# Organism & Population

**ECOLOGY:** Branch of Biology that deals with the interaction among organism and between the organism & its physical environment.
Organism →Population → Communities → Ecosystem → Biomes → Biosphere

**Populations:** Individuals of any species live in groups in well-defined geographical area, share or compete for similar resources, potentially interbreed.
Eg: All cormorants (Birds) in wet land, teakwood tree in forest, bacteria in cultural plate etc.

**Population Ecology:** Important area of ecology that links ecology to population genetics & evolution.
**Population Attributes:**

1) **Birth Rates:** The number of **live births per 1000 people** in a population in a given year.

$$\text{Birth Rate} = \left(\frac{\text{Number of Live Births in a Year}}{\text{Total Population}}\right) \times 1000$$

Per capita births. Eg: Pond had 20 lotus flower last year. 8 new plant added through reproduction.
Birth Rate = 8/20=0.4 offspring per lotus per year.

2) **Death Rate:** The number of **deaths per 1000 people** in a population in a given year.
Per capita death. Eg: 4 individuals in a laboratory population of 40 fruit flies died in a week.

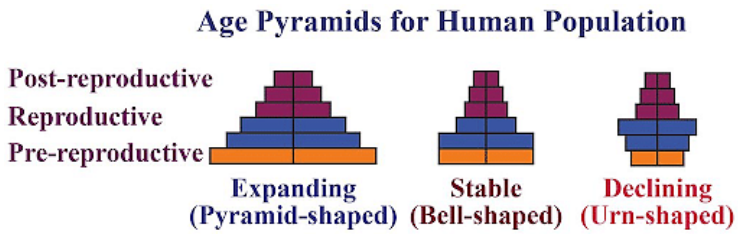
$$\text{Death Rate} = \left(\frac{\text{Number of Deaths in a Year}}{\text{Total Population}}\right) \times 1000$$

Death Rate = 4/40=0.1 individual per fruit fly per week.

3) **Sex ratio**: The number of **females per 1000 males** in a population.
The ratio of female to males in a population. Eg: 60% females & 40% males

$$\text{Sex Ratio} = \left(\frac{\text{Number of Females}}{\text{Number of Males}}\right) \times 1000$$

4) **Age Pyramid**: The structure representing geometrically the proportion of different age groups in the population of any organism




5) **Population Size/Density (N)** : The number of individuals of a species per unit area or volume.
Eg: Population density in Number: Siberian cranes at Bharatpur wetlands in any year is less than 10.

$$\text{Population Density} = \frac{\text{Number of individuals}}{\text{Unit area or volume}}$$

If there are 500 deer in a forest area of 100 km².

$$\text{Density} = \frac{500}{100} = 5 \text{ deer/km}^2$$

Population density in Biomass: In some cases measuring in number is meaning less hence population is measured in percentage cover of an area or Biomass. Eg: Chlamydomonas in a pond, Parthenium hysterophorus (Carrot grass) plant & a huge banyan tree in an area, bacteria in Petri-dish.

$$\text{Population Density} = \frac{\text{Biomass of population (kg or g)}}{\text{Unit area or volume}}$$

If the total biomass of fish in a pond is 2000 kg in 500 m³ of water,

$$\text{Density} = \frac{2000}{500} = 4 \text{ kg/m}^3$$

Relative Population density: In a huge population total number is difficult to measure in such cases without knowing is absolute density relative density is measured. Eg: No. of fishes caught in trap indicates population density of lake.

$$\text{Relative Density} = \left(\frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all species}}\right) \times 100$$

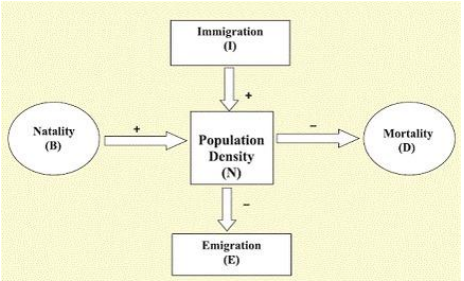
Relative density is important in **ecology** for understanding **species dominance, competition**, and **biodiversity** in a habitat.

In some cases indirect estimation id performed. Eg: Tiger census in national park is based on pug mark & faecal pellets.

