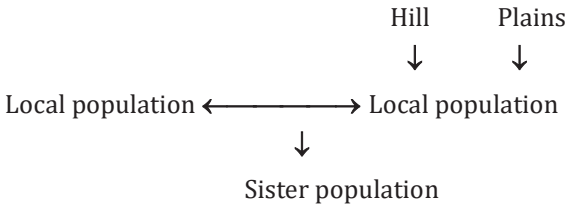
POPULATIONS

- A collection of individuals from the same species dwelling in a specific geographic area make up a population.
- Local populations or demes, which are subgroups of populations, refer to the organisms living in a particular area. For example, Homo sapiens inhabiting hills or plains.
- Sister populations are distinct groups of the same species found in different locations.



- Meta population – A set of local population which are interconnected by dispersing individuals.

Population Attributes

(A) Birth rate and Death rate :

- Populations exhibit distinct characteristics that differ from individual organisms. While individuals experience birth and death, populations express birth rate (natality) and death rate (mortality).
- Within a population, these rates are referred to as per capita birth and death rates. For instance, if a pond had 20 lotus plants last year and 8 new plants have been added, the current population is 28.
- Therefore, the birth rate of the population is calculated as 0.4. If, out of the 20 lotus plants, 4 have died, then the death rate of the population is 0.2.

(B) Sex ratio :

- An individual is either male or female, but a population has sex ratio. i.e., ratio of male and female like 60% of population are female and 40% are male.

(C) Age pyramid :

- At any particular moment, a population consists of individuals across various age groups.
- When the percentage of individuals of different ages or age groups within a population is represented graphically, it forms an Age Pyramid.
- In the case of the human population, the age pyramid typically displays the age distribution of both males and females in a single diagram.

  Age pyramid reflects the growth status of the population. i.e.,

(A) Growing
(B) Stable
(C) Declining

- The reproductive status of a population is influenced by its composition across different age groups. Ecologically, populations are often categorized into three age stages: Prereproductive, Reproductive, and Post-reproductive.
- The distribution of age groups within a population significantly impacts its growth patterns.
  Three types of age pyramids have been recognized – Triangular, Bell shaped, Urn shaped age pyramids.

(a) Triangular age pyramid

In this specific type of age pyramid, the population is characterized by a significant number of pre-reproductive individuals compared to both reproductive and post-reproductive individuals. This imbalance suggests a potential for considerable population growth in the future.

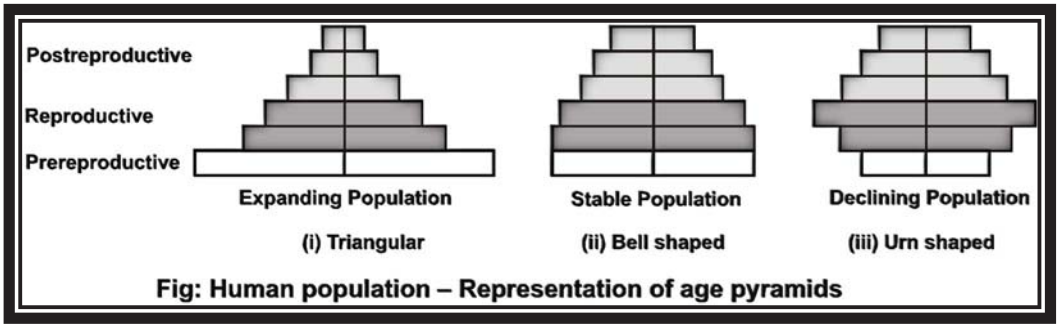


Fig: Human population – Representation of age pyramids

(b) Bell shaped age pyramid

Pre-reproductive and reproductive individuals are almost equal in number and the individuals of post-reproductive age are fewer. Thus population is stable.

(c) Urn shaped age pyramids

Population of Reproductive age group is more than prereproductive age group. Number of postreproductive individuals is also sizeable. Thus population shows negative growth.

