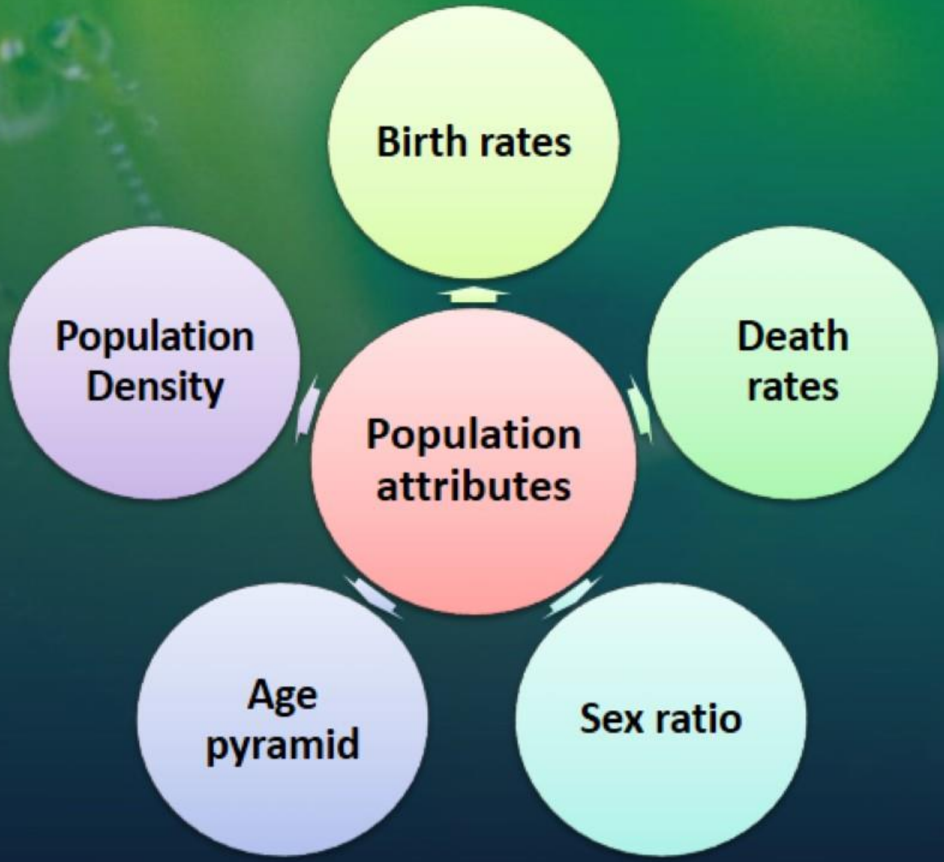
POPULATIONS

POPULATIONS

- A **population** is a group of individuals of same species that live in a given geographical area, share or compete for similar resources and potentially reproduce.
- E.g. All the cormorants in a wetland, rats in an abandoned dwelling, teakwood trees in a forest tract, bacteria in a culture plate and lotus plants in a pond etc.
- **Population ecology** is an important area of ecology as it links ecology to **population genetics & evolution.**

POPULATIONS

Population attributes



POPULATIONS

Population Attributes — Birth Rates

- It refers to *per capita* births.
- E.g. In a pond there are 20 lotus plants last year and through reproduction 8 new plants are added.

  Hence, the current population = 28

  Birth rate = 8/20 = 0.4 offspring per lotus per year.

POPULATIONS

Population Attributes — Death Rates

- It refers to *per capita* deaths.
- E.g. 4 individuals in a laboratory population of 40 fruit flies died during a week.
  Hence, the death rate = 4/40 = 0.1 individuals per fruit fly per week.

POPULATIONS

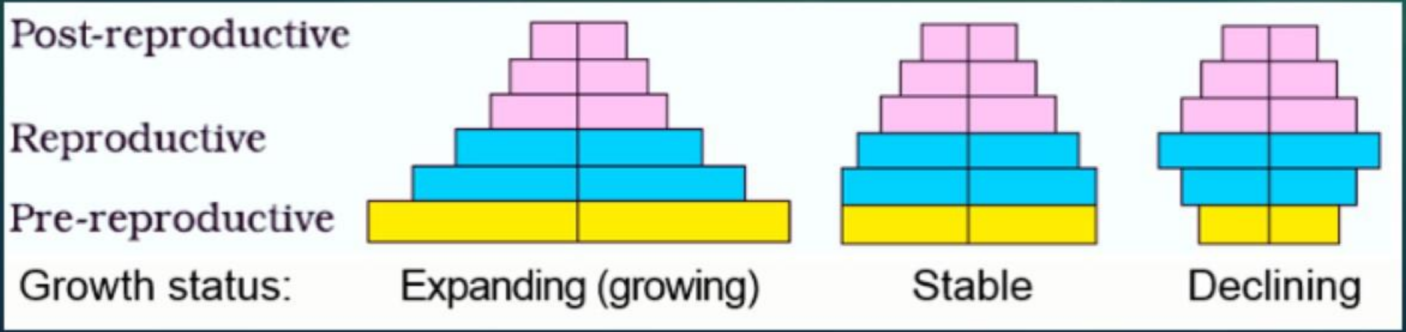
Population Attributes — Sex Ratio

- A population has a sex ratio.
- E.g. 60% of the population is females and 40% males.