Que: In a pond ecosystem, there are 80 mosquito larvae, 40 snails, and 30 small fish.
Calculate the relative density of snails in the pond.
For Snails: Total individuals = 80 + 40 + 30 = 150

$$\text{Relative Density} = \left(\frac{40}{150}\right) \times 100 = 26.67\%$$

**Population Growth:** The size of population is not static. It keeps changing with time, depending upon food availability, predation pressure and reduces weather. The main factors that determine the population growth are-

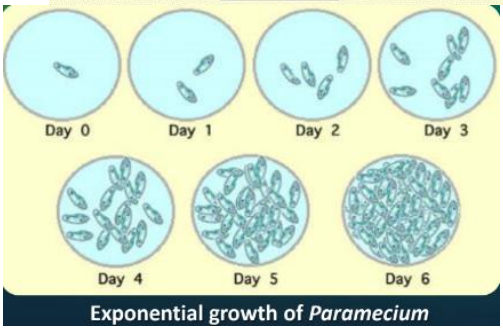



- **Natality** (number of birth during a given period in the population)
- **Mortality** (number of death during a given period in the population)
- **Immigration** (individual of same species that have come into the habitat)
- **Emigration** (individual of population that have left the habitat)

If 'N' is the population density at a time't', then its density at time t+1 is

$$N_{t+1} = N_t + [(B + I) - (D + E)]$$

Population density will increase (B + I) is more than (D + E).




**Growth Model**

Growth of population takes place according to availability of food, habit condition and presence of other biotic and abiotic factors.

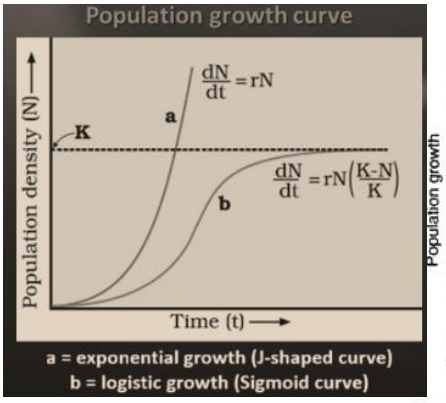
i. **Exponential Growth**- When food and space is available in sufficient amount. When resources in the habitat are unlimited, each species has the ability to realise fully its innate potential to grow in number.

If in a population of size N, the birth rates is 'b' and death rate is 'd'. Then increase and decrease in N during unit period time 't' will be

**dN / dt = rN**

Let (b – d) = **r** (intrinsic rate of natural increase)

Integral form of exponential Growth: $N_t = N_0 e^{rt}$



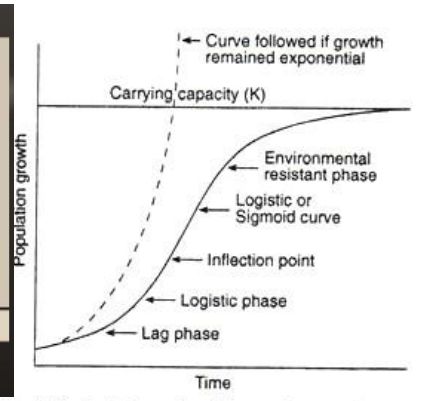




Fig. 4.42 : Logistic or sigmoid growth curve. The total size of the population grows in an S shape

$N_t$= Population density at time t

$N_0$=Population density at time zero

**e** = base of logarithms (2.718)

**r**= intrinsic rate of natural increase

(the maximum growth rate of a population under ideal environmental conditions (no limiting factors, unlimited food and space).

If rates are given **per 1000**, then: $r = \frac{b-d}{1000}$

**K** = Carrying capacity (It is the maximum population size of a species that an environment can support sustainably over time, without depleting available resources (like food, water, space).

**Question:**

A minister challenged the king to a chess game with a unique bet: if the minister won, he would ask for grains of wheat to be placed on a chessboard in such a way that 1 grain is placed on the first square, 2 on the second, 4 on the third, and so on—doubling on each of the 64 squares. The king, thinking it was a modest request, agreed. However, as the grains doubled with each square, the king was stunned by the unimaginable total.

Answer the following based on this situation:

**a)** What type of growth pattern does this illustrate?

**b)** Write the formula used to calculate the number of grains on the *n*th square.

**c)** Why is this kind of exponential growth unsustainable in the real world?

**d)** If **50,000 grains of wheat equal 1 kilogram**, calculate the **total weight of wheat (in kilograms)** the king would need to give to the minister.

ii. **Logistic Growth**- Limited resources. In this types of growth initially shows a leg phase followed by phases of acceleration, de-acceleration & finally **asymptote** (a line that a curve approaches but never touches).

