Organisms and Populations

Ecology ~ It is a branch of science which studies the interactions among organisms and b/w the organisms and its physical (abiotic) Environment.

It consists of 2 branches

① **Autecology** - Study of ecology at the level of species.

② **Synecology** - Study of ecology at the level of communities.

☆ Ecology deals with four levels of biological organization

- **Organism** → a living entity which can function on its own.
- **Population** → Sum of all living organisms of the same species living in a particular geographical area.

- Communities → A group of people living together in one place. (different species)

- Biomes → a large geographical area of various plants and animals.

ENVIRONMENT

- An environment is termed as the sum total of all external conditions which influence the organisms in terms of survival & reproduction.

- Ecology at the organismic level deals with how different organisms are adapted to their environment in terms of their survival & reproduction & is basically physiological ecology.

* Different organisms are adapted to their environment in terms of both survival and reproduction.

- Rotation of earth around the sun and the tilt of its axis cause annual variations in the intensity & duration of temp which results into distinct seasons.

- Variation of temp along with annual variation in precipitation such as rain & snow form major biomes such as desert, rain forest & tundra.

- Regional & local variations such as temp, water, light and within each biomes lead to the formation of a wide variety of habitats.

- Both abiotic and biotic components characterize the environment.

Major abiotic factors of the ecosystem:

① Temperature

- The average temperature on land varies seasonally, decreases progressively from the equator towards the poles and from plains to the mountain tops.

- Thermal springs and deep-sea hydrothermal vents are unique habitats where average temperatures exceed 100°C

- Temp. affects the kinetics of enzymes & through it the basal metabolism, activity and other physiological functions of the organism.

- Organism which can tolerate and thrive in a wide range of temperatures, they are called eurythermal organisms.

e.g. Cat, dog etc.

- Organisms which can tolerate a narrow range of temperatures such organisms are called Stenothermal Organisms.

e.g. Polar bear, fish reptile etc.

2) Water

- It is the next important factor as life is unsustainable without water.

- The amount of water in an environment determines the productivity and distribution of plants.

- For aquatic habitat, the quality of water becomes important like pH value, Salinity & temperature of water.

- Salinity of Water → less than 5 parts per thousand inland Water
  - ☆ 30-35 parts per thousand in Sea
  - ☆ >100 parts per thousand in some hypersaline lagoons

- Organism which can tolerate and thrive in wide range of salinities called euryhaline & the organisms that tolerate only narrow range of Salinities are called Stenohaline.

(3) Light

- Light is important because autotrophs make food with the help of light (photosynthesis) and O_2 is evolved during this process.

- The small plants like herbs & shrubs can perform photosynthesis under very low light condition as they are over shadowed by tall trees (Sciophytes)

- The plants depend on Sunlight to meet their Photoperiodic requirement for flowering.

- Animals use the diurnal and seasonal variations in light intensity and duration (photoperiod) as cues for timing their foraging, reproductive & migratory activities.

- However in deep oceans >500m the environment is perpetually dark.

* [Bright light – heliophytes
Photic – algae present aphotic – no producer present benthic – Corals, sponges.]

④ Soil

- The nature & properties of soil in different places vary significantly.

  It depends on—

① Climate.

② Weathering Process

③ Whether soil is transported or sedimentary

④ Soil development process

- Soil composition, grain size and aggregation determine the percolation & water holding capacity of the soils which along with parameters such as PH, mineral composition & topography determine the vegetation in any area.

- In the aquatic Environment, the sediment characteristics often determine the type of benthic animals that can thrive there.

Response to abiotic factors

Homeostasis — Maintaining a constant internal environment in an organism. (by regulating optimum temp & osmotic conc. of body fluids in accordance with varying external environmental condition.

Not all organisms adapt in similar ways. They can cope with stressful conditions by any of the following methods-

- Regulate
- Conform
- Migrate
- Suspend

REGULATE

- Thermoregulation
  Osmoregulation }

- Homeostasis is maintained by ensuring constant body temp & constant osmotic concentration.
  e.g- Birds, mammals, lower vertebrate & invertebrate.