POPULATIONS

Population Attributes — Age Pyramid

- It is the structure obtained when the **age distribution** (% individuals of a given age or age group) is plotted for the population.
- For human population, age pyramids generally show age distribution of males & females in a combined diagram.



Representation of age pyramids for human population

POPULATIONS

Population Attributes — Population size/Population density (N)

- It is the **number of individuals of a species per unit area or volume.**
- E.g. population density of Siberian cranes at Bharatpur wetlands in any year is <10. It is millions for *Chlamydomonas* in a pond.

POPULATIONS

Population Attributes → Population size/Population density (N)

- It is the **number of individuals of a species per unit area or volume.**
- E.g. population density of Siberian cranes at Bharatpur wetlands in any year is <10. It is millions for *Chlamydomonas* in a pond.
- Population size is also measured in **% cover or biomass.** E.g. In an area, 200 *Parthenium* plants and a huge banyan tree are seen. In such cases, measuring % cover or biomass is meaningful to show importance of banyan tree.

Parthenium

Banyan tree

POPULATIONS

Population Attributes › Population size/Population density (N)

- Total number is a difficult measure for a huge population. In such cases, **relative population density** (without knowing absolute population density) is used. E.g. the number of fish caught per trap indicates its total population density in the lake.
- In some cases, **indirect estimation** of population sizes is performed. E.g. Tiger census in national parks & tiger reserves based on **pug marks & fecal pellets.**

POPULATIONS

Population Growth

- The population size changes depending on factors like **food availability, predation pressure & weather.**
- Changes in population density give some idea about the population – whether it is flourishing or declining.

POPULATIONS

Population Growth

4 basic processes that fluctuate the population density:

- **Natality (B):** It is the number of births in a population during a given period.
- **Mortality (D):** It is the number of deaths in a population during a given period.
- **Immigration (I):** It is the number of individuals of the same species that have come into the habitat from elsewhere during a given time period.
- **Emigration (E):** It is the number of individuals of the population who left the habitat and gone elsewhere during a given time period.

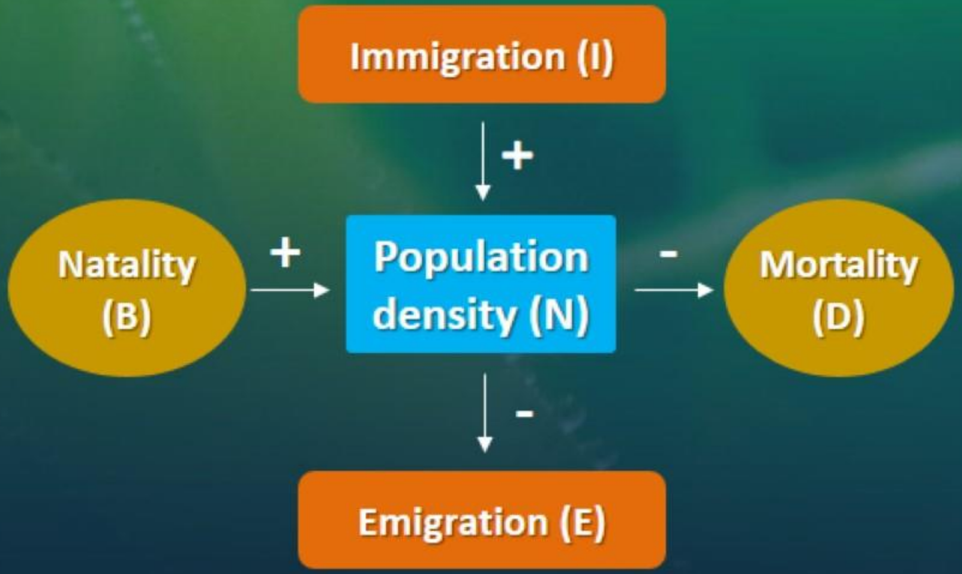
POPULATIONS

Population Growth

- Natality & Immigration increase the population density and mortality & emigration decrease the population density.
- If N is the population density at time t, then its density at time t +1 is

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

- Population density increases if B + I is more than D + E. Otherwise it will decrease.



