Ecology & wild Life Biology; ZooG-DSE-B-6-2-TH

Unit 2: Population (Attributes, Geometric, Exponential & logistic growth, equation and patterns)

Definition of Population:

Population is a set of individuals of a particular species, which are found in a particular geographical area.

The population that occupies a very small area, is smaller in size, such a population is called local population. A group of such a closely related local population is called meta-population.

Population Attributes:

A population has certain attributes that an individual organism does not have.

Some of them are given below:

(i) Population Size or Density:

It is the number of individuals of a species per unit area or volume

$$\text{Population Density (PD)} = \frac{\text{Number of individuals in a region (N)}}{\text{Number of unit area in the region (S)}} \quad \text{PD} = \frac{N}{S}$$

(ii) Birth Rate (Natality):

It is the rate of production (birth rate) of new individuals per unit of population per unit time. For example, if in a pond, there are 20 pigeon last year and through reproduction, 8 new birds are added, taking the current population to 28. Then, birth rate = 8/20 = 0.4 offspring per birds per year.

(iii) Death Rate (Mortality):

It is the rate of loss of individuals (death rate) per unit time due to death or due to the different environmental changes, competition, predation, etc. For example, if individuals in a laboratory population of 40 fruit flies died during a specified time interval. Then, the death rate = 4/40 = 0.1 individuals per fruit fly per week.

(iv) Sex Ratio:

An individual is either a male or a female but a population has a sex ratio like 60% of the population are females and 40% are males.

Age Distribution:

Age distribution is an important characteristic of population which influences natality and mortality. Mortality usually varies with age, as chances of death are more in early and later periods of life span. Similarly, natality is restricted to certain age groups, e.g., in middle age-groups in higher animals.

The individuals of a population can be divided in three ecological stages. They are:

(i) Pre-Reproductive,

(ii) Reproductive and

(iii) Post-Reproductive.

The individuals of pre-reproductive group are young, those of reproductive group are mature and those in post-reproductive group are old.

The distribution of ages may be constant or variable. It is directly related to the growth rate of the population. Depending upon the proportion of the three age groups, populations can be said to be growing, mature or stable, and diminishing.

Rapidly increasing population contains a large proportion of young individuals, a stable population shows even distribution of individuals in reproductive age group, and declining or diminishing population contains a large proportions of old individuals.

Age Pyramid:

Population at any given time is composed of individuals of different ages. When the age distribution (per cent individuals of a given age or age group) is plotted for the population, this is called age pyramid.

The age pyramids of human population generally shows the age distribution of males and females in a combined diagram.

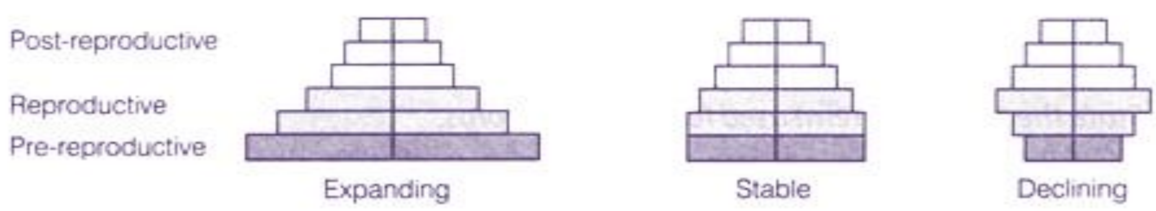
The growth status of the population is reflected by the shape of the pyramids.

That whether it is:

(i) Growing Expanding

(ii) Stable

(iii) Declining.



(i) Pyramid with Broad Base:

This pyramid shows a high percentage of young individuals and an exponential growth of population due to high birth rate, e.g., yeast, housefly, etc.

(ii) Bell-Shaped Pyramid:

This type of age pyramid shows a stable population having, more or less equal number of young and middle-aged individuals and post-reproductive individuals being smallest in number.

(iii) Pyramid with Narrow Base:

This is an urn-shaped pyramid which shows increased numbers of middle-aged and old organisms as compared to young ones in the population. This shows diminishing of population.

Population Growth:

The size of a population for any species is not a static parameter, it keeps changing with time.

It depends on the following factors:

(i) Food availability

(ii) Predation pressure

(iii) Weather

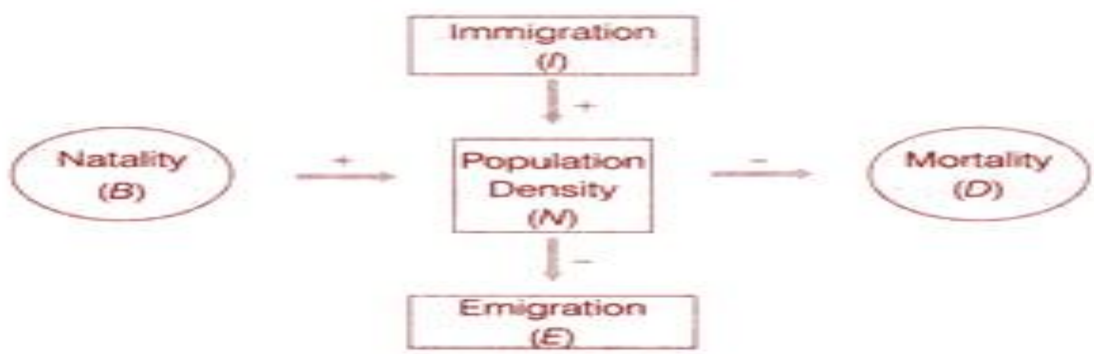
The density of a population in a given habitat during a given period, fluctuates due to the four basic processes:

(a) Natality refers to the number of births during a given period in the population that are added to initial density.

