Alpha diversity**: Refers to the number of species within a habitat or a local site.

(ii) **Beta diversity**: Refers to total number of different species present between 2 habitats.

(iii) Gamma diversity: Refers to the total number of different species present in all habitats within a region.

- **These term were introduced by R. H. Whittaker**



Community	■	⬢	▲	●	★	✦	⬟
A	2	1	2	1	3	-	-
B	2	1	2	1	-	-	1
C	-	3	2	1	1	1	-

Diversity			
Alpha	A = 5	B = 5	C = 5
Beta	A—B = 6	B—C = 7	C—A = 6
Gamma	A—B—C = 7		

Diversity index

It is a quantitative measure that reflects how many different types of species are there in a community and at the same time it also takes into account how evenly the individuals of different species distributed.

OR

It can also be defined as a numerical measurement of species diversity in a community. Diversity index gives us important information about community composition than simply species richness; it also takes the relative abundances of different species into consideration.

In this way diversity index becomes an important tool for biologists in understanding community structure and function.

How to measure diversity index?

Simpson index and Shannon diversity index are two ways to calculate the diversity of a particular community.

1. **Simpson index**

- **Formula for Simpson diversity index**

$$\text{Simpson Index (D)} = \frac{1}{\sum_{i=1}^{s} p_i^2}$$

or

$$D = 1 - \left(\frac{\Sigma\, n(n-1)}{N(N-1)}\right)$$

Where:

- **n = it is the total number of organisms of a particular species**
- **N = it is the total number of organisms of all species**

Here, value of D ranges between 0 and 1. In this index, 1 represents infinite diversity and 0, no diversity.

Example:

	Number (n)	n(n-1)
rabbit	2	2
snails	8	56
Inland typan	1	0
fox	1	0
rhino	3	6
Total	15	64
	N = 15	n(n-1) = 64

After putting the values into the formula for Simpson's Index:

$$D = 1 - \left(\frac{\Sigma\, n(n-1)}{N(N-1)}\right)$$

$$D = 1 - \left(\frac{64}{15(14)}\right)$$

Simpson's Index of Diversity comes out 0.7.

Shannon diversity index (H)

As like Simpson index, the Shannon diversity index (H) is also used to characterize species diversity of a community. Shannon's index also accounts for both abundance and evenness of the species present in a community.

How to calculate Shannon index:

- The proportion of species (i) relative to the total number of species (pi) is calculated
- And then it is multiplied by the natural logarithm of this proportion (lnpi).
- The resulting product is summed across species, and multiplied by -1:]

$$\text{Shannon Index (H)} = -\sum_{i=1}^{s} p_i \ln p_i$$

Where:

- H = the Shannon diversity index
- Pi = fraction of the entire population made up of species i
- S = numbers of species encountered
- " = sum from species 1 to species S

To calculate the index:

1. Divide the number of individuals of species 1 which you have to find in your sample by the total number of individuals of all species. And this is known **as Pi.**
2. Then multiply this Pi by its natural log (Pi * ln Pi)
3. Again repeat this for all of the different species that you have in your sample.
4. Sum all the - (Pi * ln Pi) products to get the value of H

For example;

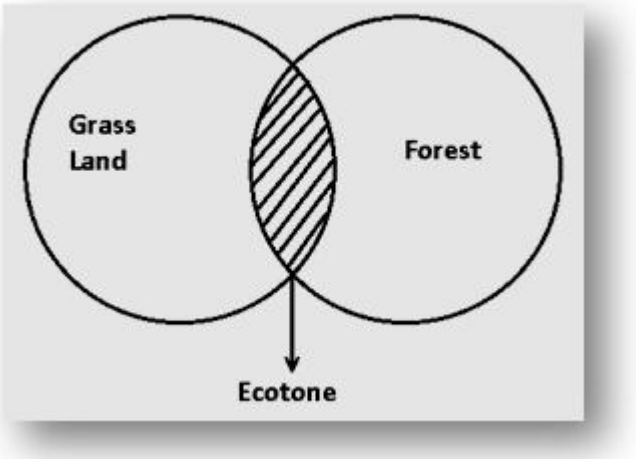
Birds	N_i	P_i	ln P_i	- (P_i * ln P_i)
Robin bird	96	.96	-.041	**.039**
Eagle	1	.01	-4.61	**.046**
vulture	1	.01	-4.61	**.046**
Crow	1	.01	-4.61	**.046**
sparrow	**1**	**.01**	**-4.61**	**.046**

H = 0.223

If there is high values of H, it means more diverse the communities is. "0" value of h means that that this community only bears a single species. Because in this case Pi will be equal to 1 and when it will multiplied by ln Pi which would be equal to zero? An even distribution of species cause high value of **"H"**. So high value of h not only means that there is species richness in a particular community, it also means that this species are also more evenly distributed in this community.