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

Since resources for growth for populations are finite and become limiting , the logistic growth model is considered a more realistic one & called Verhulst-pearl logistic growth.

**Life History Variation**

Population evolve to maximise their reproductive fitness or Darwinian Fitness (higher r value). Evolved due to limited abiotic & biotic components.

- Breed Once in a lifetime: Pacific salmon fish , Bamboo
- Breed many times: Birds, Mammals
- Produce large no. of small sized offspring: Oysters, fishes etc
- Produce small no. of large sized offspring: Birds mammals

| Species A | Species B | Name of Interaction |
|---|---|---|
| + | + | *Mutualism* |
| – | – | *Competition* |
| + | – | *Predation* |
| + | – | *Parasitism* |
| + | 0 | *Commensalism* |
| – | 0 | *Amensalism* |

**Population interaction**

All animals, plants and microbes in a biological community interact with each other. These interactions may be beneficial, detrimental or neutral to one of species or both.

**PREDATION :** It is an Interspecific Interaction where one animal kills and consumes the other weaker animal.

- All carnivores, herbivores etc are predator.
- About 25% insects are phytophagous (feeding on plant sap and other parts of plants).

***Roles of Predators***

- Transfer energy from plants to higher trophic levels (position of organism in food chain)
- Control Prey population – Eg: Prickly pear cactus (in Australia 1920)- predator moth
- Biological control of Agricultural pest
- Maintain species diversity by reducing intensity of competition among competing prey species. Eg: In the rocky intertidal communities of the American Pacific Coast when all the starfish (Pisaster) were removed, more than 10 species of invertebrates became extinct within a year, because of interspecific competition.
- Over exploitation of prey by the predators results in extinction of prey and predator. Hence, predator are **Prudent** in nature.
- Defense to lessen impact of predation
  a) Insects and frog – camouflage
  b) Monarch butterfly – distasteful due to feeding on a poisonous weed.

**Plants Morphological and Chemical Defences:**

- Thorns- defence mechanism of cactus and Acacia
- Some Plant produce and store chemical- make the herbivore sick, inhibit feeding or digestion, disrupt its reproduction or even kill it.
- Calotropis weed- poisonous cardiac glycosidase.
- Nicotine, Caffeine, Quinin, Strychnine, opium – defence against grazers & browsers

**COMPETITION** : Interaction either among individuals of same species or between individuals of different species.

According to Charls Darwin: Competition is a process in which the fitness of one species (measured in terms of its 'r' the intrinsic rate of increase) is significantly lower in the presence of another species.

Darwin believed that **interspecific competition** is a major driving force in **organic evolution**, as seen in the **struggle for existence** and **survival of the fittest**.

Occurs among closely related species but not always true.

1. Unrelated species also compete- Ex: In South American Lake flamingo (Bird) & fish compete for zooplankton
2. Interference Competition: Feeding efficiency of a species reduce due to introduction of other species even if resources are plenty – **Abingdon tortoise** in Galapagos island become extinct within a decayed due to introduction of **Goat**

**Evidence for competition**

**Connell's Field Experiment:** On rocky sea coast of Scotland two species of barnacle (crustaceous- grows on rocks or back of whales) – Balanus (large & competitive superior) and Chthamalus (smaller).

- Balanus dominate intertidal area and exclude Chthamalus.
- When Connel experimentally remove Balanus, Chthamalus colonized the intertidal zone.

**Gause's Competition Exclusion Principle-** (for limited resources)

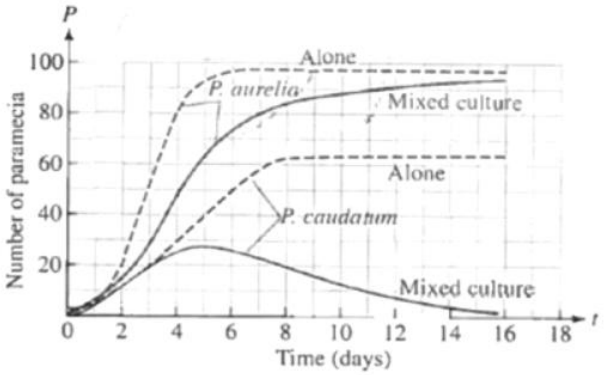
**Experiment**: Studied **Paramecium caudatum** and **P. aurelia** in the lab.

**Observation**: When grown together with limited resources, one species **outcompeted and eliminated** the other.

Two closely related species competing for same resources cannot coexist as the competitively inferior one will be eliminated.