(b) Mortality is the number of deaths in the population during a given period.

(c) Immigration is the number of individuals of the same species that have come into the habitat from elsewhere during the time period under consideration.

(d) Emigration is the number of individuals of population who left the habitat and moved elsewhere during a given period of time.



Out of these four, natality and immigration contribute an increase in population density while mortality and emigration contribute to the decrease in population density.

So, if N is the population density at time t, then its density at time t +1 is

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

Where, N = Population density

t = Time,

B = Birth rate,

I = Immigration,

D = Death rate,

E = Emigration

From the above equations, we can see that population density will increase if, (B + I) is more than (D + E).

Growth Models:

Studying about the behaviour and pattern of different animals can help us to learn a lesson on how to control the human population growth.

There are following two models of population growth:

Exponential Growth:

Availability of resources (food and space) is essential for the growth of population. The unlimited availability results in population exponential. The increase or decrease in population density (N) at a unit time period (t) is calculated as (dN/dt)

Let dN/dt = (b – d) XN

Let (b-d) = r, then, dN/dt = rN

Where, N is population size, b is birth per capita

d is death per capita, t is time period

and r is intrinsic rate of natural increase.

r, is an important parameter that assess the effects of biotic and abiotic factors on population growth. It is different for different organisms.

It is 0.015 for Norway rat and 0.12 for flour beetle. The above equation results in J-shaped curve as shown in graph.

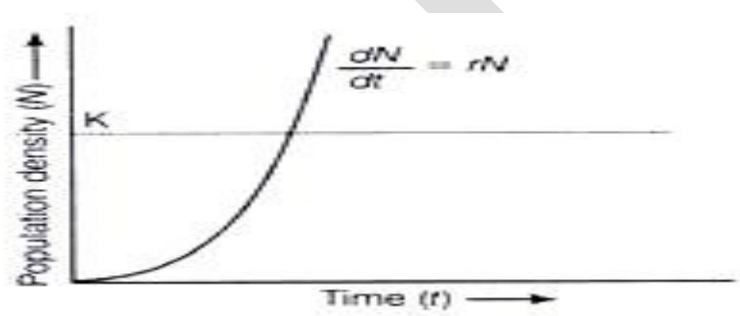


Fig. Exponential growth curve.

Integral form of exponential growth is $Nt = N0ert$

Where,

N_t = Population density after time t,

N_0 = Population density at time zero (beginning),

r = Intrinsic rate of natural increase,

e = Base of natural logarithms (2.71828).

Any species growing exponentially under unlimited resource conditions, without any checks can reach enormous population densities in a short time.

Logistic Growth:

Practically, no population of any species in nature has unlimited resources at its disposal. This leads to competition among the individuals and the survival of the fittest. Therefore, a given habitat has enough resources to support a maximum possible number, beyond which no further growth is possible.

This is called the carrying capacity (K) for that species in that habitat. When N is plotted in relation to time t, the logistic growth show sigmoid curve and is also called Verhulst-Pearl Logistic Growth and is calculated as

$$dN/dt = rN\,(K - N/K)$$

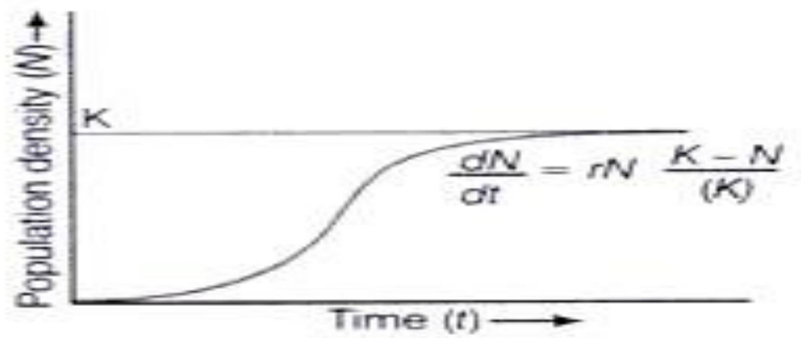


Fig. Exponential growth curve

Where, N is population density at time t K is carrying capacity and r is intrinsic rate of natural increase.

This model is more realistic in nature because no population growth can sustain exponential growth indefinitely as there will be completion for the basic needs.

Human population growth curve will become S-shaped, if efforts are being made throughout the world to reduce the rate of population growth and make it stationary.

Note:

Human population growth curve is not J-shaped.