ORGANISMS AND POPULATIONS

ORGANISM AND ITS ENVIRONMENT:

- Rotation of sun and the tilt of its axis cause annual variations in the intensity and duration of temperature, resulting distinct seasons.
- These variations along with annual variations in precipitation, forms major biomes, such as **desert**, **rain forest**, and **tundra.**
- Temperature, water, light and soil are the key elements that lead to so much variation in the physical and chemical conditions of habitats.
- Both **abiotic** (physic-chemical) and **biotic** components (pathogen, parasites, predators, competitions) characterize the habitat of an organism.

Major abiotic factors:

Temperature:

- Temperature decreases progressively from equator towards the pole and high altitudes to > 50° C in tropical deserts in summer.
- Thermal springs and deep-sea hydrothermal vents are unique with >100° C.
- Temperature affects the kinetics of enzymes, BMR and other physiological actions.
- **Eurythermals**: organism which can tolerate wide range of temperatures.
- **Stenothermal**: organism which can tolerate narrow range of temperatures.

Water:

- Water is also important factor that influence the life of organism.
- The productivity and distribution of plants is also depends on water.
- The salinity varies in aquatic environment:
  - 5% in inland waters (fresh water)
  - 30-35 in sea water
  - More than 100percent in hyper saline lagoons.
- **Euryhaline:** organism which can tolerate wide range of salinity
- **Stenohaline:** organism which can tolerate narrow range of salinity.

Light:

- Plant produce food by photosynthesis, which only possible in presence of light. Hence it very important for autotrophs.
- Plant species (herbs and shrubs) adapted for photosynthesize under canopy
- Sunlight is required for photoperiodic response like flowering.
- Animals use diurnal and seasonal variations in light intensity and photoperiod as cues for timing their foraging, reproductive and migration.

Soil:

- Properties of soil vary according to the climate, the weathering process.
- Soil composition, grain size and aggregation determine the percolation and water holding capacity of the soil.
- These characteristic along with pH, mineral composition and topography determine to a large extent the vegetation in any area.
- The sediment-characteristic often determine the type of benthic animal in aquatic environment.

Response to Abiotic Factors:

- **Homeostasis;** the process by which the organism maintain a constant internal environment in respect to changing external environment.

How does organism cope with the changing environment?

Regulate:

- Some organisms are able to maintain homeostasis physiological (sometimes behavioral also) means which ensures constant body temperature, constant osmotic concentration.
- All birds and mammals and few lower invertebrates are capable of such regulation i.e. thermoregulation and osmoregulation.
- Success of mammals is due to thermoregulation.
- We maintain a constant body temperature of 37°C.
- When outside temperature is high we sweat profusely and evaporative cooling take place to bring body temperature down.
- In winter due to low temperature outside our body temperature falls below 37°C, we start to shiver, to generate heat to raise body temperature.

Conform:

- Majority (99%) of animals and plants cannot maintain a constant internal environment; their body temperature varies according to ambient temperature.
- In aquatic animals the osmotic concentration of body fluid varies with ambient water osmotic concentration.
- All the above animals and plants are simply called as **conformer.**

Why the conformer not evolved to became regulators?

- Thermoregulation is energetically expensive for many animals.
- Small animal like shrews and humming birds cannot afford so much energy for thermoregulation.
- Heat loss or heat gain is a function of surface area.

- Small animals have larger surface area relative to their volume, they tend to lose body heat very fast when it is cold outside; then has to expend much energy to generate body heat through metabolism.
- This is why very small animals are rarely found in Polar Regions.

Alternative response for stressful conditions is localized or remains for short duration.

Migrate:

- The organism moved away temporarily from the stressful habitat to a more hospitable area and return when stressful condition is over.
- Bird migrate form the colder region to warmer region.

Suspend:

- Thick walled spores are formed in microbes to overcome unfavourable stressful external environment. Spores germinate in favourable condition.
- In higher plants seeds and other vegetative reproductive structures are means to tide over the stress. They reduce their metabolic activity and going into a state of 'dormancy'.
- **Hibernation**: during winter animals like bears escape in time
- **Aestivation:** animals like snail and fish avoid summer related problem like heat and desiccation.
- **Diapauses:** many zooplanktons undergo a stage of suspended development in unfavourable conditions.

ADAPTATION:

- **Adaptation:** is any attribute of the organism (morphological, physiological, and behavioral) that enables the organism to survive and reproduce in its habitat.