Ecotone

- An ecotone is a zone of transition between two communities.
- For e.g. the mangrove forests is an ecotone between marine and terrestrial ecosystem, grassland (between forest and desert), estuary (between fresh water and salt water) and river bank or marsh land (between dry and wet).



- It can be narrow as between grassland and forest and can be wide as in case forest and desert.
- A mature or well developed ecotone is more bio-diverse as compared to its adjacent communities.
- As a zone of transition between two adjacent communities the climatic conditions of ecotone is bit different as compared to both adjacent communities. There is a slight difference in parameter like temperature, soil texture as well as in sunlight input.
- As climatic conditions in ecotone are only slight different from adjacent communities so an ecotone zone is habitable for organisms of these communities and due to its specific climatic conditions many native species are only found in this ecotonic zone only. This effect of enhanced biodiversity is known as **edge effect**.

Edge Effect – Edge Species

- Edge effect is defined as changes in biodiversity composition and in community structure that occurs at the transition zone between two habitats.
- Number of some species and their relative abundance is high in the ecotone, much greater than either of adjacent community. This effect is known as "**edge effect**".
- The inhabitant organisms of this zone are known as **edge species**.

Important:

Most of time the edge effect of terrestrial ecosystems is especially applicable for bird's species. Birds have a greater density in such a mixed type of habitat as of ecotone. For example: Relative density of birds is high in ecotonic zone between desert and forest.

For a stable community, two components are important:

- **Resilience:** It is the ability of a community to recover after facing a disturbance or displacement.
- **Resistance:** It is the ability to avoid disturbance (any event that can alter the structure of a community) or displacement (shifting of the community to some other place).

Key biotic component of Ecological community

1. Dominant species

- In a community, a species of plant or animal is present in larger number than other species.
- It comprises the greatest biomass in an ecosystem.
- Such species are better at obtaining resources, resisting diseases and keeping in check the competition.
- Usually, the name of the dominant species is given to the community.

Eg, Redwood forest, coral reef.

2. Keystone species

- keystone species A species whose presence and role within an ecosystem has a disproportionate effect on other organisms within the system.
- Their effect on the composition of a community is greater than their abundance might suggest.
- They help maintain species richness of a community.

This can be explained with an example:

Sea otters feed on sea urchins and sea urchins feed on kelp. In areas with abundant sea otters, sea urchins are less and as a result, plentiful kelp. In other areas where sea otters are less, sea urchins are more and kelp is absent.
In the last few decades, killer whales' prey species has declined. This has led it instead to prey on sea otters. In turn, this has led to abundance of sea urchins and as a result, destruction of kelp forests.

3. Foundation species (Ecosystem engineers)

- These species cause physical changes in the environment that affects the structure of the community.
- They can occupy any trophic level in the food web.
- They may alter the environment through their behavior which can benefit other organisms.

Example

- Corals build coral reefs that is a habitat for many other species.
- Beavers remove sticks, leaves, bark of trees from the surface of the forest and use these to build a dam in a nearby stream or river. The resulting pond provides a suitable habitat for a variety of aquatic animals. They, therefore, increase biodiversity and help in flood control.

SOLVED EXAMPLES

1. Transition zone between vegetational types is **[JNU-2012]**
   (a) Ecotone (b) Ecotype
   (c) Ecocline (d) Ecological succession

Soln. **Correct option is (a)**

2. Plants growing on sand are called as **[HCU-2013]**
   (a) Chasmophytes (b) oxylophytes
   (c) lithophytes (d) psammophytes

Soln. Psammophytes are pioneer plants which can tolerate high temperatures and dryness of a desert or a sand dune.

Correct option is (d)

3. A sequence of species through which an organic molecule passes in a community is referred to as
   (a) pyramid of energy (b) food chain **[JAM-2008]**
   (c) food web (d) nutrient cycle

Soln. A food chain describes how energy and nutrients move through an ecosystem. At the basic level there are plants that produce the energy, then it moves up to higher-level organisms like herbivores. In the food chain, energy is transferred from one living organism through another in the form of food. When all food chain of a community considered at a single time then it is known as food web.