The graph represents inter-specific interaction between two species of Paramecia competing for the same resource in a culture medium. Paramecium caudatum and Paramecium aurelia were grown in separate cultures as well as in mixed cultures. It was found that each species grew in numbers according to the logistic equation.

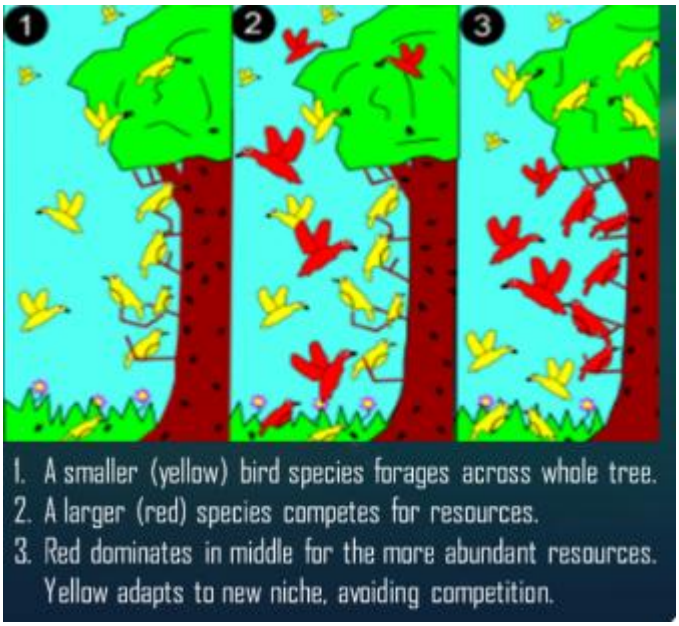
a) Which species is competitively superior? Support it with the data provided in the graph.
b) State the underlying principle for the above result and name the scientist associated with this principle.
c) Explain the mechanism in which two or more species competing with each other can co - exist.
d) Whenever Paramecium aurelia and Paramecium caudatum are placed into the same culture and given a constant supply of food under constant conditions, P. aurelia will always outcompete P. caudatum, which eventually dies off. What factors prevent P. caudatum from surviving in this situation?

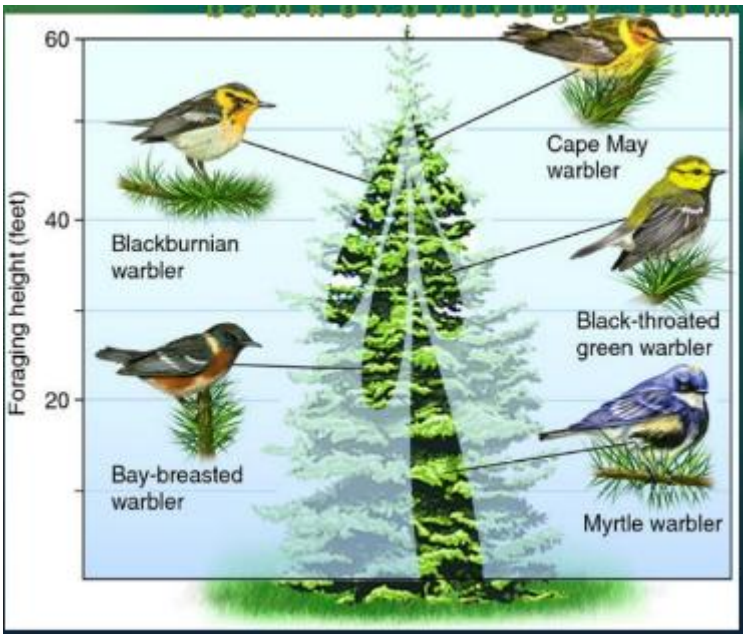



Answer: In Gause's experiment, *Paramecium aurelia* outcompetes *Paramecium caudatum* because both compete for the same limited food. *P. aurelia* grows faster and uses resources more efficiently. Due to this, *P. caudatum* cannot survive and eventually dies — showing **competitive exclusion**.

**Competitive release** – species distribution range expand if the competitive species is removed which was restricted to small areas due to competitively superior species.

**Resource partition (Mechanism for Coexistence)**–- Two competing species avoid competition by adapting different feeding and foraging patterns.
**Mac Arthur** experimentally showed 5 species of warblers (birds) co-existed due to different foraging activities.




**PARASITISM**-It is the interaction where one species (parasite) depends on the other species (host) for food and shelter, host is harmed. Some Parasites are host specific and co-evolve with host.

