CHAPTER

7 Organisms and Populations

- Ecology (at organismic and population level) studies interactions among organisms and between organism and its physical (abiotic) environment.
- Ecology is basically concerned with four levels of biological organisation-**organisms, populations, communities and biomes**.

ORGANISMS AND ITS ENVIRONMENT

- Ecology, at the organismic level, is essentially physiological ecology.
- The rotation of our planet around the sun and the tilt of its axis cause annual variations in the intensity and duration of temperature, resulting in distinct seasons.
- **Habitat** of an organism is characterised by physico-chemical (abiotic) components and biotic components like-pathogens, parasites, predators and competitors- of the organism with which they interact constantly.

MAJOR ABIOTIC FACTORS

Temperature

- Is the ecologically **most** important factor.
- Affects enzyme kinetics, metabolic activity and physiology.
- **Eurythermals** tolerate wide temperature fluctuations.
- **Stenothermals** restricted to narrow range.
- Thermal tolerance determines geographical distribution.

Water

- Life originated in water.
- Productivity and distribution of plants is dependent on water.
- **Salinity** measured in ppt is:
  < 5 in inland water,
  30-35 in sea,
  and >100 in some hypersaline lagoons.

Light

- Plants need light for photosynthesis and photoperiod for flowering.
- Animals also need light for foraging, reproduction & migration.
- Red algae are found in deepest water.

Soil

- Nature and properties of soil depends on climate, weathering and transportation.
- Composition, grain size, pH, minerals and topography determine vegetation which dictates the type of animals supported.

RESPONSE TO ABIOTIC FACTORS

- Abiotic conditions of many habitats vary drastically in time and organisms living in such habitats need to evolve strategies to survive or manage with the stressful conditions.

ORGANISMIC RESPONSE TO ABIOTIC STRESS

Regulate

- Maintain homeostasis by physiological (or behavioural) means.
- All birds, mammals and very few lower vertebrates and invertebrates are capable of this.
- Success of mammals is largely due to their ability to maintain constant body temperature and thrive in antarctica or in Sahara desert.

Conform

- 99% animals and nearly all plants are conformers.
- Body temperature changes with the ambient temperature.

Suspend

- Thick walled spore in bacteria, fungi and lower plants.
- Dormancy in higher plants, hibernation in bears, aestivation in snails and fish, diapause or suspended development in zooplanktons.

Migrate

- The organism can move away temporarily from the stressful habitat to a more hospitable area and return when stressful period is over
- Every winter the famous Keolado National Park (Bharatpur) in Rajasthan host thousands of migratory birds coming from Siberia and other extremely cold northern regions.

ADAPTATIONS- TO COPE WITH EXTREME ENVIRONMENT

Morphological

- Kangaroo rat in North American deserts is capable of meeting all its water requirements through internal fat-oxidation and ability to concentrate urine.
- CAM plants like *Opuntia* have thick cuticle, sunken stomata and photosynthetic stems.
- **Allen's Rule:** Shorter limbs and ears of mammals in cold climate to reduce heat loss.
- Thick blubber in seal.

Physiological

- Altitude sickness. Symptoms-Nausea, fatigue & heart palpitations.
- Gradually, the body compensates low oxygen by increasing RBC production, decreasing the binding affinity of haemoglobin and increasing the breathing rate.

Behavioural

- Responses to cope up with variations in environment.
- Desert lizards-bask in the sun & absorb heat when their body temperature drops below comfort zone, but move away into shade when ambient temperature starts increasing.
- Some species hide in burrow to escape from the above-ground heat.

POPULATION

Population Attributes:

- **Birth rates and Death Rates:** Refer to per capita births and deaths, respectively.
- **Sex-ratio**
- **Age-pyramids:** Shows percent individuals of a given age or age group. The shape of the pyramids reflects the **growth status** of the population. It is of three types:

  Expanding, stable and declining.
- Evolutionary changes through natural selection takes place at population level.