Adaptation of animal in desert:

- Kangaroo rat meets their water requirement from **oxidation of fat.**
- Excrete very **concentrate urine** to conserve water.

Adaptation of plant in desert (xerophytes)

- **Thick cuticle** on their leaf surfaces.
- **Sunken stomata**, both to reduce transpiration.
- Have special photosynthetic pathway **(CAM),** stomata closed during day time and remained open during night.
- Opuntia has no leaf- they are reduced to **spines.**
- Photosynthesis takes place in **flat green stems.**

Adaptation of animal in cold climate:

- ***Allen's Rule:*** mammals from colder climates generally have shorter ears and limbs to minimize heat loss.
- Seals of polar aquatic seas have a thick layer of fat called **blubber** below their skin that acts as insulator and reduces loss of body heat.

Adaptation in high altitude:

- A person move to high altitude (>3,500 meter), develop **altitude sickness.**
- Symptoms developed are nausea, fatigue and heart palpitations.
- This is due to low atmospheric pressure of high altitudes; the body does not get enough oxygen.

How the bodies solve the problem?

- The body compensates low oxygen availability by increasing red blood cell production.
- The body compensates decreasing binding capacity of hemoglobin with oxygen by increasing rate of breathing.

Behavioral adaptation:

- **Desert lizards are conformer hence they cope with the stressful environment by behavioral adaptations:**
  - They bask in the sun and absorb heat when their body temperature drops below the comfort zone in winter.
  - Move to shade when the ambient temperature starts increasing.
  - Some species burrowing into the soil to hide and escape from the above-ground heat.

POPULATION:

Population attributes:

- **Population:** a group of individual living in a well defined geographical area, share or compete for similar resources, potentially interbreed.
- Birth rate and death rate refers to per capita births and deaths respectively.
- Another attribute is **sex ratio**. The ratio between male female in a population.
- If the age distribution is plotted for a population the resulting structure is called age pyramid.
- The shape of the pyramids reflects the growth status of the population like **growing, stable** or **declining.**
- The population size is more technically called as **population density.**

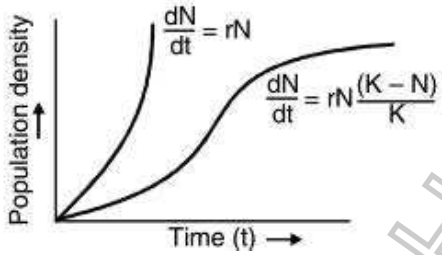
Methods for measurement of population density:

- Counting the number
- Percent cover
- Biomass.
- **Pug marks** and **fecal pellets** for tiger census

Population growth:

- The size of the population changes depending on food availability, predation pressure and reduce weather.
- Population size fluctuated due to changes in four basic processes, two of which (Natality and immigration) contribute an increase in population density and two (mortality and emigration) to a decrease.
- **Natality**: number of birth in given period in the population.
- **Mortality**: number of deaths in the population in a given period of time.
- **Immigration**: is the number of individuals of same species that have come into the habitat from elsewhere during a given period of time.
- **Emigration**: number of individuals of the population who left the habitat and gone elsewhere during a given time period.
- 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 = the number of births
I = the number of immigrants
D = the number of deaths
E = the number of Emigrants.
N = Population Density
r = Intrinsic rate of natural increase
t = Time period
K = Carrying capacity (The maximum population size that an environment can sustain)

Exponential growth:

- The Exponential growth equation is $N_t = N_0e^{rt}$
- Nt = Population density after time t
- N0 = Population density at time zero
- r = intrinsic rate of natural increase
- e = the base of natural logarithms (2.71828)

Exponential growth ('J' shape curve is obtained).

* When resources are not limiting the growth.
* Any species growth exponentially under unlimited resources conditions can reach enormous population densities in a short time.
* Growth is not so realistic.

Logistic growth model

- Verhulst-Pearl Logistic Growth is described by the following equations
- dN/dt = rN (K–N / N)
- Where N = Population density at time t
- r = Intrinsic rate of natural increase
- K = Carrying capacity

Logistic Growth (Sigmoid curve is obtained)

- When responses are limiting the Growth.
- Resources for growth for most animal populations are finite and become limiting.
- The logistic growth model is a more realistic one.