Population Density or Population size :

- Population density refers to the measure of how crowded a population is within a specific area or volume.
- It is calculated by dividing the total number of individuals by the area or volume they occupy at a given moment. For instance, there might be 50 individuals of a tree species per hectare or 70 individuals of a grass species cynodon per square meter.
- The density of plants is determined through the study of a predetermined area size.
- Human population census, or counting, is conducted every decade.
- Species density fluctuates over time and across different geographical regions.
- Typically, there is a higher density of plants during the rainy season compared to the dry season.
- The size of a population is influenced by the availability of resources such as nutrients and water at any given time.

(E) Biotic potential and Environmental resistance :

Biotic potential

The inherent maximum capacity of an organism to reproduce or increase in number is termed as biotic potential, represented by the symbol 'r'. Biotic potential can only be fully realized when environmental conditions are extremely favorable, leading to the highest possible birth rate and the lowest possible death rate. Under such conditions, the population size increases at its maximum rate.

Environmental Resistance

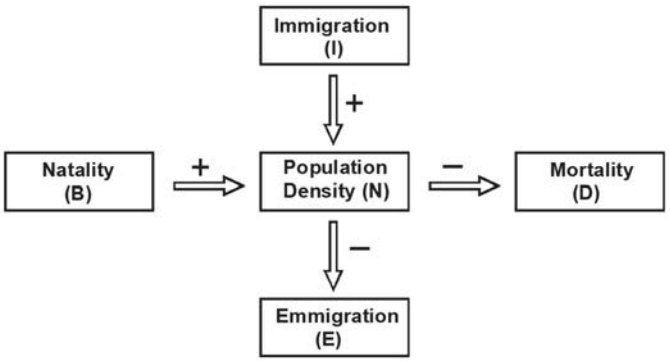
The environment regulates the size of populations by affecting their biotic potential.

- As the population grows, nature imposes greater resistance, which means it becomes harder for the population to keep expanding.
- Environmental resistance includes factors like the availability of water and space, as well as competition for food. These factors prevent organisms from reaching their maximum potential for growth, thus keeping the population size relatively lower.

Population Growth

- Population exhibits distinct patterns of growth over time, which are termed as population growth forms.
- The size or growth of a population isn't fixed; it fluctuates due to various factors like availability of food, predation pressure, water, nutrients, space, and weather.
  However, the primary reason for changes in population density within a specific habitat during a particular period is attributed to four fundamental processes.

(a) **Natality:** It represents number of births during a given period in the population.
(b) **Mortality:** Number of deaths in the population during a given period is called mortality.
(c) **Immigration:** It is permanent inward movement of some individuals into a local population.
(d) **Emigration:** It is permanent outgoing of some individuals from a local population during the time period. Therefore, if Nt is the population density at time t, then its density at time t + 1 is.



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

B = Number of Birth

l = Number of immigrants

D = Number of deaths

E = Number of emigrants

The population growth forms (Characteristic pattern of growth in unit time) is of two types.

(i) J-shaped or Exponential or Geometric Growth Form
(ii) S-shaped or Sigmoid or Logistic or Verhulst-Pearl Logistic Grwoth Form

Growth Models:

- Population shows growth in specific pattern with time. It is of two types

(1) Exponential growth :

- When the resources are unlimited, the population shows exponential or geometric growth.
- r is intrinsic rate of natural increase that is important parameter selected for assessing impacts of any biotic or abiotic factor on population growth.
- If N = size of population, b = per capita birth rates, d = per capita death rates then any increase or decrease in a population N during time t (dN/dt) will be.
  $dN / dt = (b - d) \times N$
  If $(b - d) = r$ then $dN/dt = rN$

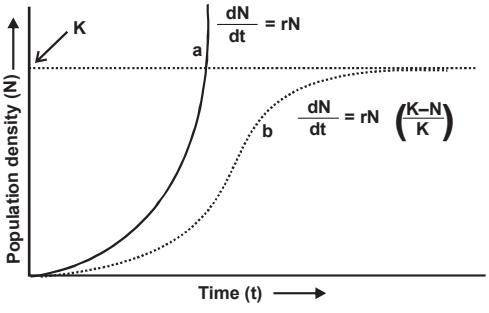


Fig: Population growth curve.

