Methods of measuring plant productivity

Relative growth rate (RGR)

- It is the gain in dry mass in unit time per dry mass of plant.

- i.e., $RGR = \frac{(M2-M1)/(T2-T1)}{M1} = \frac{M2-M1}{T2-T1} \times \frac{1}{M1}$

Where, M1 = Initial mass, M2 = Final mass, T1 = Initial time, T2 = Final time

- It is photosynthesis which leads to an increase in dry mass of plants.

- Increase in dry mass is obtained by deducting dry mass loss due to respiration from GPP.

Net assimilation rate (NAR)

- This is dry matter (mass) accumulation per unit of leaf area per unit of time.

- It is usually expressed as $gm^{-2}day^{-1}$.

- Plant samples (i.e, leaves) are collected over a period of time, and then the weight and leaf area are measured.

- The paired weight and area measurements, and time are then used to determine NAR.

Biomass

- Productivity can be measured as dry weight of organic matter of an organism.

- This is known as the biomass of the organism.

- It is usuálly expressed as gram, kilogram or megagram (tonne, metric ton).

Food chain concentration (biological magnification)

- This is the build-up of toxic substances, (e.g. DDT, heavy metals) in the bodies of organisms at higher trophic levels of food webs.

- Usually, organisms at lower trophic levels accumulate small amounts of the toxic substances. However, organisms at higher trophic levels accumulate larger amounts of the toxic substances because they eat many of the lower-level organisms.

- At the highest trophic levels the increased concentrations in tissues may become toxic.

Introduction to population ecology

What is a population?

- Population is a group of individuals of the same species that live in the same area and share a common gene pool.

- The above definition means that a population has the following features:

1) Abundance (density)
2) Boundaries
3) sex and age
4) Dynamic (change over time)
5) Distribution (pattern and scale)

What is population ecology?

- It is the study of structure and dynamics of populations, and how populations interact with the environment.

Interactions within and among populations

- Population interactions may take the form of competition; intra-specific and interspecific competition

(1) Intra-specific (intra-population) interactions

Resource competition

- This is a negative interaction that occurs among organisms where two or more organisms require the same limited resources, and therefore compete for it.

- The following mechanisms underlie resource competition:

i) acquisition of resources (or structures) by individuals.

ii) interference in resource acquisition by other members of the population.

iii) Resultant limited availability or supply of the resources.

- Resource competition is a density dependent process.

Consequences of resource competition

(i) Extinction

- Where all individuals of a population use the same amount of resources at the same rate, competition between them can cause steady decrease in the population size.

- Eventually, all the individuals will start to die at the same time.

- This rather extreme case of overcompensation is called scramble, and always leads to extinction.