POPULATION INTERACTIONS:

Predation:

- Organism of higher trophic level (predator) feeds on organism of lower trophic level (prey) is called the predation.
- Even the herbivores are not very different from predator.
- Predator acts as a passage for transfer of energy across trophic level.
- Predators keep prey populations under control.
- Exotic species have no natural predator hence they grow very rapidly. (**prickly pear cactus** introduced in Australia created problem)
- Predators also help in maintaining species diversity in a community, by reducing the intensity of competition among competing prey species. (**Pisaster** starfish field experiment)

Defense developed by prey against predators:

Animals:

- Insects and frogs are cryptically coloured **(camouflaged)** to avoid being detected by the predator.
- Some are poisonous and therefore avoided by the predators.
- **Monarch butterfly** is highly distasteful to its predator (bird) due to presence of special chemical it its body. The chemical acquired by feeding a poisonous weed during caterpillar stage.

Plants:

- **Thorns** in Acacia, Cactus are morphological means of defense.
- Many plants produce and store some chemical which make the herbivore sick if eaten, inhibit feeding, digestion disrupt reproduction, even kill the predators.
- **Calotropis** produces poisonous **cardiac glycosides** against herbivores.
- Nicotine, caffeine, quinine, strychnine, opium etc. are produced by plant actually as defenses against the grazers and browsers.

Competition:

- Interspecific competition is a potent force in organic evolution.
- Competition generally occurs when closely related species compete for the same resources that are limiting, but this not entirely true:
- **Firstly:** totally unrelated species could also compete for the same resources.
    - American lakes visiting flamingoes and resident fishes have their common food, zooplanktons.
- **Secondly:** resources need not be limiting for competition to occur.
    - **Abingdon tortoise** in Galapagos Islands became extinct within a decade after **goats** were introduced on the island, due to greater browsing ability.
- **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 dramatically when the competing species is experimentally removed.
    - **Connell's** elegant field experiment showed that superior barnacle ***Balanus*** dominates the intertidal area and excludes the smaller barnacle ***Chathamalus*** from that zone.
- Gause's '***competitive Exclusion Principle'***: two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior will be eliminated eventually.
- **Resource partitioning**: If two species compete for the same resource, they could avoid competition by choosing, for instance, different times for feeding or different foraging pattern.
    - **MacArthur** showed five closely related species of warblers living on the same tree were able to avoid competition and co-exist due to behavioral differences in their foraging activities.

Parasitism:

- Parasitic mode of life ensures free lodging and meals.
- Some parasites are host-specific (one parasite has a single host) in such a way that both host and parasite tend to co-evolve.

Parasitic adaptation

- Loss of **unnecessary sense organs.**
- Presence of **adhesive organs** or **suckers** to cling on to the host.

- Loss of **digestive system.**
- High reproductive capacity
- Parasites having one or more intermediate host or vectors to facilitate parasitisation of its primary host.
- Liver fluke has two intermediate hosts (snail and a fish) to complete its live cycle.

Effects on the host:

- Parasite always harms the host.
- They reduce the survival, growth and reproduction of the host.
- Reduce its population density.
- They make the host more vulnerable to the predators, by making it physically weak.
- **Ectoparasite:** feeds on the external surface of the host.
    - Lice on human
    - Ticks on dog
    - Marine fish infested with copepods
    - ***Cuscuta*** a parasitic plant grow on hedge plants.
- **Endoparasites:** are those that live inside the host body at different sites.
    - Life cycle is more complex.
    - Morphological and anatomical features are greatly simplified.
    - Highly developed reproductive system.
- **Brood parasitism:**
    - Special type of parasitism found in birds.
    - The parasitic birds lay its eggs in the nest of its host and let the host incubate them.
    - The egg of the host is very similar with the egg of the host.
    - Cuckoo lays eggs in the nest of the crow.

Commensalism: This is the interaction in which one species benefits and the other is neither benefited nor harmed.

- Orchids growing as an ***epiphyte*** on a mango branch.
- Clown fish living among tentacles of sea anemone.
- Barnacles on back of whales.
- Cattle Egret and grazing cattle.

Mutualism: interaction between two living organism, both are equally benefited, no one is harmed.

- **Lichen:** a mycobiont and a Phycobiont.
- **Mycorrhiza:** relationship between fungi and root of higher plant.
- Pollinating insects and flowering plants.
- **Fig trees** and its pollinating agent **wasp.**

Sexual deceit

- Mediterranean orchid **Ophrys** employs **'sexual deceit'**.
- Petal of the flower resembles the female bee.
- The male bee attracted to what it perceives as a female, 'pseudocopulates' with the flower but does not get any benefits.