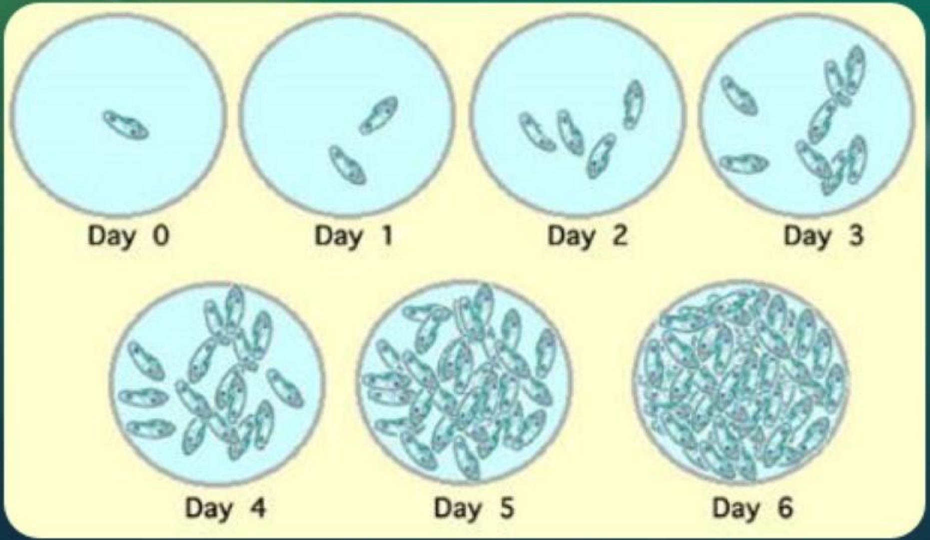
POPULATIONS

Population Growth

- Under normal conditions, births & deaths are important factors influencing population density.
- Immigration & emigration have importance only under special conditions. E.g. for a colonizing new habitat, immigration may be more significant to population growth than birth rates.

a. Exponential growth

- Resources (food & space) are essential for the unimpeded population growth.
- If resources are unlimited, each species shows its full innate potential to grow in number. Then the population grows in an exponential or geometric fashion.



Exponential growth of *Paramecium*

POPULATIONS

Population Growth | Growth Models

a. Exponential growth

- If population size = N

  Birth rates (*per capita* births) = *b*

  Death rates (*per capita* deaths) = *d*

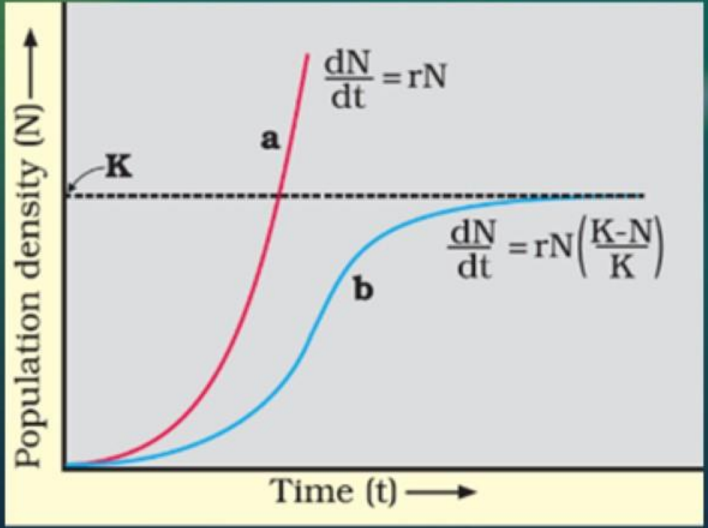
  then the increase or decrease in N during a unit time period t (dN/dt) will be

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

Let (b–d) = r, then

$$dN/dt = rN$$

Population growth curve



a = exponential growth (J-shaped curve)
b = logistic growth (Sigmoid curve)

POPULATIONS

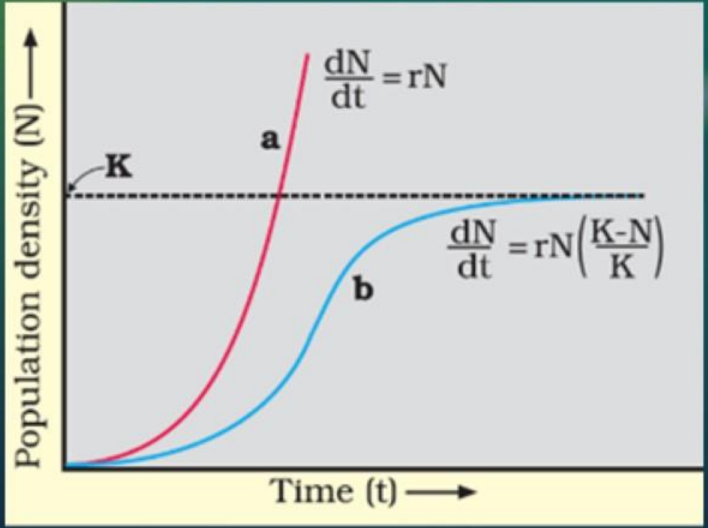
Population Growth | Growth Models

a. Exponential growth

- The r ('intrinsic rate of natural increase') is an important parameter for assessing impacts of any biotic or abiotic factor on population growth.

