ORGANISMS AND POPULATIONS

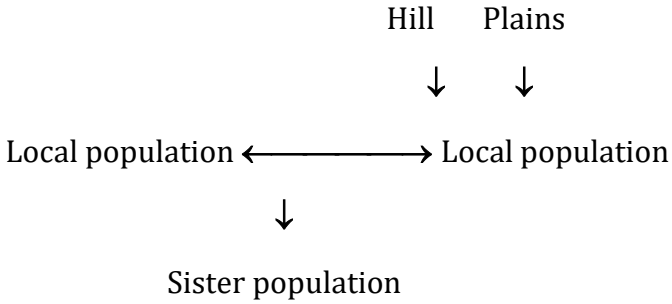
POPULATIONS

Populations

- A group of individuals (members) of same species living at one place (specific geographical area) constitute a population.

- Local Population or demes (Sub groups of population) – Population of organism inhabiting a particular area. e.g. Homosapiens inhabiting hills, plains.

- Sister population – Different population of same kind of organisms which are found in different places are known as sister population.



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

CHARACTERISTICS OF POPULATION

(A) Birth rate and Death rate :

- Population have many features different from a individual. Like individuals have birth and death, while population has birth rate (Natality) and death rate (Mortality).

- In a poulation these rates are called as per capita birth and death. It can be calculated as for example In a pond 20 lotus plants in last year, 8 new plants are added means current population is 28.

- So birth rate of population is $= 0.4$
- If out of 20 lotus plants 4 are died then death rate of populations 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 :

- A population at any given time is composed of individuals of different ages.

- If the age distribution (percent individuals of a given age or age group) is plotted for the population. the resulting structure is called Age pyramid.

- For human population, the age pyramid generally show age distribution of males and females in a combined digram.

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

(A) Growing

(B) Stable

(C) Declining

- Various age groups in a population determine it's reproductive status. In a population three ages i.e.,Prereproductive, Reproductive and Post reproductive are considered as ecological ages.

- Distribution of age groups influence the population growth.

Three types of age pyramids have been recognized – Triangular, Bell shaped, Urn shaped age pyramids.

(a) Triangular age pyramid : In this type of age pyramids, population is growing in which the number of pre-reproductive individuals is very large as compared to the reproductive individuals and post-reproductive individuals.

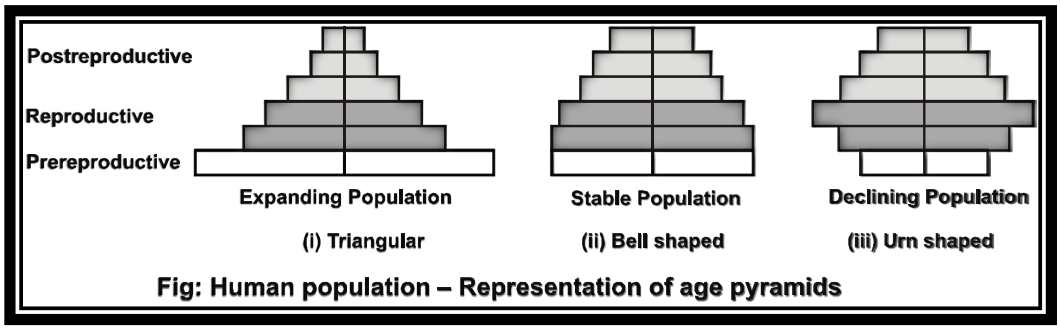


Fig: Human population – Representation of age pyramids

(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 :

- The size of the population is represented by population density.
- Population density- Total number of individuals present per unit area or volume at a given time.
  For example 50 individuals of tree species grown per hectare.
- 70 individuals of grass cynodon per square meter.
- Plant density is determined by study of predetermined size.
- Census or Counting of humen population done every ten year.
- Species density varies from time to time and from one area to another area.
- Greater density of plants in rainy season than in dry season.
- Population size is determined by available resources like nutrients, water etc. at a given time.

(E) Biotic potential and Environmental resistance :

Biotic potential : The inherent maximum capacity of an organism to reproduce or increase in number.

- Biotic potential (symbol 'r') can be realised only when environmental conditions are most favourable. So that natality rate is maximum and mortality rate is minimum. In this condition population size increase at maximum rate.

Environmental Resistance : The environmental control on population size, on it;s biotic potential.

- Nature keeps a check on expression of biotic potential. With increase in population size, the environmental resistance (against population) increase.

- Environmental resistance represents the limiting effect of abiotic (water, space) and biotic factors (food, competition). Which do not allow organisms to attain their biotic potential and keep the population size at much lower level.

Population Growth Forms :

- Population have characteristics patterns of growth with time known as population growth form.

- The growth or size of a population of a species is not a static parameter, but it keep changing time to time, due to change in biotic (Food avalability, predation pressure) factors and abiotic factors (water, nutrients, space, weather).

But main cause of change in population density in a given habitat during a given period of time is due to change in four basic processes.