(ii) Decreased population growth rate

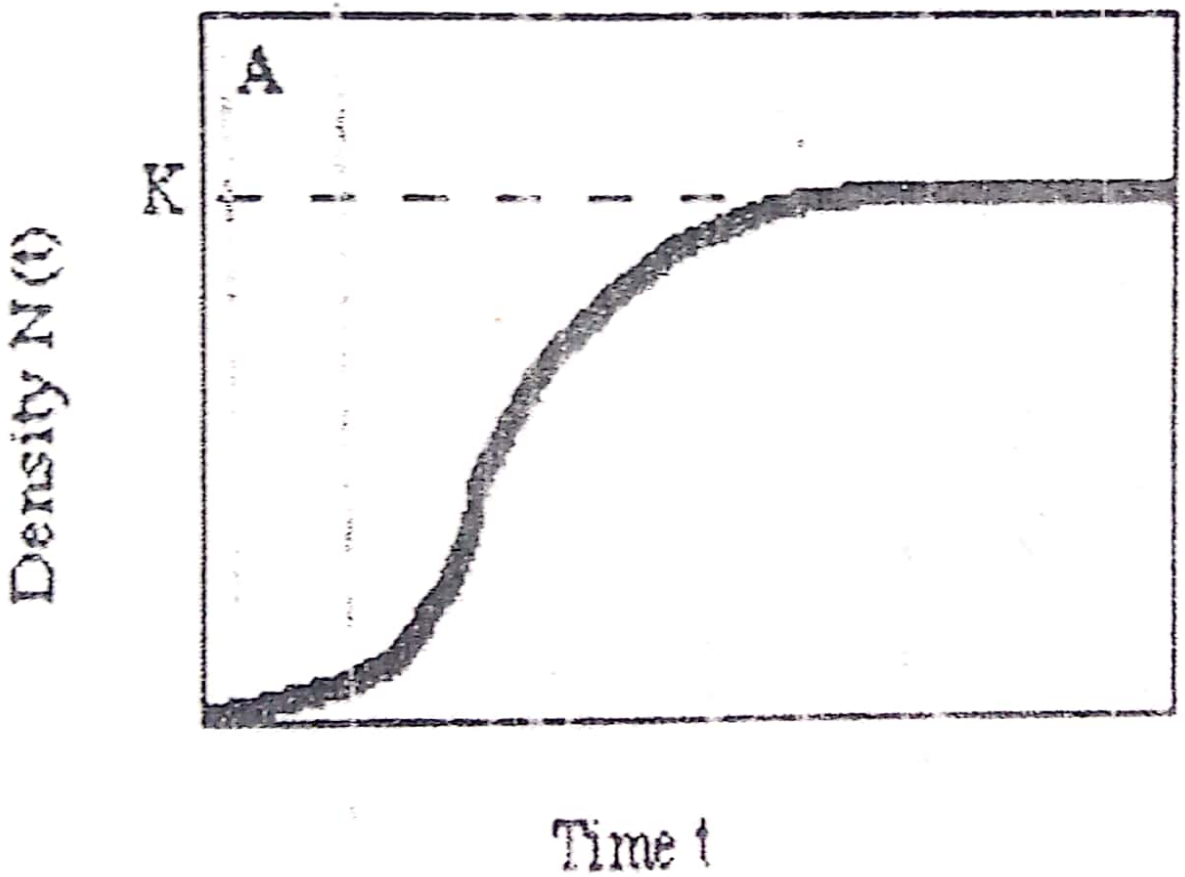
- Where individuals of a population use resources at different rates, competition does not impact on the individuals equally.

- When differences occur in resource acquisition between individuals, some of the individuals will win while others will not.

- The survivors grow and/or reproduce well, and the losers are suppressed in growth and may suffer increased mortality.

- The population growth rate decreases till it becomes constant at the carrying capacity of the ecosystem.

- At the carrying capacity, resources are sufficient for only a certain maximum number of individuals.



- Can the carrying capacity of an ecosystem be altered?

Causes of differences in resource acquisition

Timing of recruitment, establishment and growth

Variation in site quality

Genetic differences between individuals

(2) Interspecific Interactions

- Interspecific interactions may occur through competition between populations of different species for limited resources such as nutrient, light, structural support, space, food etc.

- Interspecific competition is less intense than intraspecific competition because in interspecific competition, requirements are less similar between the competitors.

Consequences of interspecific competition

(i) Coexistence

- Different competing species can coexist in the same environment due to niche differentiation.

- Niche differentiation occurs when species undergo specialisation that enables them to partition (subdivide) available resources.

- E.g. stingless bees; one species feeds in groups in high density forest patches whereas the other species feeds singly in less dense forest patches.

- E.g. African ungulates feed in different plant species and different parts of forests.

- Coexistence of different competing species can also occur due to character displacement.

- Character displacement is a phenomenon where two species living apart have similar traits but when they live together they compete and therefore develop different traits.

- Thus, character displacement allows for resource partitioning.

(ii) Competitive exclusion

The competitive exclusion principle (Gause's principle)

- If there is no niche differentiation, then one competing species will eliminate or exclude the other.