Organism	r value
Norway rat	0.015
Flour beetle	0.12
Human population in India (1981)	0.0205

Population growth curve



a = exponential growth (J-shaped curve)
b = logistic growth (Sigmoid curve)

POPULATIONS

Population Growth — Growth Models

a. Exponential growth

❖ The integral form of the exponential growth equation is

$$N_t = N_0 e^{rt}$$

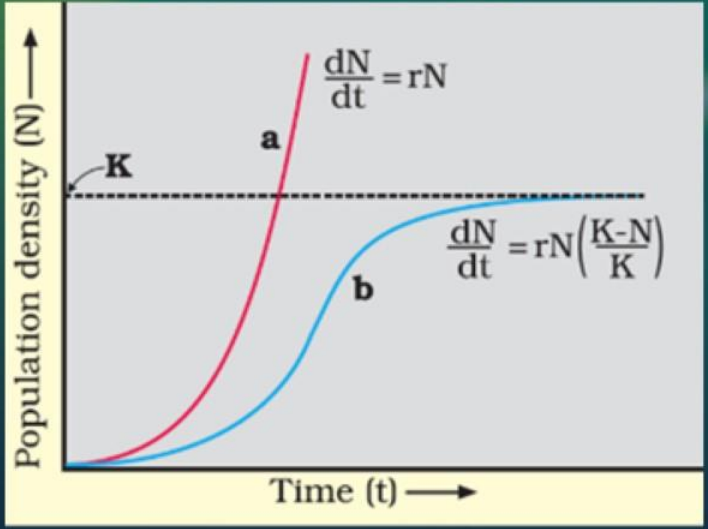
Where, Nt = Population density after time t

N_0 = Population density at time zero

r = intrinsic rate of natural increase

e = the base of natural logarithms (2.71828)

Population growth curve

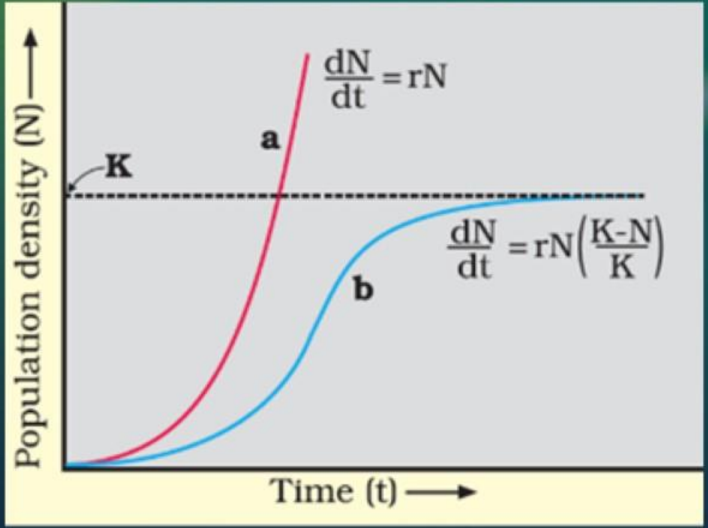


a = exponential growth (J-shaped curve)
b = logistic growth (Sigmoid curve)

b. Logistic growth

- There is no population in nature having unlimited resources for exponential growth. This leads to **competition** among individuals for limited resources. Eventually, the **'fittest'** individuals survive and reproduce.
- In nature, a given habitat has enough resources to support a maximum possible number, beyond which no further growth is possible. It is called **carrying capacity (K).**

Population growth curve



a = exponential growth (J-shaped curve)
b = logistic growth (Sigmoid curve)

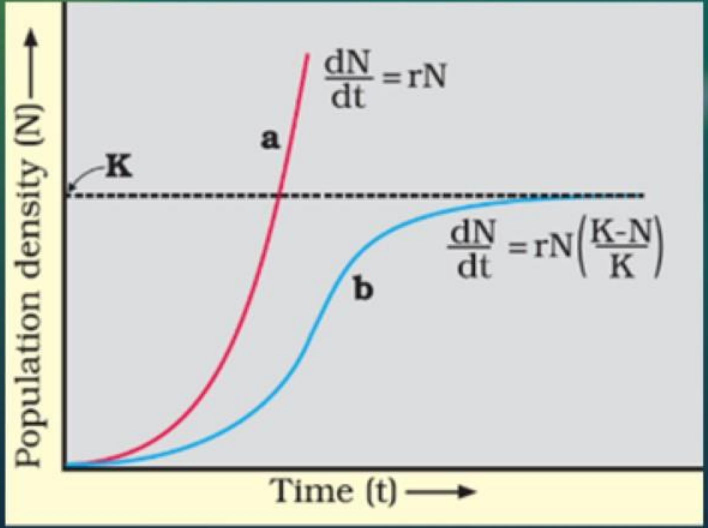
POPULATIONS

Population Growth — Growth Models

b. Logistic growth

❖ A population with limited resources shows initially a lag phase, phases of acceleration & deceleration and finally an asymptote. This type of population growth is called Verhulst-Pearl Logistic Growth.