- The equation $dN/dt = rN$ demonstrates a population's geometric or exponential growth, which is visualized as a J-shaped curve. However, population decline can swiftly occur due to limited resources or environmental obstacles.
- The mentioned equation illustrates the exponential or geometric growth of a population, leading to a J-shaped curve when plotted against time. If you possess a basic understanding of calculus, you can derive the integral form of the exponential growth equation.

  $N_t = N_0 e^{rt}$

  where

  N_t = 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)

(2) Logistic growth:

In nature, a habitat can only sustain a specific number of individuals from a population due to its limited resources. This maximum limit is referred to as the carrying capacity (K).

When resources are limited, a growing population experiences a delay in growth initially, followed by phases of increase and decrease, until it stabilizes at the carrying capacity. This pattern is known as Verhulst-Pearl logistic growth.

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

N = Population density at a time time t

r = Intrinsic rate of natural increase

K = Carrying capacity

It is also called S or sigmoid growth form. Thus logistic growth model is more realistic.

Life History Variation

Populations adapt over time to enhance their ability to reproduce, known as Darwinian fitness (measured by a high 'r' value), within their specific habitat. In response to various selection pressures, organisms evolve towards the most effective reproductive strategies. Some organisms, like Pacific salmon fish and bamboo, breed only once in their lifetime, while others, such as most birds and mammals, breed multiple times. Additionally, some species produce numerous small offspring (like oysters and pelagic fishes), while others produce fewer, larger offspring (like birds and mammals).

Determining which strategy is most advantageous for maximizing fitness depends on the ecological context. Ecologists suggest that the life history traits of organisms evolve in response to the limitations imposed by the abiotic and biotic factors of their habitat. The study of how life history traits evolve in different species is currently a significant area of research among ecologists.

Community / Biological Community / Biotic Community

A biotic community refers to the arrangement of populations from various species within a habitat, where they rely on each other and interact. Nature hosts numerous biotic communities due to two main reasons:

1. Diverse habitats exist with unique environmental conditions.
2. Various species coexist whose tolerance ranges overlap with the environmental conditions of that habitat.

When comparable conditions occur elsewhere, the same biotic community is established there as well. Each biotic community possesses ecological traits that set it apart from others.

Characteristics of Biotic community :

(A) Species composition

The species composition of a community refers to the types of plants and animals present within it.

- Species composition varies between different biotic communities, and it can also change within the same community across different seasons, especially in terms of plant species.

(B) Species Dominance / Dominance

The most abundant species in terms of both number and biomass within a community is referred to as the dominant species.

- Usually, only one or a few species in a community are present in large numbers, dominating and exerting influence over other species in terms of both their abundance and the amount of biomass they produce.
- The presence of dominant species often determines the distribution of other animals within the community. For example, in terrestrial communities, species of tall trees often serve as dominants.
- Communities are commonly named after their dominant species. For instance, a forest community dominated by pine trees is called a Pine forest, while a grassland community is named after the dominance of grasses.
- Furthermore, communities can also be named after significant environmental factors. For instance, a desert community thrives in dry conditions, while a marine community thrives in the saline conditions of the ocean.

(C) Physiognomy and Stratification

- Physiognomy refers to the outward appearance or visual characteristics of a community.
- The initial impression of a community is often formed by observing its physiognomy.
- The overall appearance or 'look' of a community is determined by the combined vertical structure and architecture of its dominant plant species. For instance, the towering appearance of a forest contrasts with the lower, more open appearance of a grassland.
- While several communities may share similar physiognomy, they can still differ significantly in terms of species composition and dominant species. For example, different types of forests may appear similar in physiognomy but have distinct species compositions.

Stratification

It illustrates the vertical arrangement of plants, with various layers occupied by different species.
This vertical arrangement gives physical structure to the plant community, providing habitats for many different forms of plant and animal life.

- Upper most - Forest canopy formed by large trees.
- then - Understorey tree layer.
- then - Shrub layer
- then lower
- most - herb layer.
- In a pond
- Community - Upper surface dwellers.
  - Lower / bottom dwellers.

Significance of stratification

Vertical stratification results in a greater number of species and allows different types of plants to use resources in a habitat more efficiently.