- Thus exclusion occurs when the realised niche of the superior competitor completely fills those parts of the inferior competitor's fundamental niche which the habitat provides.

(3) Symbiotic interactions

- Symbiosis refers to two or more organisms of different species living together in a close association.

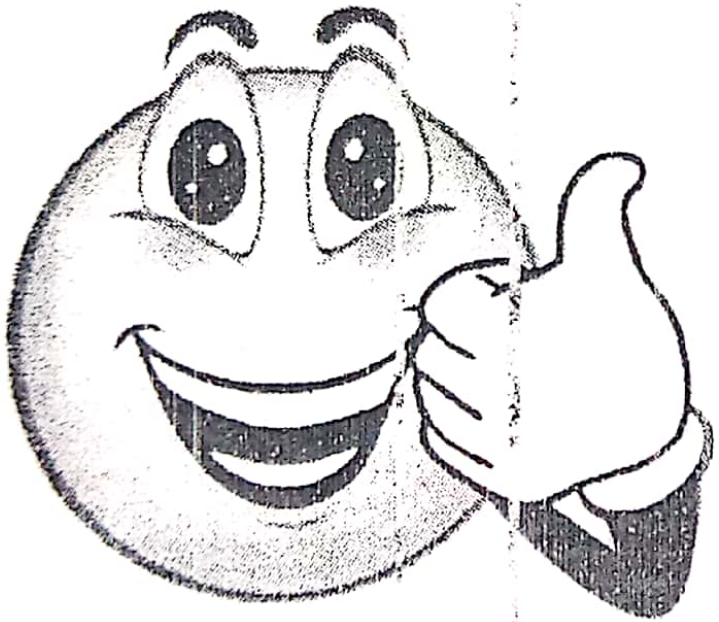
- If two populations show no interaction or have no effect on each other they exhibit neutralism.

- Some categories of interactions between organisms of different species include mutualism, commensalism, parasitism and predation.

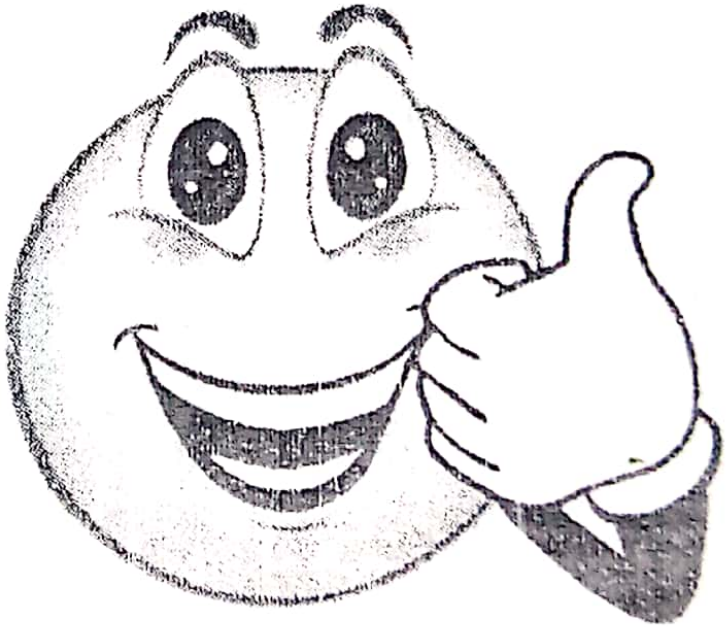
Mutualism	Commensalism	Parasitism/predation
Both organisms benefit	✓ One organism benefits ✓ The other organism is not affected in any way	✓ One organism benefits ✓ The other organism is affected by being harmed