Population growth curve



a = exponential growth (J-shaped curve)
b = logistic growth (Sigmoid curve)

POPULATIONS

Population Growth | Growth Models

b. Logistic growth

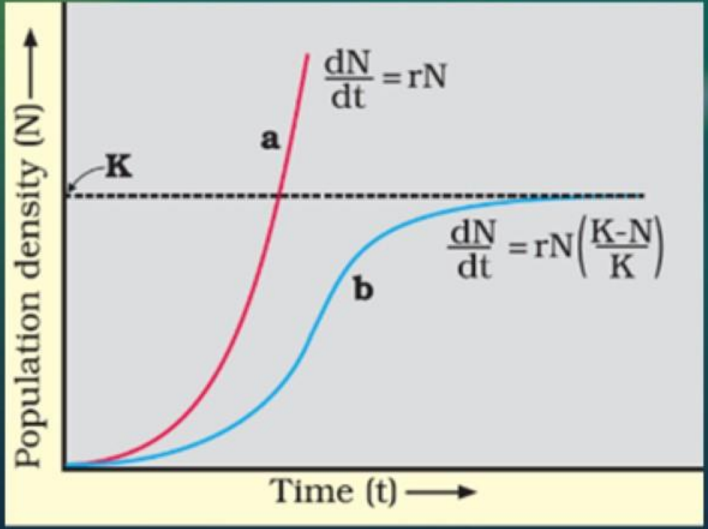
❖ **Verhulst-Pearl Logistic Growth** is described as

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

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

❖ For most animal populations, resources for growth are limited. So the logistic growth model is more realistic.

Population growth curve



a = exponential growth (J-shaped curve)
b = logistic growth (Sigmoid curve)

POPULATIONS

Life History Variation

- Populations evolve to maximise their reproductive fitness or Darwinian fitness (high r value). Under a particular set of selection pressures, organisms evolve towards the most efficient reproductive strategy.
- Some organisms breed only once in their lifetime (Pacific salmon fish, bamboo) while others breed many times (most birds & mammals).
- Some produce a large number of small-sized offspring (Oysters, pelagic fishes) while others produce a small number of large-sized offspring (birds, mammals).
- These facts indicate that life history traits of organisms have evolved due to limited abiotic and biotic components of the habitat.

POPULATIONS

Population Interactions

- Organisms interact in various ways to form a biological community.
- Interaction between two species is called **Interspecific interactions.** They include

1. Mutualism
2. Competition
3. Predation
4. Parasitism
5. Commensalism
6. Amensalism

POPULATIONS

Population Interactions

Name of interaction	Description	Species	
		A	B
Mutualism	Both species are benefitted (+).	+	+
Competition	Both species are harmed (-).	-	-
Predation	One (predator) is benefitted. Other (prey) is harmed.	+	-
Parasitism	One (parasite) is benefitted. Other (host) is harmed.	+	-
Commensalism	One is benefitted. Other is unaffected (0).	+	0
Amensalism	One is harmed. Other is unaffected.	-	0

In predation, parasitism & commensalisms, the interacting species live closely together.

POPULATIONS

Population Interactions — a. Predation

- In a broad ecological context, **all carnivores, herbivores etc. are predators.**
- About 25 % insects are ***phytophagous.***
- If a predator overexploits its prey, then the prey might become extinct. It results in the extinction of predator. Therefore, predators in nature are **'prudent'.**

Herbivores

Carnivores

Population Interactions — a. Predation

Importance of predators

1. **Predators control prey populations.**

   When certain exotic species are introduced into a geographical area, they spread fast due to the absence its natural predators in the invaded land.

   E.g. the **prickly pear cactus** introduced into Australia (in 1920's) caused havoc by spreading. Later, it was controlled by introducing a **cactus-feeding predator moth.**

Prickly pear cactus (Opuntia)

POPULATIONS

Population Interactions — a. Predation

Importance of predators

2. Predators are used in Biological control methods.
3. Predators maintain species diversity in a community by reducing competition among prey species.

   E.g. the predator starfish *Pisaster* in the rocky intertidal communities of the American Pacific Coast. In an experiment, all these starfishes were removed from an enclosed intertidal area. It caused extinction of over 10 invertebrate species within a year, due to interspecific competition.