In aquatic ecosystems, the arrangement from the surface to the bottom is determined by factors such as light penetration, temperature, and oxygen levels.

(D) Species Diversity :

- The more productive a habitat is, the greater the variety of species found in a community. For instance, coral reefs and tropical rainforests exhibit high species diversity, while deserts have low species diversity.
- Species diversity encompasses both the total number of species and their relative abundance within a community.
- Species diversity is considered the most crucial functional characteristic of a community, influencing aspects such as food chains and food webs.

(E) Keystone and Link species :

Keystone species

The species having much greater influence on community characterstics, relative to their low abundance or biomass are called Keystone speceis.

- A keystone species helps control the population sizes of other species in a community.
- If a keystone species is removed, it can severely disrupt the functioning of the community. For instance, in tropical rainforests, various species of fig trees act as keystone species by producing large quantities of fruits. During times of food scarcity, these fruits are consumed by monkeys, birds, bats, and other vertebrates. Therefore, protecting fig trees helps conserve these animals that depend on them.
- Only a few species serve as keystone species.
- For example, in forests, lions and in deserts, kangaroo rats are considered keystone species.

Link species or Critical link species

The species which establish essential link with other species to help in vital activites.

- Mycorrhizal fungi in the soil play a crucial role as they create an important connection for plants to absorb nutrients from the soil.
- Certain critical species act as a vital food source for other species in the ecosystem.
- Pollinator species such as ants, bees, and birds aid in the pollination and dispersal of seeds.
- Tropical rainforests are abundant in critical species because of their high reliance on animal-assisted pollination and seed dispersal, which is facilitated by their high species diversity.

(F) Ecotone and Edge effect :

Transiton zone/Ecotone - The transition zone between two communities is called ecotone.

The total number of species is higher in an ecotone than in the adjacent communities. For instance, in the ecotone between a grassland and a forest.

Edge Effect

The phenomenon of certain organisms showing higher diversity and density at the border or transition zone of a community, known as the ecotone, is referred to as the edge effect.

Edge species

Organisms that primarily occur, are most abundant, or spend the majority of their time in the ecotone or junctions between two communities are referred to as edge species.

Population Interactions

Interactions between different species in a habitat happen often. Biologists today call these interactions symbiosis. They can be helpful, harmful, or have no effect on one or both species involved.

(a) Positive interactions (+,+ or +, 0) : One or both partner are benefitted**.**

I. Commensalism (+,0) :

In this kind of interaction between two individuals of different species, one gains a benefit while the other experiences neither harm nor benefit.

e.g. (1) Pilot fish & Sucker fish with shark.
(2) Epiphytes like orchids on the trees like mango.
(3) E.coli in human intestine.
(4) Lianas in the tropical rain forest.
(5) Barnacles developing on the back of whale.
(6) Cattle egret birds and grazing cattles.
(7) Clown fish & sea anemone.

II. Mutualism (+, +) :

In this type of interaction between two living individuals of different species, both benefit each other, and it's crucial for their survival on Earth. This is known as obligatory mutualism.

e.g. (1) Mycorrhiza– between fungus (e.g. Boletus) and a root (e.g. Pinus)
(2) mutualistic nitrogen fixation– between legume plant and Rhizobium bacteria.
(3) Lichen.
(4) Relationship of Fig and wasp
(5) Relationship of ophrys orchid and Bumble bee

The Mediterranean orchid Ophrys uses a strategy called 'sexual deceit' to attract a certain species of bee for pollination. One of its petals closely resembles the female bee in size, color, and markings. Mistakenly, the male bee is drawn to this resemblance and attempts to mate with the flower, which results in pollen being transferred onto the bee. When this bee then visits another flower, it unintentionally pollinates it by transferring the pollen. This process illustrates co-evolution in action.

Protocooperation or facultative mutualism (+,+) :

Both living organisms of different species are mutually benefitted but they can independently survive without each other. It is nonobligatory relation.

e.g. (1) Red-blilled Ox pecker and Black rhinoceros
(2) Crocodile bird and crocodile.

(b) Negative interactions or antagonism (–,– or –, 0, or +,–) : One partner is harmed.