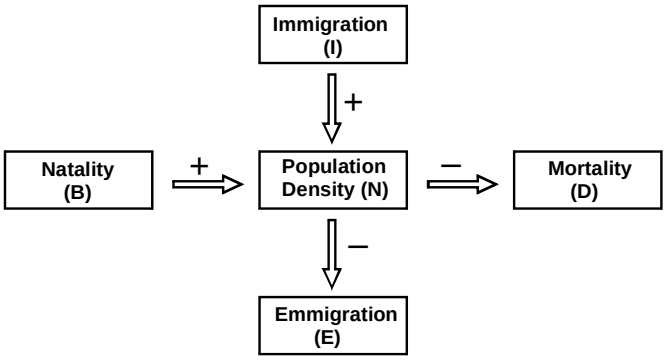
(a) Natality : It represents number of births during a given period in the population.

(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 $dN/dt = rN$

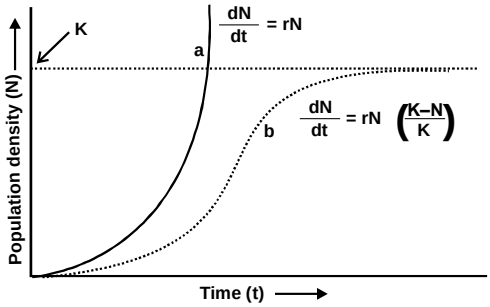


Fig: Population growth curve.

- **$dN/dt = rN$** represents geometric or exponential growth pattern of a population that can be described as J-shaped curve. Population is suddenly declined due to deficiency of resources or environmental resistance.
- The above equation describes the exponential or geometric growth pattern of a population and results in a J-shaped curve when we plot N in relation to time. If you are familiar with basic calculus, you can derive the integral form of the exponential growth equation as
- $N_t = N_0 e^{rt}$
- 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, habitat has certain limit of resources to support a certain number of individuals of a population, beyond which growth is not possible. This limit is called carrying capacity (K).
- In the presence of limited resources, growing population undergoes initially a lag phase followed by phases of increase and decrease and finally the population density reaches the carrying capacity. It is called Verhulst-pearl logistic growth that can be described as.

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

- ❖ 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 (AIPMT 2015). Thus logistic growth model is more realistic.

Life History Variation :

- Populations evolve to maximise their reproductive fitness, also called Darwinian fitness (high r value), in the habitat in which they live. 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 during their lifetime (most birds and 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). So, which is desirable for maximising fitness? Ecologists suggest that life history traits of organisms have evolved in relation to the constraints imposed by the abiotic and biotic components of the habitat in which they live. Evolution of life history traits in different species is currently an important area of research being conducted by ecologists.

COMMUNITY / BIOLOGICAL COMMUNITY / BIOTIC COMMUNITY

- Biotic community is the organization of populations of different species which are interdependent and interact with each other in a habitat.

Large number of biotic communities are found in nature due to-

(i) Existance of diverse habitat with characterstic environmental conditions.

(ii)Co-occurence of different species whose tolerance range overlap with environmental conditions obtained in that habitat.

- When similar conditions are repeated at another location the same biotic community
- established there.
- Each biotic community posses ecological characteristics which differentiate it from another community.

Characteristics of Biotic community :

(A) Species composition - The kinds of species (Plant and Animals) present in a community represents it's species composition.

- Species composition are different in different biotic communities, even in same community in different season like plant species.

(B) Species Dominance / Dominance - The highest number of organisms of a species present in a community (in terms of number and biomass) is called dominant species.

- Only one or few species in a community are in sufficient abundence (having high density) which dominates and influence other species in terms of number and biomass production.

- Dominant species also determines the animal distribution like in terrestrial communities, species of tall trees are dominants.

- Communities are generally named after their dominant species. For example, forest community with dominance of pine trees is called Pine forest, grassland community represents dominance of grasses.

- Communities are also named after important environmental factors like desert community with dry conditions, marine community due to saline conditions of ocean.

(C) Physiognomy and Stratification :

- Physiognomy is external appearance or look of a community.

- A community is first noticed by it's Physiognomy.

- The 'look' or external appearence is the total effect created by the combination of vertical structure and architecture of dominant species of vegetation. For example, high physiognamy of a forest differ from low physiognomy of a grassland.

- Several communities may have similar physiognomy, yet they differ sharply on basis of species composition and dominants. For example different forest communities or forest type.

Stratification- It represent the vertical layering of vegetation or different layers occupies by different species.

The vertical stratification provides physical structure to the plant community, in which many life forms of plants and animals live in.

- 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 leads increase in number of species and leads to effecient use of resources of a habitat by different types of plants.

- In aquatic ecosystems, the stratification from surface to bottom is determined by light penetration, temperature profile and oxygen profile.

(D) Species Diversity :

- More the productive habitat more the diversity of species in a community. For example, coral reef and tropical rain forest show high species diversity while desert community show low species diversity.
- The species diversity includes the total number of species present in community and the relative abundence of these species.
- Species diversity is the most important functional property of a community. (Food chain, Food web)

(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.

- Keystone species regulates relative abundance of other species.