POPULATIONS

Population Interactions — a. Predation

Defenses of prey species to lessen impact of predation

- Camouflage (cryptic colouration) of some insects & frogs. Some are poisonous.
- The Monarch butterfly is highly distasteful to its predator bird. It is due to a special chemical in its body. It is acquired during its caterpillar stage by feeding on a poisonous weed.

Camouflaged frog

Leaf insect

Monarch butterfly

POPULATIONS

Population Interactions — a. Predation

Defenses of prey species to lessen impact of predation

- **Thorns:** Most common morphological means of defense of plants. E.g. *Acacia*, *Cactus etc.*
- Many plants produce chemicals that make the herbivore sick, inhibit feeding or digestion, disrupt its reproduction or kill it.

  E.g. *Calotropis* produce poisonous cardiac glycosides. So cattle or goats do not eat it.

  Nicotine, caffeine, quinine, strychnine, opium, etc. are defenses against grazers and browsers.

POPULATIONS

Population Interactions — b. Competition

- It is a process in which fitness of one species ('r' value) is significantly lower in presence of another species.
- Interspecific competition is a potent force in organic evolution.
- Competition occurs when closely related species compete for the same limited resources.

POPULATIONS

Population Interactions — b. Competition

- Unrelated species can also compete for the resource.
  E.g. **Flamingoes & fishes** in some shallow South American lakes compete for zooplankton.
- Competition occurs in abundant resources also.
  E.g. In **interference competition,** the feeding efficiency of one species is reduced due to the presence of other species, even if resources are abundant.

POPULATIONS

Population Interactions — b. Competition

Evidences for competition

1. **Abingdon tortoise** in Galapagos Islands became extinct within a decade after goats were introduced on the island, due to greater browsing efficiency of the goats.

POPULATIONS

Population Interactions › b. Competition

Evidences for competition

2. **Competitive release:** It is the **expansion of distributional range** of a species when the competing species is removed.

   Connell's field experiments: On the rocky sea coasts of Scotland, there are 2 barnacle species: ***Balanus*** (larger & competitively superior) & ***Chthamalus*** (smaller). *Balanus* dominates intertidal area and excludes *Chthamalus.*

   When Connell experimentally removed *Balanus, Chthamalus* colonized the intertidal zone.

POPULATIONS

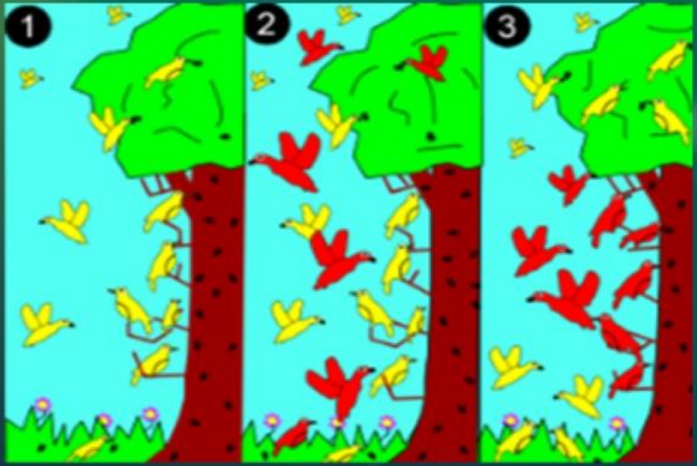
Population Interactions — b. Competition

Gause's 'Competitive Exclusion Principle'

- It states that *two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eliminated eventually.*

  This may be true in limited resources, but not otherwise.

- Species facing competition may evolve mechanisms for co-existence rather than exclusion. E.g. resource partitioning.



1. A smaller (yellow) bird species forages across whole tree.
2. A larger (red) species competes for resources.
3. Red dominates in middle for the more abundant resources. Yellow adapts to new niche, avoiding competition.