POPULATION GROWTH

- Food availability, predation pressure and adverse weather are the factors which affect population.
- Population density, in a given habitat during a given period, fluctuates due to changes in **four** basic processes.
  - **Natality, immigration** increase it.
  - **Mortality, emigration** decrease it.
- Tiger census in our national parks & tiger reserves is often based on **pug marks and fecal pellets**
- If N is the population density at time 't', then its density at time 't + 1' $N_{t+1} = N_t [(B + I) – (D + E)]$
  - If births plus immigration (B + I) is more than deaths plus emigration (D + E), population density will increase
  - Under normal conditions, births & deaths are most important factors influencing population density
  - If a new habitat is just being colonised, immigration is more significant to population growth than birth rates.

GROWTH-MODELS

Exponential Growth

- When resources in the habitat are unlimited, then the population grows in an exponential or geometric fashion. It is given by the equation, $N_t = N_o e^{rt}$.
- It results in J-shaped curve.

LOGISTIC GROWTH

- The natural resources are limited in nature, this leads to competition.
- The population growing in a habitat with limited resources shows, lag, acceleration, deceleration and finally asymptote.
- It results in S-shaped or sigmoid curve also called as **Verhulst**-Pearl **logistic** curve.
- Given by the equation: $\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$
- Logistic growth model is realistic.
- **Asymptote**-When population density reaches the carrying capacity.

LIFE HISTORY VARIATION

- Populations evolve to maximise their reproductive fitness, also called **Darwinian fitness** (high 'r' value), in the habitat in which they live and evolve towards the most effective reproductive strategy.

Reproductive Strategies in Organisms

- Breed only once in their life time. e.g., Pacific salmon fish, Bamboo.
- Breed many times during lifetime. e.g., Most birds & Mammals.
- Some produce large number of small-sized off springs e.g., Oysters, Pelagic fishes.
- Others produce a small number of large-sized off springs. e.g., Birds & Mammals.

POPULATION INTERACTIONS

Predation (+; –)

- One species benefits and other is harmed.
- Used as biological control method for pest-control.
- Maintain species diversity by reducing competition among prey.
- Prey species evolved defenses: Camouflage - Insects & frogs, monarch butterfly- Chemical defense, thorns-*Cactus, Acacia.*

- Many plants produce and store chemicals that make herbivore sick when they are eaten, e g., *Calotropis* produces cardiac glycosides.

Competition (–; –)

- Both the species are negatively affected.
- Totally unrelated species can compete for same resources.
- The fitness (‘**r**’ **the intrinsic rate of increase**) of one species is significantly lower in presence of another species.
- **Competitive release** - The distributional range increase dramatically when the superior species is removed., eg. *Balanus* & *Chathamalus.*
- **Gause’s competitive exclusion principle** states two closely related species competing for the same resources cannot co-exist. e.g., Abingdon tortoise and Goats in galapagos island.
- Two species compete for the same resource could avoid competition by **resource partitioning** eg. 5 closely related species of warblers on a tree.

Parasitism (+; –)

- One species benefits and other is harmed.
- Free lodging and meals.
- Parasites are host specific, i.e., **co-evolve.**
- Human liver fluke depends on a snail and a fish to complete its life cycle.
- Parasites reduce survival, growth and reproduction of host make them weak
- **Brood parasitism** in birds eg. Cuckoo and crow. The eggs of parasitic bird had evolved to resemble host’s egg in colour and size.
- Ectoparasites feed on external surface of host (Ex. ticks, lice, *Cuscuta*) and endoparasites live inside the host (e.g., *Ascaris* lives in intestine)

Commensalism (+; 0)

- One species benefits and the other is neither harmed nor benefited.
- An orchid growing as an epiphyte on a mango branch, barnacles growing on back of a whale, cattle egret and grazing cattle, sea anemone that has stinging tentacles and clown fish that lives among them are few examples.

Amensalism (–; 0)

- One species is harmed whereas the other is unaffected.

Mutualism (+; +)

- Both the species get benefits by this interaction.
- Lichens, mycorrhiza, plant - animal relationships for pollination.
- Plants offer rewards or fees like pollen, nectar for pollinators and fruits for seed dispersal.
- Mediterranean orchid ***Ophrys*** employs **sexual deceit** to get pollination done by a species of bee by **pseudo copulation**.
- Shows co-evolution and one to one relationship like fig and partner wasp.