Population dynamics

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Definition

- Population dynamics is the portion of ecology that deals with the variation in time and space of population size and density for one or more species (Begon *et al*. 1990).
- Approaches to population study:

  i) Mathematical models

  ii) Laboratory studies

  iii) Field studies

Theory of population growth

- **Geometrical or exponential increase model**- assumes that there are no environmental constraints on population growth. Example: binary fission in Protozoa.

- $\mathbf{N_t = N_0\ (2^t)}$
- A more generalised equation will be $\mathbf{N_t = N_0\ (e^{rt})}$

  This is exponential growth equation

e is universal constant , the base of natural logarithm and has value of 2.718.

r is intrinsic rate of natural increase. r = natality rate minus mortality rate.

But most populations do not show exponential increase because their environment prevents this.

Carrying capacity

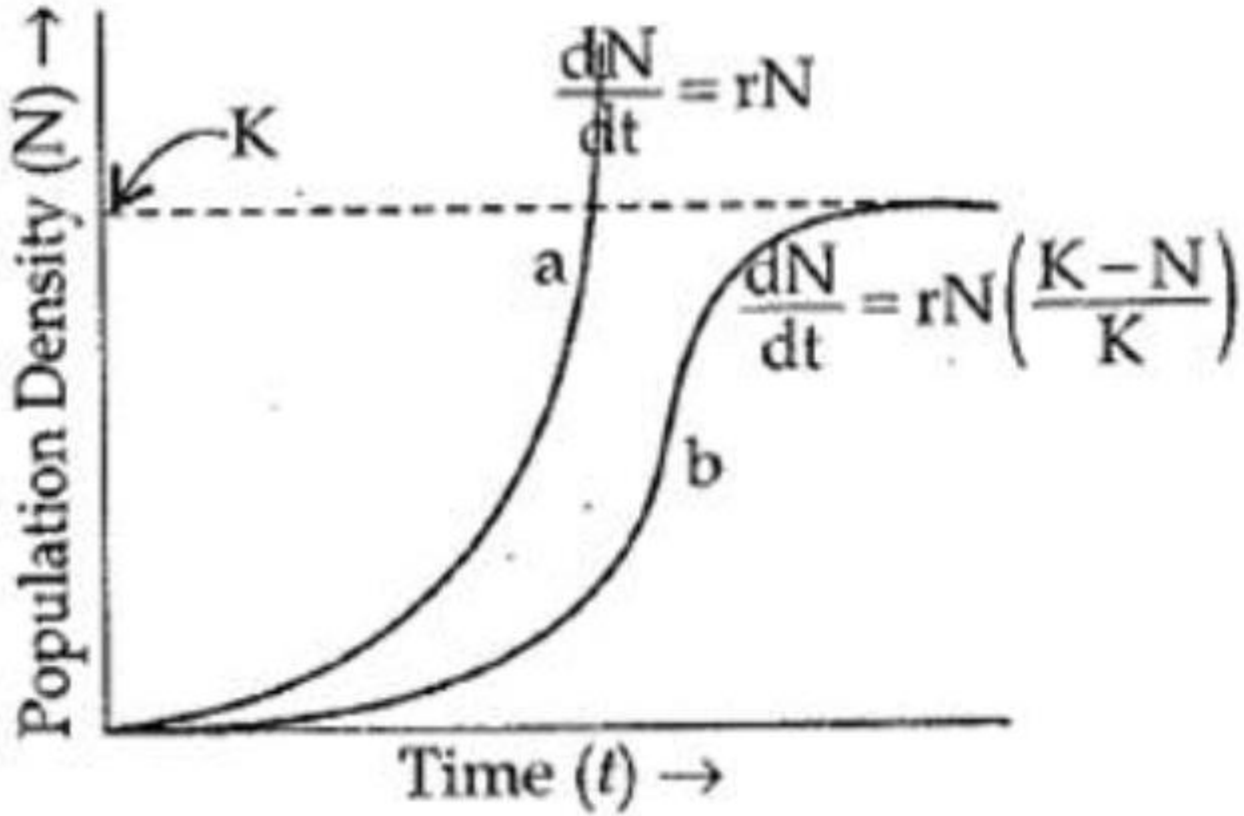
- In an ecosystem, other species present and a variety of abiotic conditions etc. act in a way that a given population will have an upper size limit that cannot be exceeded. Such a limit is called **carrying capacity** of the environment for that population.
- Carrying capacity is determined by the availability of resources such as food and space. It is represented by ‘K’.

Logistic Equation

- It was deviced by **Verhulst** in 1838 to describe a population growth with an upper limit.
- Suppose K is the carrying capacity for a particular population.
- Then logistic equation assumes, that intrinsic rate of natural increase (r) is progressively reduced as population size increases towards that carrying capacity.
- If N = 10 and K = 100, then remaining resources can support a further K-N = 90 individuals and the proportion of remaining resources is

  K-N/K = 0.9

- **$N_t = N_0\, e^r\, (K\text{-}N/K)^t$ is the logistic growth equation**
- The logistic growth is **S-shaped** on arithmetic coordinates.
- Using differential calculus, the logistic equation becomes:
- $$\frac{dN}{dt} = rN\left[\frac{K-N}{K}\right]$$



Verhulst-Pearl logistic growth curve

Regulation of population density

The logistic model and its derivatives assume that a population will **level off** at its carrying capacity, that there is an upper limit to population density set by the environment and that the population is regulated at or around that level.

Nature of factors that regulate population density

Population density can only be increased by **natality** or **immigration** and decreased by **mortality** or **emigration**. These factors may be density dependent or density independent.

Density dependent factors e.g. competition and predation

Density independent factors e.g. flood, fire etc.

Plant population dynamics

Self Thinning

Self thinning is the natural process whereby number of trees per unit area **decreases** as average tree size increases over time.

It is intrinsic to all forests and plant communities whose composition and structure are influenced by competition for growing space.

r and *k* selection

- Organisms that live in unstable environment tend to make many cheap organisms i.e., ***r*-selection** (requiring little energy investment).
- Organisms that live in stable environment tend to make few expensive organisms i.e., ***k*-selection** (requiring a lot of energy investment).

	r-selected	*k*-selected
Environment	Variable and unpredictable	Constant or predictably variable
Population characteristics	Survivorship curve concave	Survivorship curve Convex
	High fecundity	Low fecundity
	Density variable usually well below carrying capacity	Density fairly constant at or near carrying capacity
	Scramble type intraspecific competition	Contest type interspecific competition
Individual characterstics	Small body size Good dispersal powers Outcrossing Low level of social organisation	Large body size Poor dispersal powers Parthenogenetic or vegetative reproduction High level of social organisation

References

- Elements of Ecology by P.D.Sharma
- Fundamentals of Ecology by Eugene Odum