

Organisms and Populations

Ecology = study of interactions among organisms and with their environment.

Levels of Organisation

(1) Organism → (2) Population →
(3) Community → (4) Biome →
(5) Biosphere

Ecologist asks 4 key questions :

- * how organism is built physiologically / morphologically to survive in its habitat,
- * how it gets food / mates with members of its species, ~~how~~ interacts with others.

Major Biomes of India

Tropical rain forest ; Deciduous forest ;
Desert (Thar) ; Sea-coast ; Tundra (Himalayan).

Biome = large region with

- * ← characteristic
- ← climate + biota

Biome depends mainly on annual temperature & precipitation patterns.

Major Abiotic Factors

Four major abiotic factors :

Temperature , Water , Light , Soil .

1. Temperature

Most ecologically relevant factor.

Varies : -2°C (polar seas) to $>100^{\circ}\text{C}$

(thermal springs / deep-sea vents).

* Eurythermal \rightarrow tolerate wide T range

* Stenothermal \rightarrow narrow T range only

Affects : kinetics of enzymes, \leftarrow basal metabolism,
 \leftarrow activity, geog. dist.

2. Water

Life originated in water ; still essential.

For aquatic life temp water quality

(pH , chem. composition) matters.

* Euryhaline \rightarrow wide salinity range

* Stenohaline \rightarrow narrow salinity range

Many freshwater animals cannot live in

sea-water (osmotic problems) and vice versa.

Abiotic Factors (contd.)

3. Light

Needed for : photosynthesis (autotrophs) ,
photoperiodism (flowering) , vision , and
pigment synthesis in animals.

Sun = ultimate source ; less light reaches
forest floor -> shade-adapted herbs evolved.

Photoperiod cues : breeding in birds &
mammals ; diapause in insects ; flowering
in short-day / long-day plants.

4. Soil

Nature depends on : weathering of rocks,
climate, soil-development process (humus).

Properties that decide vegetation :

soil composition, grain size, aggregation
-> set percolation & WHC (water holding
capacity) ; pH, mineral comp., topography.

Soil + climate -> vegetation

<- vegetation in turn
<- decides fauna

Responses to Abiotic Factors

Organisms maintain homeostasis. Four ways :

(i) Regulate

Keep body temp / osmotic conc. **CONSTANT**,
irrespective of external change. * *

e.g. all birds, mammals (incl. humans),
few lower vertebrates / invertebrates.

Means : sweating , shivering , panting.

(ii) Conform

99% animals + nearly all plants do this.

Body T / osmotic conc. change **WITH** ambient.

Thermoregulation is energy-expensive ;

small animals (high SA/V) lose heat fast

-> rare in arctic; better to conform.

(iii) Migrate

Move temporarily to a more hospitable area.

e.g. Siberian crane -> Keoladeo NP (Bharatpur)
every winter ; returns in summer.

(iv) Suspend

Avoid stress by ~~dying~~ dormancy : seeds,
spores ; hibernation / aestivation / diapause.

Adaptations

Heritable morphological / physiological / behavioural trait that helps an organism to survive & reproduce in its habitat.

Examples

- * Kangaroo rat (N. American desert) :
meets water needs from internal fat oxidation ; excretes concentrated urine.
- * Desert plants : thick cuticle, sunken stomata, CAM photosynthesis (Opuntia \rightarrow leaves reduced to spines, stem flat & green).
- * Mammals of colder climates : SHORT ears / limbs \rightarrow minimize heat loss (Allen's rule).
- * High-altitude (>3500 m, Rohtang etc.) :
body compensates low O_2 by - higher RBC count , high binding affinity of Hb , increased breathing rate. (altitude sickness)
- * Archaeobacteria : flourish in hot springs & deep-sea vents ($T > 100^\circ C$) -- biochem is adapted to such extreme conditions.

Population - Attributes

Population = group of individuals of the SAME species in a given area, sharing or competing for similar resources, potentially interbreeding.

1. Population Density (N)

$$N = \text{No. of individuals} / \text{unit area or volume}$$

Sometimes biomass / % cover / pug-marks (tiger census) used as proxies for N.

2. Natality (B) & Mortality (D)

B = births per capita per unit time

D = deaths per capita per unit time

3. Sex Ratio

Ratio of males : females in population.

4. Age Distribution

Age pyramid \rightarrow pre-reproductive, reproductive, post-reproductive ages.

Shape predicts growth status :
expanding / stable / declining.

Population Growth Models

Change in N depends on 4 processes :

Natality (B) , Immigration (I) ,

Mortality (D) , Emigration (E).

$$N(t+1) = N(t) + [(B+I) - (D+E)]$$

*

(a) Exponential growth

When resources are unlimited :

$$dN/dt = r N$$

$\leftarrow r = \text{intrinsic rate}$
 $\leftarrow \text{of natural increase}$

$$N(t) = N(0) e^{(rt)} \quad \leftarrow \text{J-shaped curve}$$

(b) Logistic growth

Resources finite \rightarrow carrying capacity K .

$$dN/dt = r N (K - N) / K \quad \leftarrow \text{S-shaped}$$

$\leftarrow \text{sigmoid curve}$

Verhulst-Pearl logistic equation.

Lag \rightarrow acceleration \rightarrow deceleration \rightarrow

asymptote at K (more realistic model).

Used by ecologists & resource managers.

Population Interactions

Sign convention (effect on each species) :

(+) benefit , (-) harm , (0) no effect

Six Categories

Mutualism (+ , +)

Competition (- , -)

Predation (+ , -)

Parasitism (+ , -)

Commensalism (+ , 0)

Amensalism (- , 0)

Predation

Nature's way of energy transfer to higher trophic levels. Keeps prey density in check.

Defences : thorns (Acacia), spines (Cactus), camouflage (frog), toxins (Calotropis cardiac glycosides), - Monarch butterfly is distasteful.

Competition

Gause's competitive exclusion principle :

two close ~~species~~ competitors can't co-exist indefinitely - inferior is eliminated.

e.g. Abingdon tortoise extinct when goats introduced. (Galapagos) -> grazing won.

Interactions (contd.)

Parasitism (+, -)

Parasite gains nutrition / shelter at the host's cost. Host-specific co-evolution.

Adaptations - loss of unneeded organs, adhesive / suction organs, high reproductive capacity, complex life cycles with vectors.

Types : ecto- (lice, ticks), endo- (Plasmodium, Ascaris), brood (Cuckoo lays in crow's nest).

Commensalism (+, 0)

- * Orchid growing on a mango branch.
- * Barnacles on whale's back.
- * Cattle egret + grazing cattle \rightarrow egret catches insects stirred up by the cattle.

Mutualism (+, +)

- * Lichen = fungus + algae (or cyanobact.)
- * Mycorrhizae = fungi + roots of higher plants
- * Pollination : fig - wasp ; Yucca - Pronuba moth (obligate / species-specific partnerships).

Sexual deception : Mediterranean orchid *Ophrys* mimics female bee \rightarrow male tries pseudocopulation.