Mutualism

Organism *A*

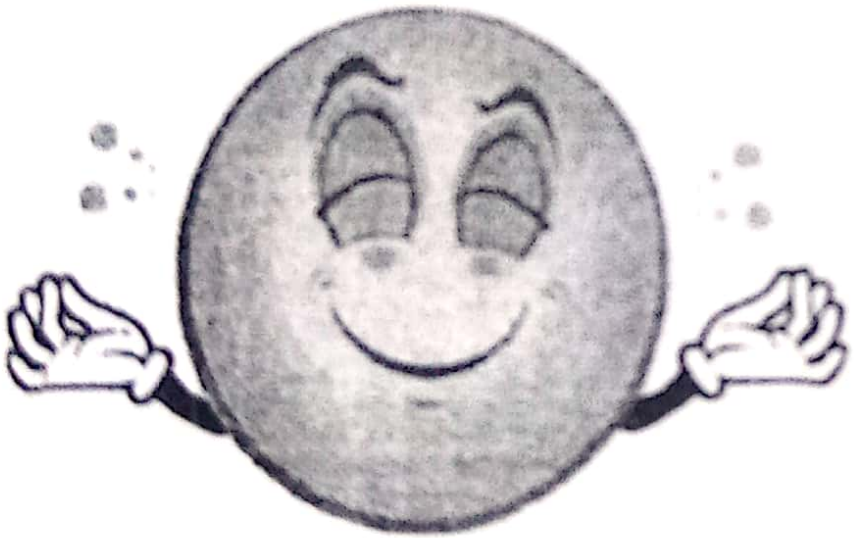


Organism *B*

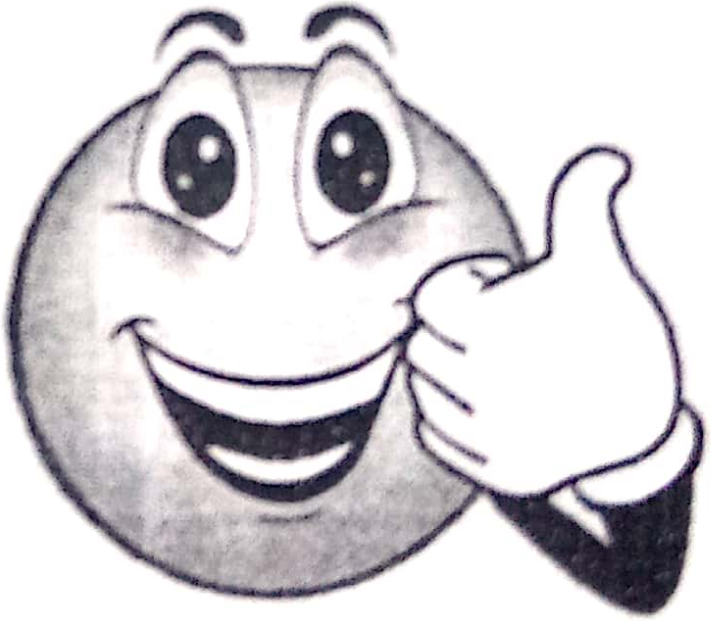


Commensalism

Organism *A*

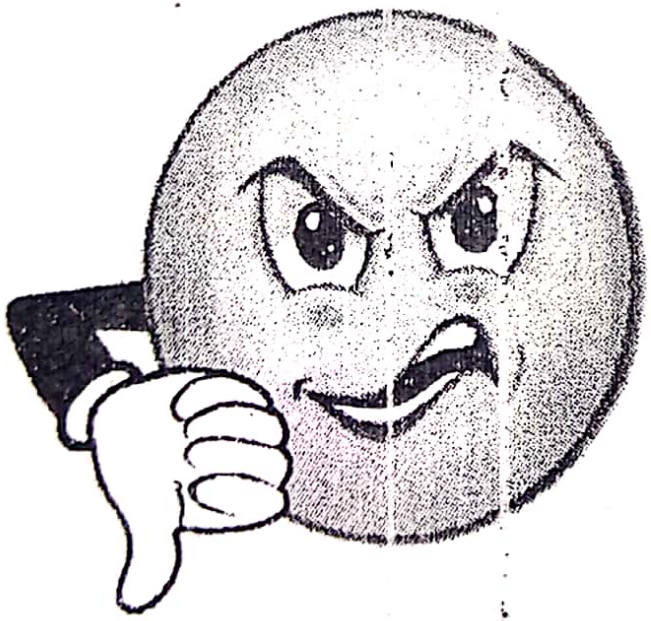


Organism *B*

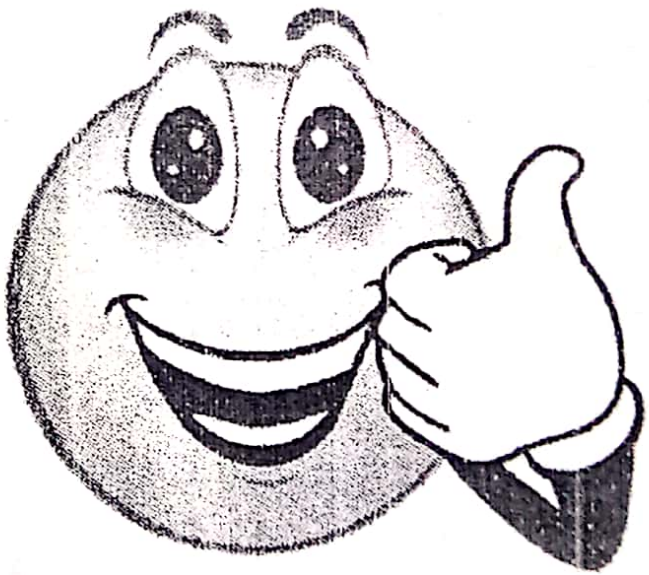


Parasitism/predation

Organism *A*



Organism *B*



Examples of mutualism

- Aphids and ants. Both organisms can live independently, but when they are