ORGANISMS AND POPULATIONS

INTRODUCTION

1. Living world is fascinatingly diverse and amazingly complex. Complexity can be investigated at various levels of biological organisation- macromolecules, cells, tissues, organs, individual organisms, population, communities, ecosystems and biomes.

2. Ecology 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 organism level is essentially physiological ecology which tries to understand how different organisms are adapted to their environments in terms of survival and reproduction.
- The 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.
- 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. These variations together with annual variation in precipitation (both rain and snow) account for formation of major biomes such as desert, rain forest and tundra.
- Over a period of time, the organism evolved to optimise its survival and reproduction in its habitat through natural selection.
- Regional and local variations within each biome lead to the formation of a wide variety of habitats. Temperature, water, light and soil affect the habitat.
- Niche of an organism has an invariably defined range of conditions that it can tolerate, diversity in the resources it utilises and a distinct functional role in the ecological system.

MAJOR ABIOTIC FACTORS

Temperature

- Ecologically most important factor
- Affects enzyme kinetics, metabolic activity & 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 part per thousand:-
1) < 5 in inland water.
2) 30-35 in sea
3) > 100 in some hypersaline lagoons
- some organism are tolerant of a wide range of salinities (Euryhaline).
- some organism are restricted to the narrow range of salinities (Stenohaline).

Light

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

Soil

- Nature 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.
- Which ensures constant body temperature and osmotic concentration.
- All birds, mammals and very few lower vertebrates and invertebrates are capable of this.

CONFORM

- 99 % animals & nearly all plants.
- Their body temperature changes with the ambient temperature.

MIGRATE

- Temporarily move away to escape the condition and return when the period is over. e.g. siberian cranes visit Bharatpur every winter.

SUSPEND

- Thick walled spore in bacteria, fungi & lower plants.
- Dormancy in higher plants.
- Hibernation in bears and Aestivation in snails and fish
- Diapause, or suspended development in zooplanktons.

Success of mammals is largely due to their ability to maintain constant body temperature and thrive in antarctica or in Sahara desert.

ADAPTATIONS- TO COPING WITH EXTREMES IN THEIR ENVIRONMENT

GENETICALLY FIXED

- Kangaroo rat in North American deserts.
(i)internal fat-oxidation for water
(ii)ability to concentrate urine
- CAM plants like *Opuntia*.
- Allen's Rule - Shorter extremities 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

- 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.

Organisms living in extreme environments like hot springs, deep sea hydrothermal vents, antarctic fishes in freezing conditions or at > 100 times normal atmospheric pressure – show biochemical adaptations.

POPULATION

Birth rates and Death Rates : refer to per capita births and deaths.

Sex-ratio : Ratio of males to females in a population.

Age-pyramids : Shows percent individuals of a given age or age group. For human population age pyramids generally show age distribution of males and females in a diagram. The shape of the pyramids reflects the growth status of the population.

- Evolutionary changes through natural selection takes place at population level.
- Tiger census in our national parks & tiger reserves is often based on pug marks and fecal pellets.

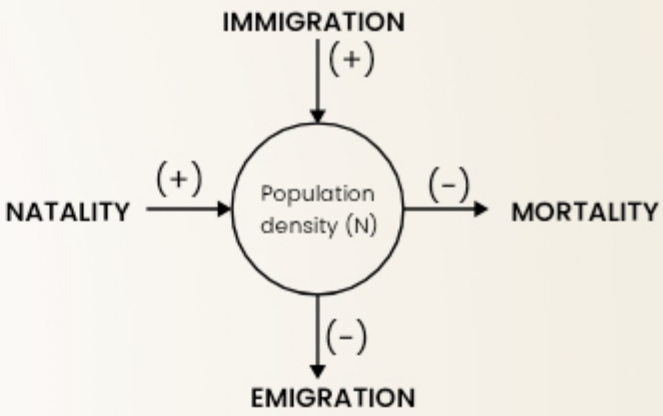
POPULATION GROWTH

1 Population for any species is not a static parameter.

2 Food availability, predation pressure and adverse weather are the factors which affect population.

3 Population density,in a given habitat during a given period, fluctuates due to changes in four basic processes, two of which **(natality, immigration)** increases the density and two **(mortality, emigration)** decrease it.