It is of two types

(A) Exploitation
(B) Amensalism

Exploitation:

When an individual of one species harms another species to obtain food, shelter, or support, it can happen directly or indirectly. This harmful interaction involves the following types:

(i) Predation (+,–) :

In this kind of interaction, one species captures, kills, and consumes individuals of another species. This is when a predator hunts and eats its prey. For example, carnivorous animals like lions, tigers, wolves, and snakes eat other animals. Also, there are insect-eating plants like Nepenthes, Utricularia, Dionea, and Drosera. For instance, a sparrow may eat seeds of plants as a herbivore or insects as a predator or consumer. This means a sparrow occupies two different trophic levels.

(ii) Parasitism (+,–) :

In this types of interaction, one organism of a species called parasite obtains its food directly from living organism of other species called host. The host is always larger than the parasite.

Types of Parasite :

basis of parasites position on the host, the parasites are classified into two categories.

(a) Ectoparasite

They live on the surface of host e.g. Lice, Bedbug, mosquito, Leech,

(b) Endoparasite

They live inside the host e.g. Plasmodium, Entamoeba, Tapeworm, Roundoworm

On the basis of duration of attachment over host, parasites have been classified into two categories.

(i) Permanent parasites

They are attached with host through out the life e.g. Ascaris, Entamoeba, lice

(ii) Temporary Parasites

They are attached with host for some time or attached during feeding time only
e.g. Leech, mosquito, Bedbug.

Other form of parasites are as follow

Holoparasites and Hemiparasites

- Holoparasites are parasites that rely entirely on their host for all their needs. For example, Cuscuta, a total stem parasite, and Rafflesia, a total root parasite, fall into this category.
- Hemiparasites, on the other hand, are only partially dependent on the host. For instance, Viscum and Loranthus, both partial stem parasites, and Santalum, a partial root parasite, exhibit this partial dependency.

Hyperparasite

This type of parasite lives on another parasite. For example, bacteriophages and Cicinnobolus cesatii on powdery mildew exhibit this behavior.

Brood parasitism

A parasitic bird lays its eggs in the nest of another bird or animal. For example, the cuckoo lays its eggs in the nest of a crow.

Competition (–,–) :

It is found between two or more organisms for obtaining the same resources.
Competition is of two types–

i. **Intraspecific :** It takes place between individuals of same species.
ii. **Interspecific :** It takes place between individuals of different species.

- When Darwin discussed the struggle for survival and the concept of survival of the fittest in nature, he strongly believed that competition between different species plays a significant role in the evolution of living organisms.
- In interference competition, one species may experience a decrease in feeding efficiency because of the obstructive and hindering presence of another species.

Competitive release

When a species is confined to a small area because a stronger species outcompetes it, it's called competitive release. Connell's clever experiments in the field demonstrated this concept. Along the rocky shores of Scotland, the bigger and more dominant barnacle, Balanus, takes over the intertidal region, pushing out the smaller barnacle, Chathamalus, from that zone.

Gause's competitive exclusion principle

According to this idea, when two closely related species share a niche, one of them is eventually eliminated. Gause observed that when two species of Paramecium are grown together, one of them disappears.

- Although not always definitive, there is strong evidence in some cases. For example, the Abingdon tortoise in the Galapagos Islands went extinct within ten years of goats being introduced, likely due to the goats' more efficient browsing.
- Sometimes, competing species can live together because they specialize differently, such as feeding at different times. This is called resource partitioning. For instance, 14 species of finches can coexist in the Galapagos Islands because they have developed different feeding habits. Similarly, five species of Warblers birds can share the same tree by adjusting their feeding times. This is also called resource partitioning.

Amensalism (0,–):

In this type of interaction, an organism of one species prevents another species from growing or living nearby by releasing certain chemicals called allochemics.

For example:

(i) Crops like barley, sorghum, and sunflower produce chemicals that prevent weeds from growing nearby.
(ii) The Black Walnut tree secretes juglone, which inhibits the growth of apple and tomato plants.
(iii) Marigold plants release chemicals that are toxic to soil nematodes.
(iv) Penicillium fungus prevents the growth of Staphylococcus bacteria.