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((Ecology))

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Population growth models

By

Prof. Dr. Dhurgham Ali Al-Sultany

Population growth models

The term population growth refers to how the number of individuals in a population increases or decreases with time. This growth is controlled by the rate at which new individuals are added to the population through the processes of birth and immigration and the rate at which individuals leave the population through the processes of death and emigration.

We refer to populations in which immigration and/or emigration occur as **open populations.** Those in which movement into and out of the population does not occur (or is not a significant influence on population growth) are referred to as **closed populations**.

Population growth reflects the difference between rates of birth and death

Suppose we were to monitor a population of an organism that has a very simple life history, such as a population of freshwater hydra growing in an aquarium in the laboratory. We define the population size as $N(t)$, where t refers to time.

Let us assume that the initial population is small, so that the food supply within the aquarium is much more than is needed to support the current population. How will the population change through time? Because no emigration or immigration is allowed by the lab setting, the population is closed. The number of hydra will increase as a result of new "births" (note that hydra reproduce asexually by budding). Additionally, the population will decrease as a result of some hydra dying. Because the processes of birth and death in this population are continuous, we can define the proportion of hydra producing a new individual per unit of time as *b,* and the proportion of hydra dying per unit of time can be *d.* If we start with $N(t)$ hydra at time *t,* then to calculate the total number of hydra reproducing over a given time period, Δt (the symbol Δ refers to a "change"), we simply need to multiply the proportion reproducing per unit time by the total number of hydra and the length of the time period. However, the equation below represent the growth of population

ΔN/Δt (growth) = (*b* - *d*) *N*

Where , N is the initial population size

A. *Exponential Growth (J-shaped growth curve).*

If a population were suddenly presented with an unlimited environment, it would tend to expand exponentially. In other word the organisms reproduce continuously at a constant rate all the time – like humans.

The equation for population growth can be Written

ΔN/Δt = r max N

Where:

ΔN = the change in number of individuals

Δt = the change in time

r = is the net reproductive rate =The difference between birth rate (b) and death rate (d).

b = the average of birth rate (includes immigrations)

d = the average of death rate (includes emigrations)

N=is the initial population size

When conditions are optimal, r is at its highest value (r max), called the specific rate of increase.

Real populations do not grow exponentially for long because of environmental limitations. **This Environmental limitations include :**

1.Food 2. Water 3.Space 4. Diseases 5. Density 6.Oxygen

The exponential growth model is applicable only to initial growth after colonization of an unexploited habitat so it is a transient phenomenon. Natural population growth more closely an S-shaped curve.

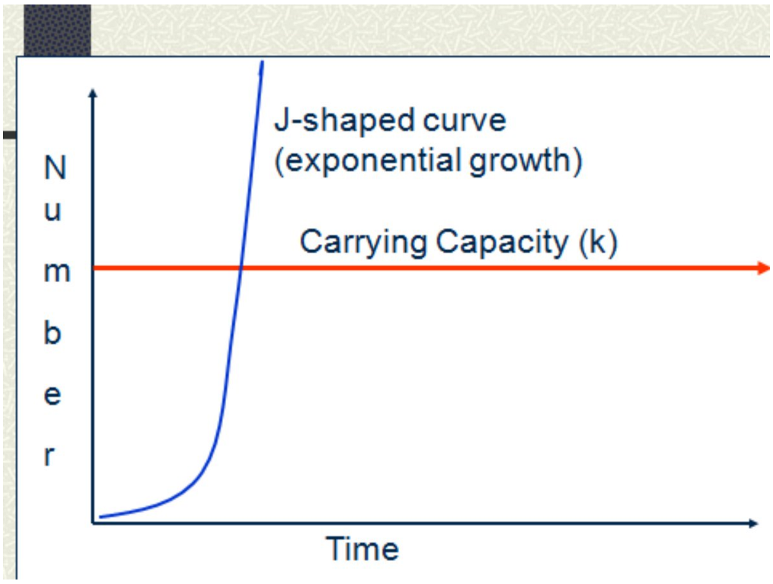

Figure 8: J-shaped growth curve

B. Logistic Growth (S-shaped growth curve)

The population in this pattern grows and then eventually levels off as the carrying capacity is reached. As population density increases, competition for available resources among its members increases (and disease etc). The effects of increasing competition on the population begin to slow the rate of growth until growth rate becomes zero and the population is at a theoretical equilibrium level with its environment. In general all populations will follow this pattern eventually.

Figure 9: *S*-shaped growth curve

Carrying Capacity (K) , is the maximum number of individuals that the environment can support. The logistic growth equation is:

$\Delta N/\Delta t = r\ max\ N\ (K\text{-}N/K)$

where:

r max = Maximum rate of increase under ideal conditions.

When N nears K, the right side of the equation nears zero.

- **N/K** = Environmental resistance.

Reproductive strategies

There are a wide range of reproductive strategies employed by different populations/species.

r/*K* selection theory

The terms *r-selection* and *K-selection* have been used by ecologists to describe the growth and reproductive strategies of various organisms.

A- *K-strategist:*

They are called *k*-selected (for carrying capacity), because they are adapted to thrive when the population is near its carrying capacity. However, Population growth in *K*-selected species behaves according to the logistic growth equation. Species that follow this pattern usually.

1- Long life
2- Slower growth
3- Later maturity
4- Few, large offspring
5- High parental care and protection
6- Adapted to stable environment
7- High trophic level

B- r-strategist:

They are called *r*-selected species (for *rate* of increase). Population growth in *r*-selected species behaves according to the exponential growth equation. By contrast with k- selected when populations of are far below the carrying capacity, resources may be abundant. Costs of reproduction may be low , and selection will favor individuals with highest reproductive rates. Species that follow this pattern usually.

1- Short life
2- Rapid growth
3- Early maturity
4- Many small offspring
5- Little parental care and protection
6- Adapted to unstable environment
7- Low trophic level

Semelparity and Iteroparity

Semelparity and iteroparity refer to the reproductive strategy of an organism.

A- Semelparity

The word semelparity comes from the Latin *semel* 'once, a single time' and *pario* 'to beget'. A species is considered semelparous if it is characterized by a single reproductive episode before death. A classic example of a semelparous organism is Pacific salmon which lives for many years in the ocean before swimming to the freshwater stream of its birth, spawning, and dying. Other semelparous animals include many insects, including some species of butterflies, and mayflies, and some molluscs such as octopus.

B- Iteroparity

The term iteroparity comes from the Latin *itero*, to repeat, and *pario*, to beget. Individuals that normally experience several or many such reproductive events. During each period of reproductive activity the individual continues to survival and possibly growth, and beyond each it therefore has a chance of surviving to reproduce again. Results in overlapping generations. An example of an iteroparous organism is a human—though people may choose only to have one child, humans are biologically capable of having offspring many times over the course of their lives. Iteroparous vertebrates include all birds, most reptiles, virtually all mammals, and most fish. Among invertebrates, most mollusca and many insects (for example, mosquitoes) are iteroparous. This distinction is also related to the difference between annual and perennial plants. An annual is a plant that completes its life cycle in a single season, and is usually semelparous. Perennials live for more than one season and are usually (but not always) iteroparous.