ECOLOGY

SYNOPSIS

Chapter 13 – ORGANISMS AND POPULATIONS

Ecology is a branch of Biology which studies the interactions among organisms and between the organism and its physical (abiotic) environment.

Ecology is basically concerned with four levels of biological organisation – organisms, populations, communities and biomes.

ORGANISM AND ITS ENVIRONMENT

Ecology at the level of organisms is essentially physiological ecology. It tries to understand how different organisms are adapted to their environments in terms of not only survival but also reproduction.

Life exists not only in a few favourable habitats but even in extreme and harsh habitats. Variation in the physical and chemical conditions of different habitats is because of the abiotic components and the biotic components with which they constantly interact.

Every organism has its own niche. **Niche** is a well defined range of conditions that an organism can tolerate, diversity in the resources it utilises and the distinct functional role it plays in the ecological system.

Major Abiotic Factors:

The major abiotic components / factors are temperature, water, light and soil.

Temperature:

The average temperature on land varies seasonally. The geographic distribution of different species is determined by the levels of their thermal tolerance.

Organisms which can tolerate and survive in a wide range of temperatures are called **eurythermal** organisms. **Stenothermal** organisms are organisms which are restricted to a narrow range of temperatures.

Water:

Life on earth originated in water and is unsustainable without water. Special adaptations are required for organisms to live in deserts where its availability is limited. Water also determines the productivity and distribution of plants. The quality of water (chemical composition, pH, salinity, etc.) is also important for organisms living in different aquatic habitats.

Organisms which are tolerant to a wide range of salinities are called **euryhaline** organisms. **Stenohaline** organisms are organisms which are restricted to a narrow range of salinities.

Light:

Light is the chief source of energy for photosynthesis in autotrophs. Many plants depend on sunlight for their photoperiodic requirement for flowering. Animals also use the diurnal and seasonal variations in light intensity and duration (photoperiod) as signals for timing their foraging, reproductive and migratory activities. Light is closely

linked to temperature. The UV component of the spectrum is harmful to many organisms.

Soil:

Soil characteristics like soil composition, grain size and aggregation determine the percolation and water holding capacity of the soils. The vegetation in any area is determined by soil characteristics, pH, mineral composition and topography. This dictates the type of animals that can be supported. In the aquatic environment, the sediment-characteristics determine the type of benthic animals that can survive there.

Responses to Abiotic Factors:

Organisms manage stressful conditions by homeostasis. **Homeostasis** is the maintenance of a relatively constant internal environment (within the body) despite varying external environmental conditions.

Methods by which orgnaisms cope with the changing environmental conditions / stressful external conditions:

(a) Regulate:

Organisms which maintain homeostasis (thermoregulation, osmoregulation, etc.) irrespective of any change in the external environment are called **regulators**.

(b) Conform:

The organisms which cannot maintain a constant internal environment (whose internal environment changes according to the external environment) are called **conformers**. 99% of animals and nearly all plants cannot maintain a constant internal environment.

If the stressful external conditions are localised or remain only for a short duration, the organism has two other alternatives – either they migrate or suspend.

(c) Migrate :

The organism temporarily moves away from the stressful habitat to a more favourable area and returns when stressful period is over. This is called **migration**.

(d) Suspend:

Many organisms tide over unfavourable conditions by remaining inactive or dormant during that period.

Ex: formation of thick-walled spores in bacteria, fungi, etc., dormancy of seeds and other vegetative reproductive structures in higher plants, hibernation (winter sleep). aestivation (summer sleep) in animals, diapause, etc.

Adaptations:

Adaptation is any morphological, physiological or behavioural attribute of the organism that helps it to survive and reproduce in its habitat.

Adaptations in desert plants and animals:

Desert plants and animals have developed mechanisms to minimize loss of water and to store water.

Adaptations in colder climates:

Many mammals generally have shorter ears and limbs to minimise heat loss (Allen's Rule – morphological / anatomical adaptation). Aquatic mammals like seals in

the polar seas have a thick layer of fat called blubber below their skin that acts as an insulator.

Adaptations in high altitudes:

Low atmospheric pressure and very low oxygen content in high altitudes cause **altitude sickness** (nausea, fatigue and heart palpitations). But, gradually the body gets acclimatised and stops experiencing altitude sickness because of physiological adaptation.

Behavioural adaptations for stressful environmental conditions:

Animals also exhibit behavioural adaptations to overcome stressful environmental conditions.

POPULATIONS:

Population Attributes:

Population is a group of individuals of any species that live in a well defined geographical area, share or compete for similar resources and potentially interbreed.

A population has certain attributes that an individual organism does not. They are;

(a) Birth rate:

It is the per capita births in a population, i.e. it is the increase in numbers with respect to members of the population. An individual has birth and not birth rate.

(b) Death rate:

It is the per capita deaths in a population, i.e. it is the decrease in numbers with respect to members of the population. An individual has death and not death rate.