★ Endotherms- Animals that obtain heat primarily form from metabolic reactions.

- The mechanism used for regulation in most mammals are similar to ones used by humans who have a constant body temperature of 37°C, ~~Ex~~ e.g during summer, (Sweating) occur & the evaporation brings down the temp of the body 37°C.

During winter Shivering occurs (a kind of exercise that produces heat) & raise the body temp again to 37°C.

- Plants do not have such mechanism to maintain their internal temp.

Conform

- About 99% of animals & almost all plants cannot maintain a constant internal environment. ~~their~~ Their body temp changes with the ambient temp.

Ectotherms - Animals that obtain heat primarily from the environment.

- e.g fish, amphibians & reptiles.

- majority of aquatic animals change the osmotic conc. of their body fluid according to the environment called osmoconformer.

- Thermoregulation - energetically expensive for many organisms. this is true for small animals like shrews & humming birds. Heat loss & gain is a function of surface area.

- Small animals have a larger surface area relative to their volume, they tend to loose body heat very fast in cold environmental conditions.

☆ - They have to ~~do~~ ~~mu~~ expend much energy to generate body heat through metabolism. Due to this very small animals are rarely found in Polar regions.

- Partial regulators

During course of evolution, some species have evolved the ability to regulate their environmental condition but, only over a limited range, beyond which they simply conform.

Migrate

- Temporary movement of organisms from unfavorable places to suitable ones till the weather conditions become suitable.

e.g. Keoladeo National Park in Bharatpur (Rajasthan) hosts 1000 of migratory birds Coming from Siberia.

Suspend

- Organisms escape / hide / remain inactive during unfavorable conditions.

- Some bacteria, fungi & lower plants under unfavourable Conditions form thick-walled spores to overcome stressful conditions.

- In higher plants – Seeds & some other vegetative reproductive structure (Propagules) help to pass over stress period & dispersal. They reduce metabolic activity & enter into dormancy.

- Some organisms unable to migrate so they might avoid stress by escaping in time.
  They undergo Deep sleep & conserve energy
  – hibernation. eg – Polar bear (winter sleep)

- Aestivation – Period when fishes get into the inactive mode during very hot / dry conditions.
  fishes go undergo Summer sleep

- Under unfavourable Conditions, many Zooplanktons enter diapause
  ↓
  a stage of Suspended development.

ADAPTATION

- Any attribute of an Organism that enables it to Survive & reproduce in its habitat can be referred to as adaptation.

- Features have evolved over a long period of time through process of natural selection.

- These adaptation become Genetically fixed.

☆ Adaptation in Plants
(Xerophytic Plants)

① Adaptations in Desert Plants

- Roots grow very deep to explore any possibility of available underground water

- Many desert plant have a thick cuticle on their leaf surface & have their Stomata arranged in deep pits to minimise water loss (Transpiration)

- Special photosynthetic Crassulacean Acid Metabolism (CAM) that enables their Stomata remain close during day time so to minimise transpiration.

- desert plant like — Opuntia No leaves. leaves reduced to spines. Photosynthesis occur in flattened stem.

(2) Adaptation in Aquatic Habitats (Hydrophytic Plants)

- They have evolved aerenchyma for buoyancy and floating.
- They have covering of wax to avoid damage through water.
- Generally Root absent
- e.g. Hydrilla and Nymphaea.

(3) Adaptation to Saline Environment (Halophytic plants)

- The plants of Saline habitats which not only have the ability to tolerate high Conc. of Salts in in their rooting medium but are also able to obtain water supply from the same called - halophytes.

- Found in tidal marshes, Coastal dunes, mangroves and Saline soils.

- Certain Green algae are also found in these areas - e.g. Dunaliella.

- Mangroves ~~have~~ are areas not only excess water salt but also have excess water & anaerobic condition. besides difficulty in anchoring & seed germination.

- A No. of plants posses small -vely Geotrophic vertical roots called: pneumatophores. (have lenticels for gaseous exchange) e.g A.ogiatilis.