- If N is the population density at time t, then its density at time t + 1 is $N_{t+1} = N_t + [(B+I) - (D + E)]$
- 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 population grows in an exponential or geometric fashion.
- Integral form of the exponential growth equation

$Nt = N_0e^{rt}$

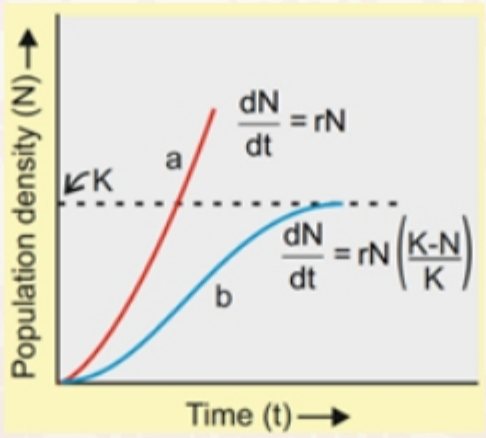
Where =

N_t = Population density after time 't'

N_0 = Population density at time zero.

r = intrinsic rate of natural increase called Biotic potential.

e = base of natural logarithms (2.71828).



a→Exponential plot

b→Logistic plot

k→Is carrying capacity.

LOGISTIC GROWTH

- In nature resources are limited.
- This leads to competition.
- The fittest survive and reproduce.
- So, it shows, lag, acceleration, deceleration and finally asymptote.
- It gives *Verhulst-Pearl logistic* growth curve.

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

Where =
N = population density at time t
r = Intrinsic rate of natural increase
K = Carrying capacity

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 offsprings e.g., Oysters, Pelagic fishes.	Others produce a small number of large-sized offsprings. e.g., Birds & Mammals.

POPULATION INTERACTIONS

No organism in nature (animals, plants and microbes) can live in isolation but interact in various ways to form a biological community. These interactions can be beneficial (+); detrimental (–) or neutral (0).

1. PREDATION (+;-)

- Predators act as conduits for energy transfer across trophic levels.
- Keep prey population under control.
- Used as biological control method for pest-control.
- Maintain species diversity by reducing competition among prey eg. *Pisaster* & 10 species of invertebrates.
- Predators in nature are prudent.
- Prey species evolved defences:-
  (a) Camouflage - insects & frogs
  (b) Monarch butterfly- Chemical defence
  (c) Thorns-Cactus, Acacia
- Many plants produce and store chemicals that make herbivore sick when they are eaten, e.g., *Calotropis* produces cardiac glycosides

COMPETITION (-;-)

- Darwin said interspecific competition is a potent force in organic evolution.
- 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 of lower species increases dramatically when the superior species is removed. eg. *Balanus* & *Chathamalus.*
- Gause's competitive exclusion principle = eg. *Abingdon* tortoise and Goats in galapagos island.
- Co-Existence by resource partitioning eg 5 closely related species of warblers.

PARASITISM (+;-)

- Free lodging and meals.
- Parasites are host specific, i.e., co-evolve.
- Parasitic adaptations = loss of sense organs, presence of adhesive organs or suckers, loss of digestive system & high capacity of reproduction.
- Human liver fluke depends on a snail and a fish to complete life cycle.
- Parasites reduce survival, growth and reproduction of host making 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 on surface and Endoparasites inside host.
- Life cycles of Endoparasites are more complex because of their extreme specialisation. Their morphological and anatomical features are simple but reproductive potential is very high.

COMMENSALISM (+;0)

- 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. In Amensalism one species is harmed whereas the other is unaffected.

MUTUALISM (+;+)

- Lichens, Mycorrhizae,
- Plant - animal relationships for pollination.
- Plants offer rewards or fees like pollen, nectar for pollinators and fruits for seed dispersers.
- And safeguards against cheaters.
- It also shows co-evolution and one to one relationship like fig and partner wasp.
  Mediterranean orchid *Ophrys* employs 'sexual deceit' to get pollination done by a species of bee, by pseudo copulation.

AMENSALISM (- ; 0)

- one species is harmed, and other species remain unaffected.
- It can be seen as a form of interaction or competitive behaviour among other organisms.
- eg. An example of antibiosis is the interaction between *Penicillium* and bacteria. The mould *Penicillium* creates the secretion known as penicillin, which is extremely toxic to bacteria.
- eg. when an organism such as a goat feeds on the same type of shrub as an insect (such as a beetle). The goat is unharmed when it consumes the shrub, however, the beetle loses significant quantities of food and may accidentally be eaten by the goat.