(c) Sex ratio:

It is the ratio between the males and the females in a population. An individual is either a male or a female but a population has a sex ratio.

(d) Age structure:

A population at any given time is composed of individuals of different ages.

The per cent individuals of a given age or age group in a population is called **age distribution**. **Age pyramid** is the graphic representation obtained by plotting age distribution for the population. The shape of the pyramids reflects the growth status of the population – whether it is (a) growing, (b) stable or (c) declining.

Population size is more technically called **population density** (N).

Population Growth:

The size of a population for any species keeps changing in time, depending on various factors including food availability, predation pressure and adverse weather. The population density in a given habitat during a given period fluctuates due to changes in four basic processes. They are;

(a) Natality:

It is the number of births during a given period in the population that are added to the initial density.

(b) Mortality:

It is the number of deaths in the population during a given period.

(c) Immigration:

It is the number of individuals of the same species that have come into the habitat from elsewhere during the time period under consideration.

(d)Emigration:

It is the number of individuals of the population who left the habitat and gone elsewhere during the time period under consideration.

Natality and immigration contribute to an increase in population density whereas; mortality and emigration contribute to a decrease in population.

If **N** is the population density at time **t**, then its density at time **t +1** is;

$$N_{t+1} = N_t + [(B + I) - (D + E)]$$

where, **B** is the number of births (natality), **I** is the number of immigrants, **D** is the number of deaths (mortality) and **E** is the number of emigrants.

The population density will increase if the number of births plus the number of immigrants **(B + I)** is more than the number of deaths plus the number of emigrants **(D + E)**, otherwise it will decrease.

Growth Models:

(a)Exponential growth:

The population grows in an exponential or geometric fashion when the resources in the habitat are unlimited.

The integral form of the exponential growth equation is;

$$N_t = N_0 e^{rt}$$

where,

N_t = Population density after time **t**

N_0 = Population density at time zero

r = Intrinsic rate of natural increase

e = Base of natural logarithms (2.71828)

Exponential growth model is not realistic.

(b)Logistic growth:

A population growing in a habitat with limited resources shows an initial lag phase, followed by phases of acceleration and deceleration and finally an asymptote, when the population density reaches the carrying capacity. When population density (**N**) is plotted in relation to time (**t**), a sigmoid curve is obtained. This type of population growth is called ***Verhulst-Pearl Logistic Growth***. It is represented by the following equation;

$$dN/dt = rN\left[\frac{K - N}{K}\right]$$

Where,

N = Population density at time t

r = Intrinsic rate of natural increase

K = Carrying capacity

Since resources for growth for most animal populations are finite and become limiting sooner or later, the logistic growth model is considered a more realistic one.

Population Interactions:

Animals, plants, microbes and other kinds of organisms interact in various ways to form a biological community. Interaction between populations of two different species is called **interspecific interaction**. The interactions could be beneficial, harmful or neutral to one of the species or both.

Species A	Species B	Name of Interaction
+	+	Mutualism
-	-	Competition
+	-	Predation
+	-	Parasitism
+	0	Commensalism
-	0	Amensalism

'+' → Beneficial interaction
'-' → Harmful interaction
'0' → Neutral interaction

(a) Predation:

It is a type of interaction in which a larger organism called predator of higher trophic level feeds on another organism called prey of lower trophic level. In this type of interaction, predator is benefitted while the prey is harmed.

Predators act as links for energy transfer across trophic levels and also keep prey populations under control.

Agricultural pest control by **biological control** methods is based on the ability of the predator to regulate prey population.

(b) Competition:

It is a type of interaction in which two organisms (of the same species or unrelated species) compete for the same resources. Both the partner's may be harmed.

- **Interference competition:** Interference competition is a type of competition in which the feeding efficiency of one species might be reduced due to the interfering and inhibitory presence of the other species, even if resources (food and space) are abundant.
- **Gause's Competitive Exclusion Principle:** It states that two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eventually eliminated.
- **Resource partitioning:** If two species compete for the same resource, they could avoid competition by choosing different times for feeding or different foraging patterns.
- **Competitive release:** A species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range when the competing species is experimentally removed.

(c) Parasitism:

Parasitism is a type of interaction in which one organism depends on the other completely for its food and shelter. One partner is benefited while the other is harmed.

Parasites may be ectoparasites or endoparasites.

Ectoparasites are parasites that feed on the external surface of the host organism.

Endoparasites are parasites that live inside the host body at different sites.

Brood parasitism:

It is a kind of parasitism in which the parasitic bird lays its eggs in the nest of its host and lets the host incubate them.

Commensalism:

It is an interaction in which one species benefited and the other is neither harmed nor benefited.

Ex: egrets foraging with grazing cattle, clown fish lives among the tentacles (containing stinging cells) of sea anemone, etc.

(d)Mutualism:

This is a type of interaction in which both the interacting species are benefited.

Ex: lichens, mycorrhizae, plants and pollinating animal agents, etc.

(f) Amensalism:

It is a type of interaction in which one species is harmed whereas the other is unaffected.