- Other adaption for Mangrove is Vivipary (Seed germination while the fruit is still attached to plants) e.g → Rhizophora.

☆ Adaptation in Animals

① Adaptation in Kangaroo rat

- Kangaroo rat in North American Deserts is capable of meeting all its water requiremed by internal oxidation of its body fat (Water is byproduct)

- Also conc. its urine so that minimal volume of water is used to expel excretory product.

② Adaptation in Desert Lizards

- They show behavioural responses.

- They absorb heat from sun when body temp drop below the comfort zone & move into shade when the ambient temp starts increasing.

- Some species burrow into the soil & escape from the above ground heat.

③ Adaptations in Mammals

- Mammals from colder climates generally have shorter ears and limbs to minimise heat loss. Called – Allen's rule.

- Polar regions, aquatic mammals like seals have a thick layer of fat below their skin that acts as an insulator & reduces the loss of body heat.

☆ Adaptations at High Altitudes in Humans

- At high altitude place like Rohtang Pass near Manali (> 3500m) & Mansarovar (In china occupied Tibet) people suffer from altitude sickness.

- Symptoms - nausea, fatigue & heart palpitations.
  because at low atmospheric pressure & high altitude, body does not get enough oxygen.

- Relief occurs gradually due to acclimatisation.

- body copes up with this low ~~oxgen~~ oxygen stress by -

i ~~Incra~~ Increasing RBC production.

ii decreasing the binding affinity of haemoglobin.

iii Increasing the breathing rate.

NOTE → an archaebacteria can survive in more than 100°C. (help of certain enzymes)

invertebrates & fishes can tolerate temperatures below 0°C by solute like Glycerol & anti-freeze proteins that lower the freezing point of body fluids.

Populations

- Number of organisms of a species living in a particular area at a particular time Population
- Population that occupies a very small area and is smaller in size, called local population.
- A group of such closely related local populations is called metapopulation.
- is an important area of ecology because it links ecology to population genetics & evolution Population ecology.

Population Attributes

1- Population Size or density

- No. of individuals of a species per unit area or volume.

Population Density (PD)

$$= \frac{\text{Number of individuals in a region (N)}}{\text{Size of unit area in the region (S)}}$$

$$\left[PD = \frac{N}{S}\right]$$

2- Birth rate or Natality →
Number of births during a given period in the population.

3- Mortality death rate → Number of deaths during a given period in the population.

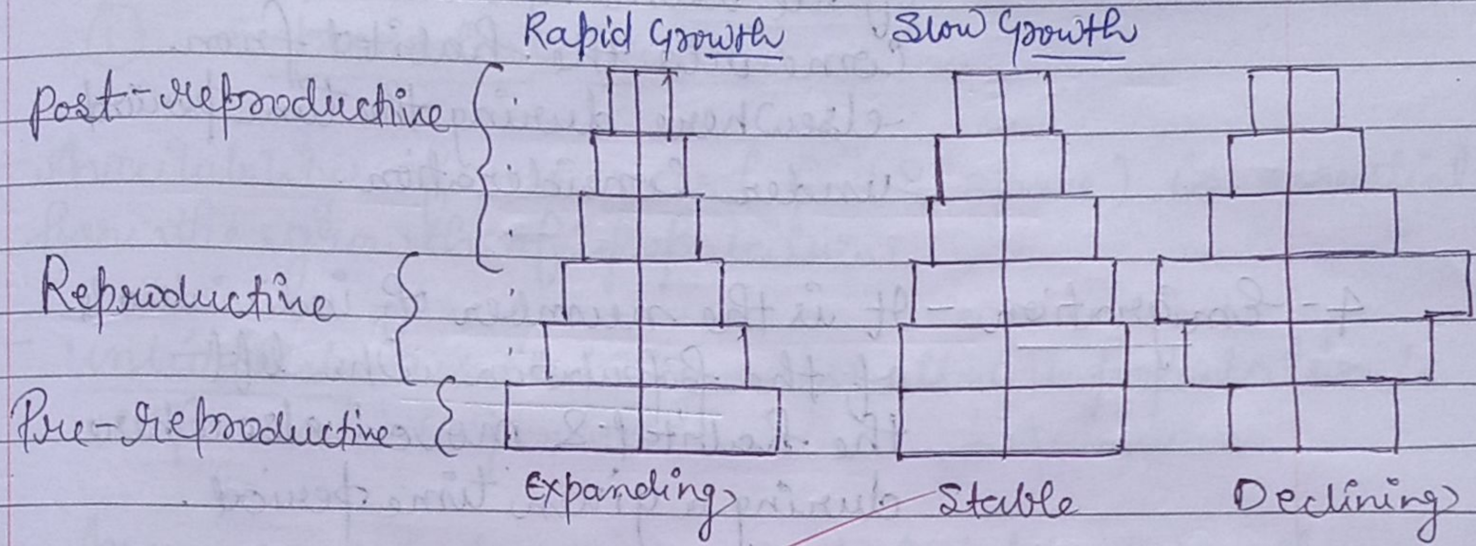
4- Sex ratio → Expressed in percentage of males & females.
- No. of males & females per 1000 individuals of a population in a given time.