- Removal of keystone species seriously distrupt the functioning of a community. For example, in tropical rain forest different species of Fig are Keystone species as they produce large quantity of fruits. During food scarcity, these fruits are eaten by mankeys, birds, bats and other vertebrates. So by protecting Fig trees, these animals dependent on them are also conserved.
- Very few species works as keystone species.
- Lion in forest, Kangaroo rat in desert are 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 soil are critical link species as they establish essential link in absorption of nutrients from soil provide to host plants.
- Some critical link species provide food for network species.
- Pollinator species like ants, bee, birds which helps in pollination and seed dispersal.
- Tropical rain forests are rich in critical link species, due to high degree of animal dependent pollination and dispersal due to 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 greater in ecotone than in adjoinig communities. For example ecotone between grassland and forest.

- **Edge Effect -** The tendency of increased variety and density of some organisms at the community border or ecotone or transition zone is called Edge effect.

- **Edge species -** The organisms which occur primarily or most abundantly or spend most of their time in ecotone or junctions between two communities are called Edge species.

Population Interactions :

Interspecific interactions are quite common between two different species in a habitat. According to modern biologists, they are involved in symbiosis. These interactions may be beneficial, harmful or neutral for one of the species or both.

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

(i) Commensalism (+,0) :

In this type of interaction of two living individuals of different species, one is benefitted while the other is neither harmed nor benefitted.

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 types of interaction of two living individuals of different species in which both are mutually benefitted and it is essential for their survival on earth (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* employs 'sexual deceit' to get pollination done by a species of bee. One petal of its flower bears an uncanny resemblance to the female of the bee in size, colour and markings. The male bee is attracted to what it perceives as a female, 'pseudocopulates' with the flower, and during that process is dusted with pollen from the flower.When this same bee 'pseudocopulates' with another flower, it transfers pollen to it and thus, pollinates the flower. Here you can see how co-evolution operates.

(iii) 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

(A) Exploitation :

For obtaining food or shelter or support directly or indirectly, Individual of one species is harmful for the individual of other species. It involves following types.

(i) Predation (+,–) :

In this type of interaction, individual of one species captures, kills and eats up individual of other species (Predator destroys the prey).

e.g. (1) Carnivorous animals (lion, tiger, wolf, snake) eat up other animals.

(2) Insectivorous plants like, Nepenthes, Utricularia, Dionea, Drosera.

- A sparrow may eat seeds of plants (as herbivores) or insects (as - predator or consumer)- hus we can say sparrow may bear two different trophic levels - AIPMT main 2011

(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 :

On the 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

(1) Holoparasites and Hemiparasites: Holoparasites are those parasites which are completely dependent on the host for all their requirements, e.g. Cuscuta, (Total stem parasite), Rafflesia (total root parasite).

Hemiparasites are partially dependent on the host. e.g. Viscum & Loranthus (both are partial stem parasite), santalum (Partial root parasite).

(2) Hyperparasite : This type of parasite lives on another parasite, e.g. bacteriophages, Cicinnobolus cesatii on powdery mildew.

(3) Brood parasitism : Parasitic bird lays its eggs in the nest of its host or other animal e.g. Cuckoo lays its eggs in the nest of crow.

(iii) Competition (–,–) :

It is found between two or more organisms for obtaining the same resources.

Competition is of two types–

(1) Intraspecific : It takes place between individuals of same species.

(2) Interspecific : It takes place between individuals of different species.

- When Darwin spoke of the struggle for existence and survival of the fittest in nature, he was convinced that interspecific competition is a potent force in organic evolution.
- In interference competition, the feeding efficiency of one species might be reduced due to the interfering and inhibitory presence of the other species.

Competitive release : A species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species it is considered as Competitive release. Connell's elegant field experiments showed that on the rocky sea coasts of Scotland, the larger and competitively superior barnacle Balanus dominates the intertidal area, and excludes the smaller barnacle Chathamalus from that zone.

Gause's competitive exclusion principle: According to this hypothesis, no two organisms of two closely related species can have the same niche. One of the two is eliminated. Gause found that out of two species of Paramecium grown together one is eliminated.

- Strong and persuasive circumstantial evidence does exist however in some cases. The Abingdon tortoise in Galapagos Islands became extinct within a decade after goats were introduced on the island, apparently due to the greater browsing efficiency of the goats.
- Some times competing species may coexist due to different specilizations like difference in feeding time. It is called resource partitioning e.g. 14 species of finches to coexist in Galapagos islands due to development of different feeding habits. Similarly, five species of Warblers birds coexist same tree by changing the time of feeding. It is called resource partitioning.

(B) Amensalism (0,–):

In this type of interaction an organism of a species does not allow the organism of other species to grow or live near it for this purpose the former secretes some chemicals called allochemics.

e.g (1) Smoother crops likes barley, sorghum and sunflower do not allow the weeds to grow nearby.

(2) Black Walnut (Juglans nigra) secretes juglone that inhibits the growth of apple, tomato.

(3) Marigold (Tagetes) secretes chemicals toxic to soil nematodes.

(4) Penicillium does not allow the growth of Staphylococcus bacterium.