together, the ants protect the aphids against predation and in return, the aphids provide the ants with sugary fluid.

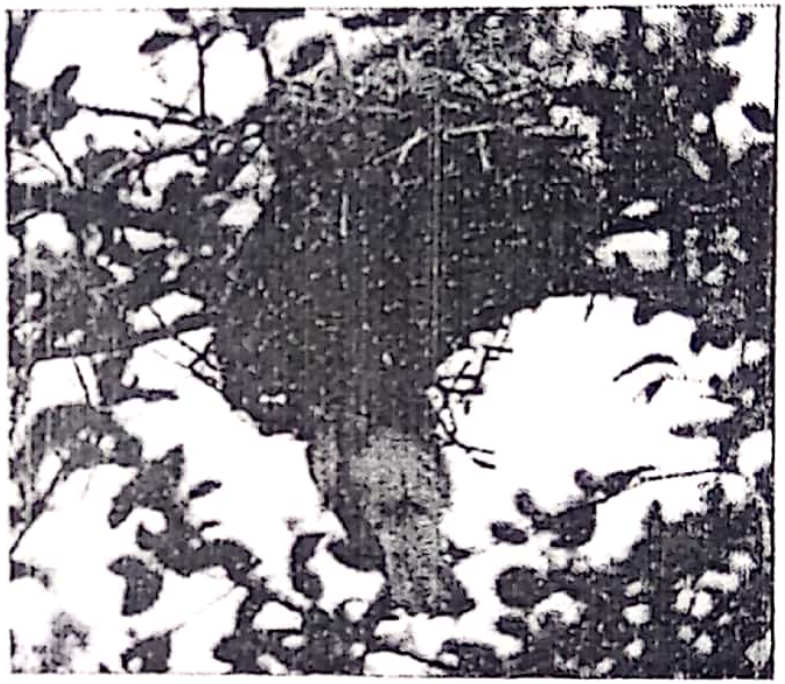
Facultative mutualism

Cellulose digesting bacteria live in the gut of ruminants. They feed on cellulose in the host's diet and convert it into simple forms which the ruminant can digest, absorb and assimilate. In return, the bacteria get food from the gut.