AGE PYRAMID

- Population at any given time is composed of individuals of different ages. When the age distribution is plotted for the population called age pyramid.

- age pyramids of human population generally show the age distribution of males & females in a combined diagram.

- Three Types of age pyramids are as follows -



Population Growth

- Size of a population for any species is not a static parameter, it keeps changing with time.
  It depends on factor
  Such as food availability, predation pressure & adverse weather.

★ density of a population in a given habitat during a Given period fluctuates due to four basic Process

① Natality - No. of births during a given period in the population that are added to the initial density.

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

3- 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.

4- Emigration - It is the number of individuals of the population who left the habitat & moved elsewhere during a given time period.

☆ If natality & immigration contribute to an increase in population density.

☆ If emigration ~~contru~~ & mortality contribute to the decrease in population density.

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; N = Population density, t = Time, B = Birth rate, I = Immigration, D = Death rate and E = Emigration.

From the ~~abs~~ above eqn we can see that population density will increase, if (B+I) is more than (D+E).

Growth Models

(1) Exponential Growth

- Availability of resources (food & space) is essential for the growth of population.

- unlimited availability results in population's exponential growth.

- Increase or decrease in population density during a unit time period (t) is calculated as

$$dN/dt = (b-d)N$$

Let $(b-d) = r$,

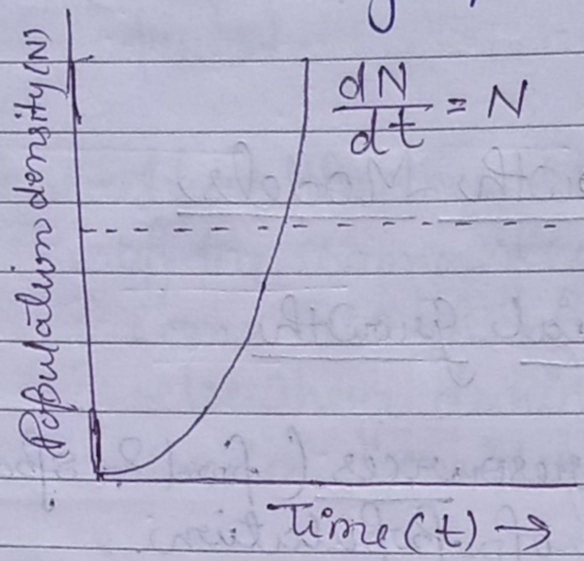
$$\left[\text{then } \frac{dN}{dt} = rN\right]$$

Where N = population size.
r = intrinsic rate of natural increase.

- r is important parameter that asseses the effects of biotic & abiotic factors on population growth.

- It is different for different organisms.
e.g → its value 0.015 for Norway rat & 0.12 for flour beetle

→ above eqn results in a J - shaped Curve as shown in graph.