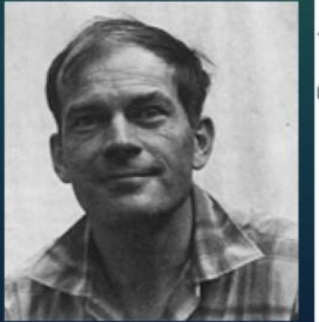
POPULATIONS

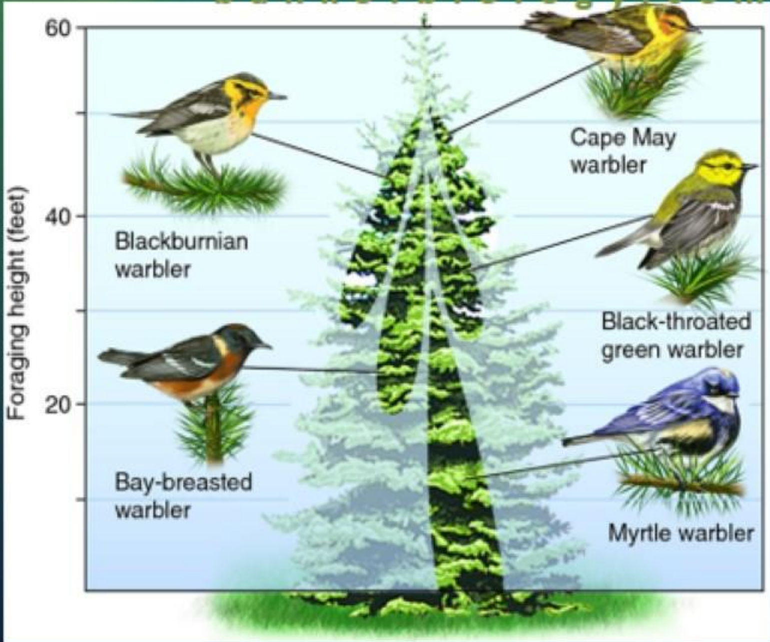
Population Interactions — b. Competition

Gause's 'Competitive Exclusion Principle'

Resource partitioning

- It is the division of limited resources by species to avoid competition. For this, they choose different feeding times or different foraging patterns.
- E.g. MacArthur showed that five closely related species of warblers living on a tree could avoid competition and co-exist due to behavioural differences in their foraging activities.

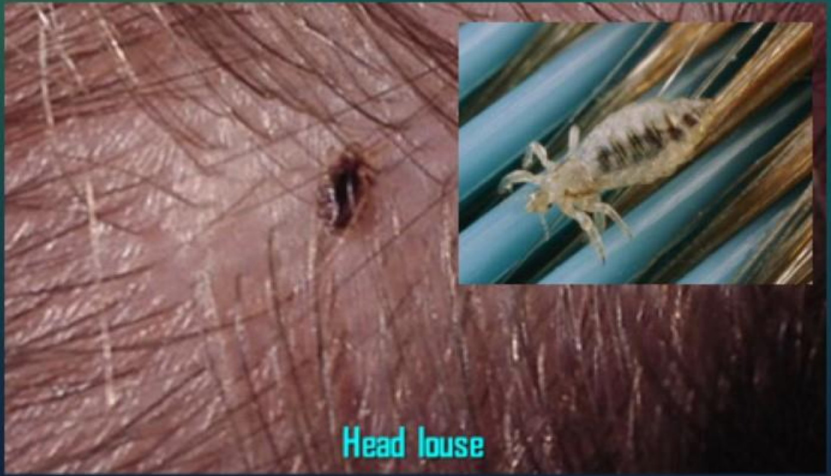




POPULATIONS

Population Interactions — c. Parasitism

- Many parasites are **host-specific** (they can parasitize only a single host species).
- They tend to **co-evolve.** i.e., if the host evolves special mechanisms against the parasite, the parasite also evolves mechanisms to counteract them to remain with the same host.

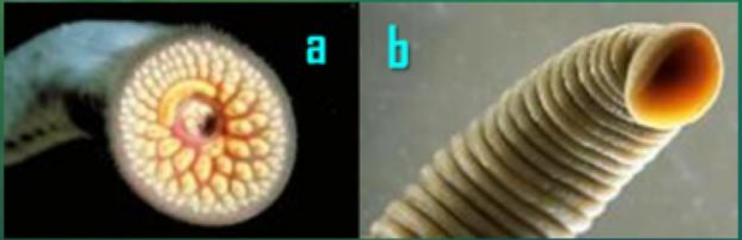


POPULATIONS

Population Interactions — c. Parasitism

Adaptations of parasites

- Loss of sense organs.
- Presence of adhesive organs or suckers to cling on to the host.
- Loss of digestive system.
- High reproductive capacity etc.



Suckers in
a. Lamprey
b. Leech

Hirudinaria (Blood Leech)

Ascaris

POPULATIONS

Population Interactions — c. Parasitism

- Life cycles of parasites are often complex. E.g.
  - **Human liver fluke** depends on 2 intermediate hosts (a snail & a fish) to complete its life cycle.
  - **Malarial parasite** needs mosquito to spread to other hosts.

- Parasites harm the host.
- They reduce the survival, population density, growth and reproduction of host.
- They may make the host physically weak and more vulnerable to predation.