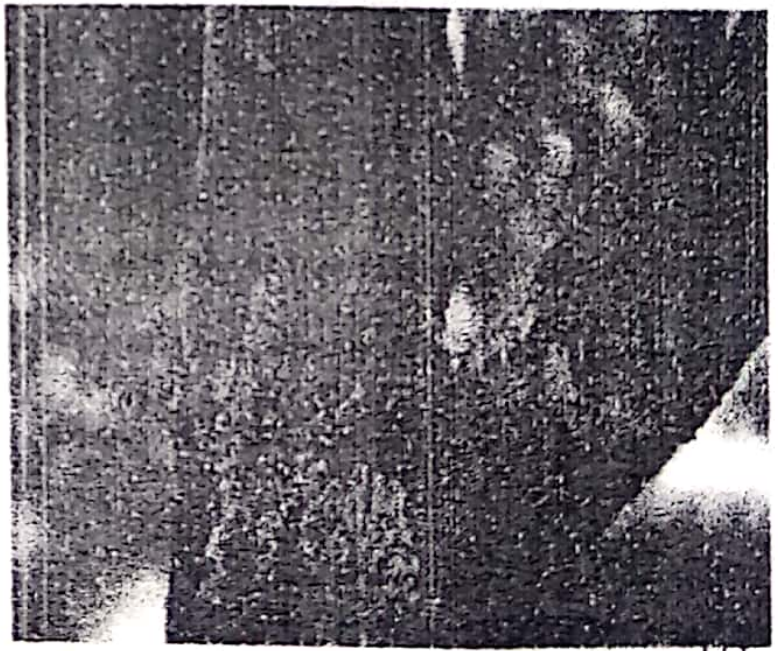
Obligate mutualism

Examples of commensalism

1. Birds benefit from trees by constructing their nests on trees but they trees are not harmed and do not benefit from the bird.



2. Lichens attach themselves to tree barks and obtain water and nutrients from them. However, trees do not benefit from the presence of lichens and they are not harmed by them.



Examples of parasitism

- Fungi that parasitise trees. E.g. *Armillaria* sp.
- *Candida albicans* in humans.
- Facultative parasites

- Flatworm, *tapeworm*, roundworm, flea etc.
- Obligate parasites

Adaptations of parasites

1) Some have structures that enable them to penetrate into hosts.

2) Endo-parasites have adhesive structures like hooks, suckers etc.

3) The presence of resistant body cover. E.g. nematodes body surface is covered with cuticle.

4) Some intestinal parasites produce anti-enzymes to neutralise digestive enzymes of hosts.

5) Some parasites living in certain parts of the body with low oxygen content are able to live as facultative anaerobes. E.g. *Ascaris lumbricoides*

6) Parasites have high reproductive potential. E.g. *Ascaris lumbricoides* lays about 200,000 eggs per day.

Predation

- Predation occurs when a species (predator) eats another species (prey).

- The predatory activity of predators results in a reduction in the fitness of preys.

- Predator-prey relationships are essential to maintaining the balance of organisms in an ecosystem.

- Is there any ecological significance of predation?

Types of predation

(a) True predation

- This is where a predator kills and eats its prey.

E.g snakes, lions, cat

b) Grazing predation

- This is where a predator eats part of the prey without killing it.

E.g herbivores such as goats, sheep, cattle

- Herbivores feed on grasses but the grasses do not die, and they regrow.

Ecological importance of predation

(For class discussion)

Population growth dynamics

- Populations fluctuate in size in characteristic ways due to intrinsic and extrinsic factors.

- Population size, which refers to the number of individuals of a species within a specific area, is partly governed by reproductive potential of individuals.