★ Integral form of exponential growth equation is.

$$\frac{dN}{dt} = rN$$

$$\int_0^t \frac{dN}{N} = \int_0^t r\,dt$$

$$\left[\ln N\right]_0^t = rt$$

$$\ln N_t - \ln N_0 = rt$$

$$\ln \frac{N_t}{N_0} = rt \Rightarrow \frac{N_t}{N_0} = e^{rt} \Rightarrow \left[N_t = N_0 e^{rt}\right]$$

Exponential Growth equation: Interpretation

(1) $b > d$

$b - d > 0$

$\therefore \frac{dN}{dt} > 0$

unbounded Growth

(2) $b < d$

$b - d < 0$

$\therefore \frac{dN}{dt} < 0$

[Extinction]

(3) $b = d$

$\therefore \frac{dN}{dt} = 0$

[Stable popⁿ]

- Any species growing exponentially under unlimited resources conditions without any check, can reach enormous population densities in short time.

NOTE → r Value for human Population was 0.0205 in 1981.

Longistic Growth

- no population of any species in nature has unlimited resources at its disposal.

- leads to competition among the individuals and the survival of the fittest.

- A given habitat has enough resources to support a maximum possible number, beyond which no further growth is possible called carrying capacity (k) for that species in that habitat.

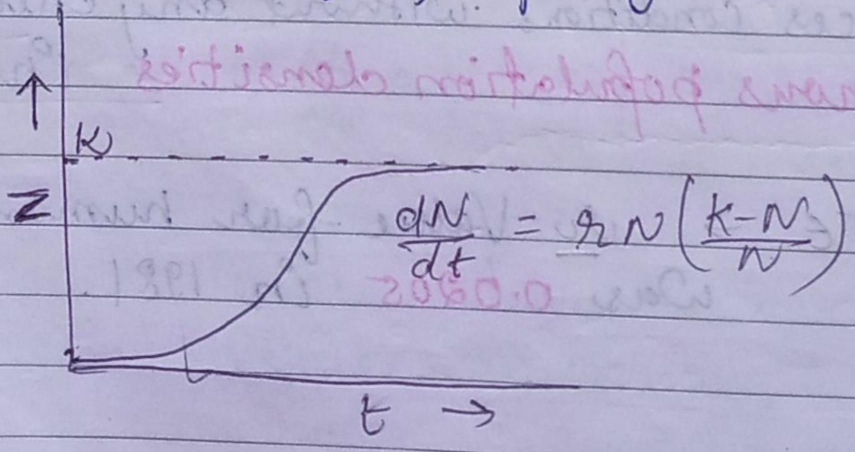
- N is plotted in relation to time t, the logistic growth shows Sigmoid curve and this type of growth called Verhulst-Pearl Logistic Growth.

Calculated as -

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

→ population density.

K is carrying capacity.



- This model is more realistic, because no popⁿ growth can sustain exponential growth indefinitely as there will be competition for the basic needs due to finite resources.

NOTE → First census carried out in 1872.
☆ Census is conducted as per the provisions made under the Census Act, 1948.

LIFE HISTORY VARIATIONS

- Under a particular set of selection pressure, organisms evolve the most efficient reproductive strategy.

- Rate of breeding varies from species to species.

- Some species breed only once in their lifetime (Pacific salmon fish & bamboo) while some breed many times in their lifetime (birds & mammals)

- Some organism produce a large number of small-sized offsprings (oysters). Where others produce a small number of larger-sized offsprings (birds & mammals).

- According to ecologists, life history traits of organisms have evolved in relation to the constraints imposed by the biotic & abiotic components of habitats in which they live.

Phases in Logistic Growth

- Lag phase

* Slow growth in population

- Log Phase

* Rapid growth in population

- Stationary Phase

* Population growth rate decrease

* Carrying capacity reached.