Human liver fluke

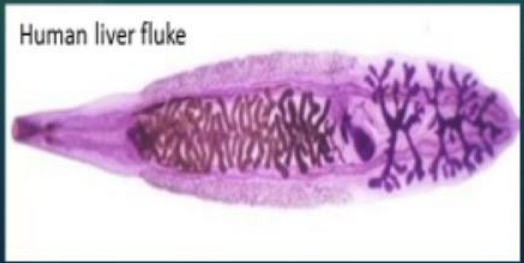
POPULATIONS

Population Interactions — c. Parasitism

Types of parasites

1. Ectoparasites

2. Endoparasites



POPULATIONS

Population Interactions — c. Parasitism

Types of parasites — 1. Ectoparasites

- They feed on the external surface of host. E.g.
  - Lice on humans.
  - Ticks on dogs.
  - Ectoparasitic Copepods in many marine fishes.
  - *Cuscuta* plant on hedge plants. It has no chlorophyll and leaves. It derives nutrition from the host plant.

Female mosquito is not considered a parasite because it needs our blood only for reproduction, not as food.

Copepods (sea lice) attached to eye of an arrowtooth flounder

POPULATIONS

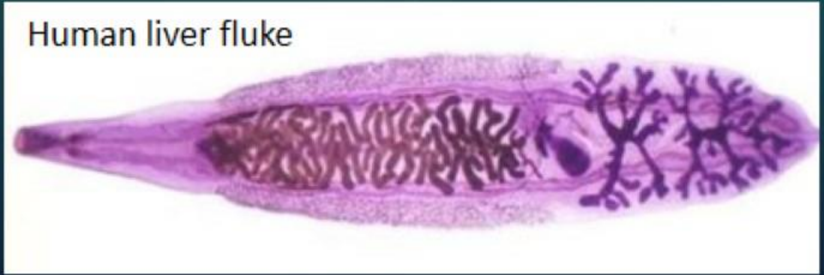
Population Interactions — c. Parasitism

Types of parasites — 2. Endoparasites

- Parasites that live inside the host body at different sites (liver, kidney, lungs, RBC etc).
- The life cycles of endoparasites are more complex.
- They have simple morphological & anatomical features and high reproductive potential.


Roundworms


Tapeworm


Human liver fluke

POPULATIONS

Population Interactions — c. Parasitism

Brood parasitism in birds

- Here, the parasitic birds lay eggs in the nest of its host and lets the host incubate them.
- During evolution, eggs of the parasitic bird have evolved to resemble the host's egg in size and colour. So the host bird cannot detect and eject the foreign eggs easily.
- E.g. Brood parasitism b/w cuckoo & crow.

POPULATIONS

Population Interactions — d. Commensalism

Examples

- Orchid (+) growing as *epiphyte* on mango branch (0).
- Barnacles (+) growing on back of a whale (0).
- Cattle egret (+) & grazing cattle (0). The egrets forage close to where the cattle are grazing. As the cattle move, the vegetation insects come out. Otherwise it is difficult for the egrets to find and catch the insects.
- Sea anemone (0) & clown fish (+). Stinging tentacles of sea anemone gives protection to fish from predators.

POPULATIONS

Population Interactions — e. Mutualism

Examples

1. **Lichen:** It is a mutualistic relationship between a **fungus & photosynthesizing algae or cyanobacteria.**
2. **Mycorrhizae:** Associations between **fungi & the roots of higher plants.** The fungi help the plant in the absorption of essential nutrients from the soil while the plant provides the fungi with carbohydrates.

Population Interactions

e. Mutualism

Examples

3. **Mutualism b/w plant & animal through pollination & seed dispersion:**

a. Fig trees & wasps

- Fig species is pollinated only by its partner wasp species and no other species.
- The female wasp pollinates the fig inflorescence while searching for suitable egg-laying sites in fruits.
- The fig offers the wasp some developing seeds, as food for the wasp larvae.

(a) Fig flower is pollinated by wasp
(b) Wasp laying eggs in a fig fruit

POPULATIONS

Population Interactions — e. Mutualism

Examples

3. Mutualism b/w plant & animal through pollination & seed dispersion:

b. Orchids

- Orchids show diversity of floral patterns.
- They attract the right pollinator insect (bees & bumblebees) to ensure pollination.
- Not all orchids offer rewards.

POPULATIONS

Population Interactions — e. Mutualism

Examples

3. **Mutualism b/w plant & animal through pollination & seed dispersion:**

c. 'Sexual deceit' of *Ophrys* (Mediterranean orchid)

- One petal of its flower resembles female bee in size, colour & markings. So male bee **'pseudocopulates'** with the flower and is dusted with pollen.
- When this bee 'pseudocopulates' with another flower, it transfers pollen to it.

POPULATIONS

Population Interactions — e. Mutualism

Examples

3. **Mutualism b/w plant & animal through pollination & seed dispersion:**

c. 'Sexual deceit' of *Ophrys* (Mediterranean orchid)

- If the female bee's colour patterns change slightly during evolution, pollination success will be reduced unless the orchid flower co-evolves to maintain the resemblance of its petal to the female bee.