- If environmental resources within ecosystems are unlimited, the rate of reproduction in organisms would be maximum. That is, the maximum reproductive potential (biotic potential) of organisms would be realised.

- However, in reality, full biotic potential is unattainable due to environmental resistance.

- Consequently, reproductive potential of organisms is one of the factors that affects the growth rates of their populations.

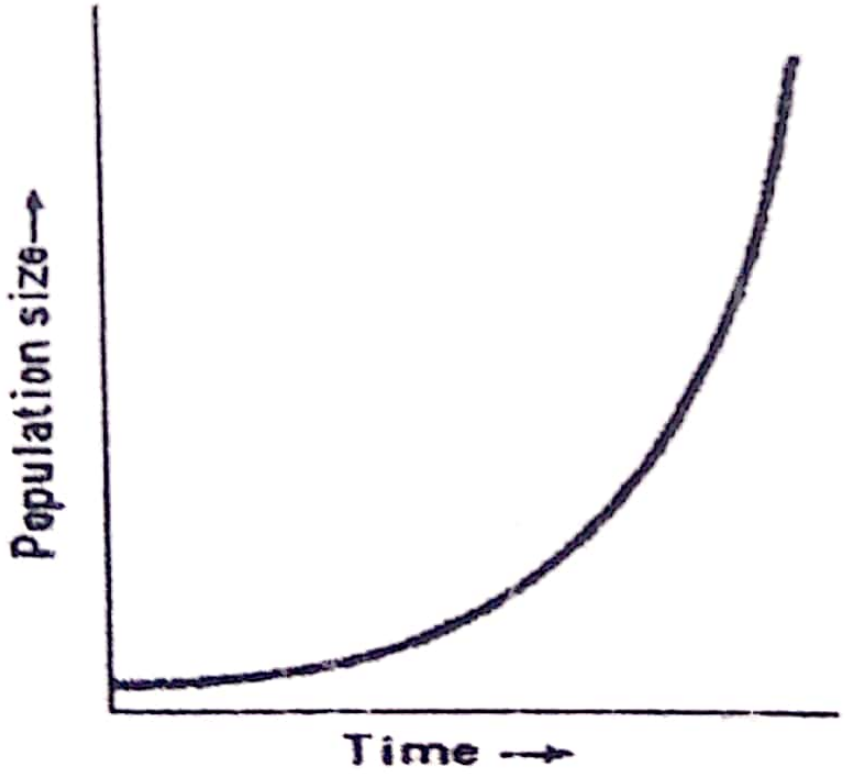
- Apart from reproductive potential (birth rate), there are other factors that affect population growth rate: death rate, immigration and emigration.

- There are environmental resistance factors that affect the number of individuals that can survive and reproduce as well as migrate in a habitat .

Population growth curves

Exponential growth rate

- If birth rate and immigration exceed death rate and emigration, then a population grows exponentially resulting in a characteristic J-curve.