POPULATION INTERACTIONS

- In nature living organisms such as animals, plants and microbes, can't live in isolation & therefore, interact in various ways to form a biological community

- Population of Two species living together within a Community Called Interspecific interaction

- Interaction Could be beneficial. (+)
- Interaction Could be detrimental (-)
- Interaction Could be Neutral (0)

(1) Predation

- It is an interspecific interaction interaction, Where animal called Predator kills and Consumes the other weaker animal called Prey.
- This is biological Control method.
- Nature's way of transferring energy to higher trophic levels,
- Fixed by plants at 1st trophic level.

important role of predators are as follows

i) Absence of predators, prey species could achieve very high population density & cause instability besides acting as Conduits for energy transfer across trophic levels, play important role in maintaing population stability.

ii — Help in maintaing species diversity in Community. By reducing Competition among Competing prey species.

eg → Predator starfish Piaster in the rocky intertidal Communities of American Pacific Coast.

★ In a Field experiment

When all starfish were removed from the area, more than 10 species of Invertebrate became extinct within a year because of interspecific competition.

iii When exotic species are introduced into a Geographical area, they become invasive and start spreading fast because the invaded land doesn't have natural predators.

eg → Prickly pear cactus introduced in Australia in early 1920, was brought under Control by introducing its predator (i.e. a moth) in the Country.

*- If predator is too efficient & over exploits its prey then prey become extinct - predator will also become extinct because of lack of food.

- This is why predator in nature are prudent.

* Prey species have evolved various defence mechanisms to lessen the impact of predation.

These are as follows

- (a) Some species of insects & frogs are cryptically coloured (camouflaged) to avoid being detected easily by the predator.

Some are poisonous & therefore, avoid by the predators.

Monarch butterfly is highly distasteful to its predators (birds) because special chemical present in its body.

The butterfly ~~is~~ acquires chemical during its Caterpillar stage by feeding on poisonous weed.

- (b) Nearly 25% of all insects are known to be Phytophagous (feeding on plant sap and other parts of plant) apart from other herbivores.

So, plants have evolved various defences against them.

e.g. thorns of Acacia & Cactus are most common morphological means of defence.

- Some plants produce highly poisonous chemicals like cardiac glycosides, e.g. herbivore sick etc.

- Chemicals like nicotine, caffeine, quinine, strychine, opium etc. are actually defence mechanism against grazers & browsers.

Competition

It is generally believed to occur when closely related species compete for the same resources that are limiting. However this is not always true.

- Some totally unrelated species could also compete for the same ~~resources~~ resources.
e.g. In some shallow South American lakes, visiting flamingoes and resident fishes compete for their common food. i.e → Zooplanktons.

- Resources need not be limiting for competition to occur.

In interference Competition feeding efficiency of one species might be reduced due to the interfering & inhibitory presence of other species, although the resources are plenty.

e.g. Abingdon tortoise became extinct when Goats were introduced in Galapagos Islands (a decade due to greater browsing efficiency of the goats).

Therefore, Competition can be best defined as a process in which the fitness of one species (measure in terms of its r) is significantly lower in the presence of another species.

Competitive release → Provide another evidence of competition in nature. It is a phenomenon, in which 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 competing species is experimentally removed.

☆ Connell's elegant field experiments
Showed that on the rocky sea coasts of Scotland, the larger & competitively superior barnacle Balanus dominates the intertidal area & excludes the smaller brancle Chathamalus from that zone.

- Gause's Competitive exclusion Principle

Two ~~competing~~ closely related species competing for the same resources can't co-exist indefinitely & the competitively inferior one will be eliminated eventually.

This may hold true in case of limited resources but not in other cases.

- Resource partitioning:

Is a mechanism evolved by competing species for co-existence. If two species compete for the same resource, they could avoid competition by choosing for instance, different times of feeding or different foraging patterns.

- MacArthur In this relation showed that 5 closely related species of warblers living on the same tree were able to avoid competition & co-exist due to behavioural differences in their foraging activities.

Parasitism

- One organism is benefitted while other one is being harmed.

- Mode of interaction b/w two species in which one species depends on the other species for food & shelter & damage the host.

i Adaptation methods of a parasite are -

- It is host specific
- Both host & parasite tend to Co-evolve

According to lifestyle, a parasite evolved special adaptations as:

(a) loss of unnecessary sense organs.
(b) Presence of adhesive organs or sucker for clinging on to host.
(c) Loss of digestive systems.
(d) High reproductive capacity.

ii The life cycles of parasites are often complex, involving one or two intermediate hosts or vectors to facilitate Parasitisation of its Primary host. For example

(a) Human liver fluke (a trematode parasite) depends on two intermediate hosts (a snail & a fish) to complete its life cycle.