Correct option is (c)

4. In ecotone, some species become abundant and they are called **[JAM-2016]**
   (a) sibling species (b) endemic species (c) rare species (d) edge species

Soln. Edge effects refer to the changes in population or community structures that occur at the boundary of two habitats (ecotone). Sometimes the number ofspecies and the population density of some of thespecies in the ecotone is much greater than either community. For example bird species. Species which are present in ecotone region are known as edge species.

Correct option is (d)

5. A species introduced into an area from somewhere else is called — species. **[JNU-2015]**
   (a) mutant (b) cultivar (c) exotic (d) native

Soln. Exotic species, which are also known as alien species, invasive species, non-indigenous species, and bioinvaders, are species of plants or animals that are growing in a nonnative environment. Alien species have been moved by humans to areas outside of their native ranges.

Correct option is (c)

6. Keystone species **[B.H.U.-2015]**
   (a) exert impact disproportionate to abundance (b) detect presence of pollutants
   (c) are prone to extinction (d) are of direct human value

Soln. A keystone species is often a dominant predator whose removal allows a prey population to explode and often decreases overall diversity. Other kinds of keystone species are those, such as coral or beavers that significantly alter the habitat around them and thus affect large numbers of other organisms. Keystone species exert impact disproportionate to their abundance in a community.

Correct option is (a)

PRACTICE QUESTIONS

PART-A [MCQ]

1. Which of these represent a seral community?
   (a) Complex food chains and food webs (b) High biomass
   (c) Large individuals (d) Low diversity
2. Difference between dominant and keystone species is that
   (a) Dominant species are the most abundant while keystone species have an ecological role in the community
   (b) Keystone species are most abundant while dominant species have an ecological role in the community
   (c) Dominant species help maintain species richness of a community but keystone species do not.
   (d) Keystone species are the first to colonize a barren land and dominant species invade it later when conditions are favourable.
3. What is the other force called, if the two opposite forces operate in the growth and development of every population and one of them is related to the ability to reproduce at a given rate?
   (a) Mortality (b) Environmental resistances
   (c) Biotic control (d) All of the above
4. Extinction of which species will lead to destruction of all the other members in the community?
   (a) Dominating species (b) Keystone species
   (c) Both (a) and (b) (d) None of the above
5. Transition area between two biomes is called?
   (a) Transition zone (b) Ecotone
   (c) Ecotype (d) Biosphere
6. What is the population of individuals called that share a same genetic stock but differ in their morphology?
   (a) Ecotone (b) Ecad
   (c) Twins (d) None of the above
7. What is the tendency towards increased variety and density of species at community junction called?
   (a) Variability (b) Vital index
   (c) Edge effect (d) Biotic potential
8. A community is said to be _____, that have high species diversity and low dominance
   (a) unproductive but stable (b) productive but less stable
   (c) productive and stable (d) none of the above
9. Following four types of species were observed in a community:
   A) Species A has a large effect on community because of its abundance
   B) Species B has a large role in community out of proportion to its abundance
   C) Status of species C provides information on the overall health of an ecosystem
   D) Significant conservation resources are allocated to species D which is single, large and instantly recognizable

According to above description species A, B, C and D are called respectively

(a) Dominant, Keystone, Indicator and Flagship
(b) Keystone, Flagship, Dominant and Indicator
(c) Keystone, Dominant, Indicator and Flagship
(d) Flagship, Dominant, Keystone and Indicator

PART-B [MSQ]

10. Which species exert major effects on communities?
(a) Dominant species
(b) Keystone species
(c) Foundation species
(d) Endemic species

11. Which of the following could be an explanation for a species to become dominant in a community?
(a) It has all the dominant alleles in its gene.
(b) They can exploit limited resources like water or nutrients really well.
(c) They can avoid predation and impact of disease really well.
(d) They have high biotic potential than other species in the community

12. Which of the following statements about communities are correct?
(a) The distribution of almost all organisms is probably affected to some extent by both abitoci gradients and interaction with other species
(b) some animal species distribution within community are linked to other species
(c) Many plant species in communities seem to be independetly distributed
(d) The trophic structrue of a community describes abiotic factors such as rainfall & temperature affecting members of the community

13. Why bological communities changes with time
(a) Because new species move in, displacing old species
(b) old species evolve into new species
(c) each stage modifies the environment and adapts for a later stage
(d) None of above

ANSWER KEY

PART-A [MCQ]

1. (d)	**2.** (a)	**3.** (b)	**4.** (b)	**5.** (b)
6. (b)	**7.** (c)	**8.** (a)	**9.** (a)	

PART-B [MSQ]

10. (b)	**11.** (d)	**12.** (a, b, c)	**13.** (c)