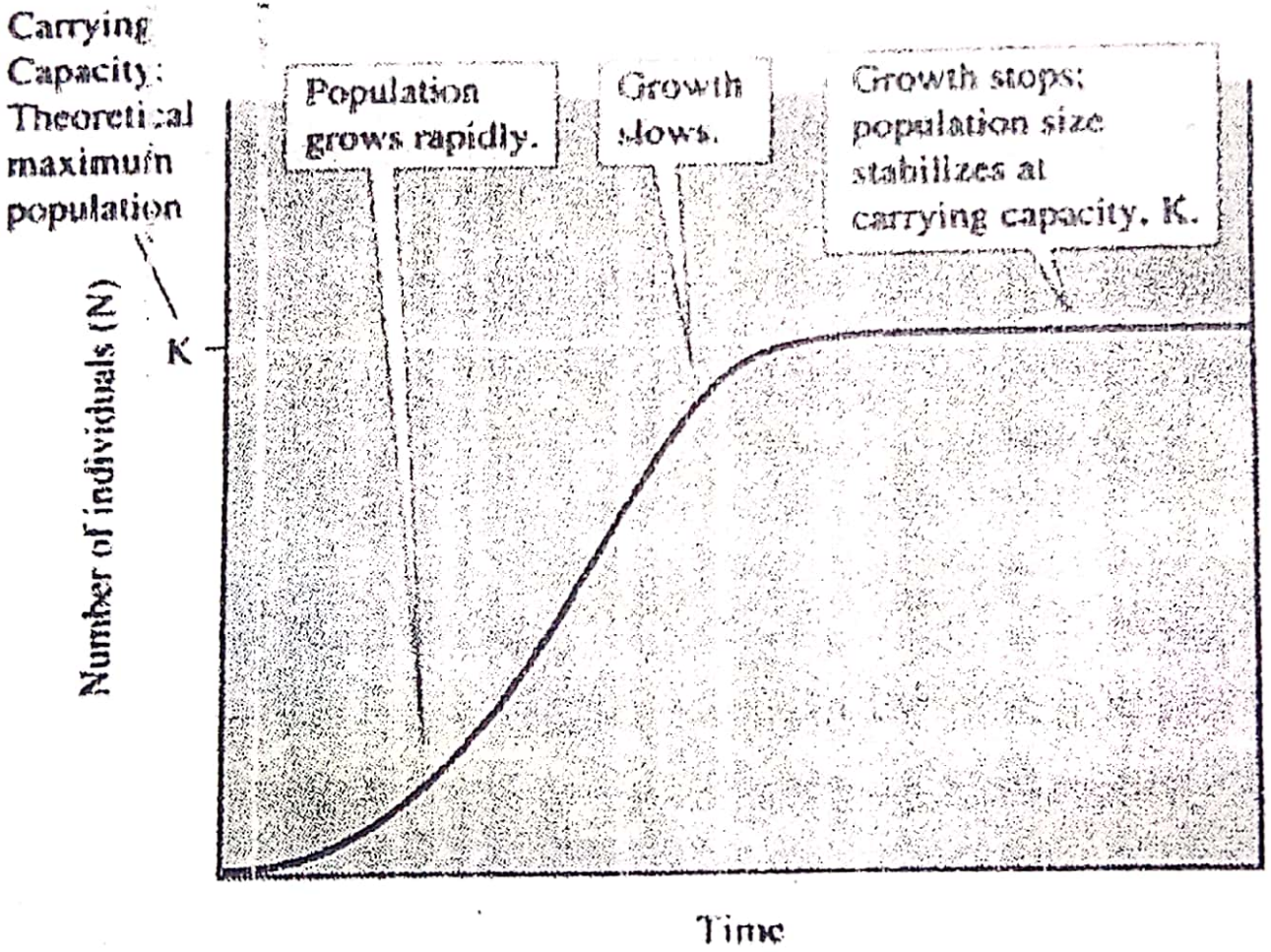
- This type of growth is very characteristic of small populations.

- It can only occur in an ecosystem where environmental resources are not limited.

- However, since in reality resources in ecosystems are limited, then this type of growth rate would hardly ever occur in nature. Where it occurs, it can only exist for a short time.

- The J-curve growth type is density independent.

Logistic growth rate



- As indicated earlier, exponential growth cannot continue forever due to limited resources.

- In the logistic growth rate, the population density of a species increases slowly initially, and then increases rapidly, approaching exponential growth rate.

- As the population size increases, growth rate eventually slows down until a zero population growth rate occurs. At this point, rate of reproduction balances rate of mortality. And it is at this point that maximum carrying capacity occurs.

- This type of growth rate is density dependent because as the population density increases, competition for resources increases, resulting in increased mortality and reduced biotic potential, that eventually brings growth rate to zero.

- The shape of the graph produced from the logistic growth rate is S-shaped.