(b) Malarial Parasite (Plasmodium) need a vector (mosquito) to spread to other hosts.

iii. Majority of parasites harm the host. The harm is done in the following ways -

- They reduce the survival, growth & reproductive ability of host.
- They reduce its population density.
- They might render the host more vulnerable to predation by making it physically weak.

Types of Parasites

1. Ectoparasites → depends on the external surface of the host organism for food & shelter.

   e.g. Lice on human, Cuscuta, a parasitic plant that grows on hedge plants, copepods in marine fishes.

2. Endoparasites → live inside host's body at different sites like liver, kidney, lungs etc for food & shelter.

   e.g - Tapeworm, liver fluke, Plasmodium etc.

   - The life cycle of endoparasites are more complex because of their extreme specialisation.

Brood Parasitism → One organism (Parasite) lays its eggs in the nest of another organism (host) for the later to incubate them.
The birds have evolved their eggs to resemble the host's egg to reduce the chances of host bird from detecting & ejecting the parasitic eggs from nest.

e.g. Cup Cuckoo (Parasite) & Crow (host) during breeding season (Spring to Summer)

Commensalism

- Interaction b/w two species, where one species is benefitted & the other is neither harmed nor benefitted.

Some examples

- An orchid growing as an epiphyte on a mango tree gets shelter & nutrition from mango tree, Mango tree neither benefitted nor harmed.

- Barnacles growing on the back of whale are benefitted by getting moved to different locations for food as well as shelter, while whale is neither benefitted nor harmed.

- Egrets always forage closets area where the cattle are grazing. The cattle egrets are benefitted by the cattle through easy detection of the insects.
  When the cattle stir up the bushes, insects are flushed out from the vegetation to be catched by cattle egrets.

- Sea anemone has stinging tentacles and the clown fish lives among them. The fish gets protection from predators, which stay away from the stinging tentacles.

The anemone does not appear to derive any benefit by hosting the clown fish.

Mutualism

Interaction benefits both the interacting species.

Some examples

- Lichens: mutualistic relationship b/w a fungus and photosynthesising algae or cynobacteria. fungus helps in the absorption of nutrients and provides protection while algae prepares for food.

- Mycorrhizae: association b/w fungi and the roots of higher plants. Fungi help the plants in absorption of nutrients, while plant provide food for the fungus.

- Plant need help from animals for pollination and dispersal of seeds. In return plant provide ~~nectors~~ nectar, pollen and fruits to them.

- To safeguard mutually beneficial system, plant-animal interactions involve co-evolution of the mutualists.

  e.g → Evolution of the flower and its pollinator species are tightly linked with one another.

  For example

i. Fig & its partner wasp species, female wasp uses the fruit not only as an oviposition (egg-laying) site but uses the developing seeds within the fruit for nourishing its larvae.

In return the wasp pollinates the fig inflorescence, while searching for suitable egg-laying sites.

ii. Mediterranean orchid ophrys employs sexual deceit to get pollinated by a species of bee.

One petal of its flower bears an uncanny resemblance to the female of the bee in size, colour & markings. The male bee is attracted to what it perceives as a female & pseudocopulates with the flower.

During this process pollens are dusted from the flower onto the male bee. When the same bee pseudocopulates with another flower, it transfers pollens to it & thus, pollinates the flower.

Amensalism

- Interaction b/w different species, in which one species is harmed & the other is neither benefitted nor harmed.

→ Penicillium a mould secretes penicillin w
kills bacteria but the mould unaffected.

NOTE

Protocooperation is an interaction b
two different species in which both
mutually benefitted but they can l
without each other. Called facult
mutualism.

e.g → Sea anemone is carried f
place to place by the moving crab an
is benefitted by getting more place
the food. Hermit crab may also deri
benefit through camouflage and prot
provide by sea anemone because of t
presence of stinging cells in the later