Parasites-
(i) Reduce the survival of host & population density.
(ii) Growth and reproductive rate are reduced
(iii) Makes host vulnerable to its predators by making them weak

| **Adaptations of parasites** |
|---|
| Loss of unnecessary sense organs |
| Presence of Hooks and sucker |
| Loss of digestive system |
| High Reproductive capacity |

**Types of parasite**
**ECTOPARASITES–**depend on external surface of host
Example – head lice on humans, ticks on dogs, leech (Hirudinaria), copepods/ sea lice (on marine fish), Cascuta (Plant parasite lacking chlorophyll has haustoria to get nutrition from plant)

**ENDOPARASITES–**take shelter within the body of the host organism. Their lifecycle is more complex because of their extreme specialisation & simple morphological & anatomical features with high reproductive potential.
Example – Ascaris (causes Ascariasis - abdominal pain, nausea, vomiting), Tape worm (taeniasis- Abdominal pain, Nausea and Diarrhea) , Plasmodium- needs mosquito to spread, Liver fluke- Human liver fluke (fascioliasis- abdominal pain, fever, nausea, and liver enlargement) depends on two intermediate hosts (a snail & a fish) to complete its lifecycle.

**Brood parasitism** : Parasitic bird (cuckoo/koel ) lays its eggs in the nest of its host (crow) and lets the host incubate them. Evolution leads to resemble the host's egg in size & colour hence reduce the chances of ejecting them from nest.

**Note**: Female mosquito is not considered as parasite because it needs our blood only for reproduction not as food.

**COMMENSALISM:** The interaction in which one species benefits and the other is neither harmed nor benefited.

- An orchid (+) growing as an epiphyte on a mango branch (0).
- Barnacles (+) growing on the back of a whale (0).
- The cattle egret (+) and grazing cattle (0). The egrets always forage close to where the cattle are grazing As cattle move, the vegetation insects comes out otherwise it will be difficult for the egrets to find & catch insect.
- Sea anemone (0) that has stinging tentacles that gives protection to the clown fish (+).

**MUTUALISM-**It is interaction in which both the interacting species are benefited. Examples-
1. Lichen – fungi (provide shelter & raw material) and algae (prepare food)
2. Mycorrhizae – fungi (helps in absorption of essential nutrients) and roots of higher plants (provide food)
3. Pollination & seed dispersal of plants by insects (gets nector)
4. Fig gets pollinated only by wasp. Wasp gets suitable egg-laying site in fruit and gets food for its larva from its seed.
5. Mediterranean orchid- sexual deceit for pollination – one petal of Ophrys Orchid appears as female bee/ bumblebee, so male be pseudo-copulates with flower. Not all orchids offer rewards.

**AMENSALISM:** Interaction between two different species, in which one species is harmed and other species is neither harmed nor benefited. Example. Bacterial culture, after few days fungus growth like Pencillium. Its secretions of chemical will kill bacteria, but no benefits to fungi.

**Que: How does the Bird Sing? What is it significance?**
Ans: Bird sings through voice box and vibrating box. Bird sing as it needs to communicate to its mate during breeding season.

**Q1: Why are night-blooming flowers generally white?**
**Answer:** Night-blooming flowers are usually white or pale in color because white reflects the most light, making the flowers more visible in the dark. This helps attract nocturnal pollinators like moths and bats that rely on sight and scent to locate flowers at night.

**Q2: How does the bee know which flower has nectar?**
**Answer:** Bees can detect nectar-rich flowers through:

- Color patterns visible in ultraviolet light, which humans can't see but bees can.
- Fragrance emitted by flowers.
- Past learning and memory, as bees remember which flowers previously provided nectar.

**Q3: Why does cactus have so many thorns?**
**Answer:** Cactus plants have many thorns (modified leaves) to:

- Prevent water loss by reducing surface area.
- Protect the plant from herbivores in arid environments.
- Provide shade and reduce air flow around the plant, helping to conserve moisture.

**Q4: How does the chick (spur) recognize her own mother?**
**Answer:** A chick recognizes its mother through a process called **imprinting**, which occurs shortly after hatching. During this sensitive period, the chick forms a strong attachment to the first moving object it sees — usually its mother.
The hormone **oxytocin-like neuropeptides** and **thyroid hormones** in birds play a role in promoting **social bonding and memory formation** during imprinting. These hormones influence the chick's brain to **store and recall** visual and auditory cues of the mother, helping it identify and follow her.