

Organisms and Populations

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Introduction

- The living world is fascinatingly diverse and remarkably complex.
- To understand this complexity, biologists investigate processes at various levels of **biological organisation**, such as:
 1. Macromolecules
 2. Cells
 3. Tissues
 4. Organs
 5. Individual organisms
 6. Populations
 7. Communities
 8. Ecosystems
 9. Biomes

Two Types of Biological Questions

When studying nature, scientists often ask two types of questions:

A. How-type Questions (Mechanistic Approach)

- **Definition:** Seeks to explain *how* a process occurs.
- **Example:** “How does the bulbul sing?”
- **Answer:** Due to the operation of the voice box (**syrinx**) and the vibration of certain bones in the bird.

B. Why-type Questions (Functional/Significance Approach)

- **Definition:** Seeks to explain *why* a process occurs, focusing on its purpose or adaptive value.
- **Example:** “Why does the bulbul sing?”
- **Answer:** To communicate with its mate during the breeding season.

Examples of Scientific Curiosity in Nature

- When we observe nature scientifically, many such questions arise:
 - Why are night-blooming flowers generally white?
 - How does a **bee** know which flower contains nectar?

- Why does a **cactus** have so many thorns?
- How does a **chick** recognise its mother?

Ecology – Definition and Scope

Definition:

- Ecology is the study of interactions among organisms and between organisms and their **physical (abiotic) environment**.

Main Focus:

- Understanding how living beings relate to each other and to their surroundings.

Levels of Ecological Organisation

- Ecology primarily studies **four major levels**:
 1. **Organisms** – Individual living beings.
 2. **Populations** – Groups of individuals of the same species in a specific area.
 3. **Communities** – Groups of interacting populations of different species.
 4. **Biomes** – Large-scale global ecosystems with characteristic climate and life forms.

Populations

Population Attributes

Definition of a Population

- In nature, organisms are rarely found as isolated individuals.
- Most live in **groups** within a well-defined geographical area where they:
 - Share or compete for resources.
 - Potentially interbreed.
- Such a group constitutes a **population**.

Note:

- “Interbreeding” usually implies sexual reproduction, but in ecology, even a group from **asexual reproduction** is considered a population.

Examples:

- All cormorants in a wetland.
- Rats in an abandoned house.
- Teakwood trees in a forest.
- Bacteria in a culture plate.

- Lotus plants in a pond.

Importance of Studying Populations

- Individuals cope directly with environmental change.
- **Natural selection** acts at the **population level**, influencing the evolution of traits.
- Population ecology links ecology with population genetics and evolution.

Unique Population Attributes

- Unlike individuals, populations have measurable rates and structures:

A. Birth Rate (Natality)

- Number of new individuals **per unit population** per unit time.
- Example:
 - Last year: 20 lotus plants in a pond.
 - New plants added: 8 → total 28.
 - Birth rate = $8 \div 20 = 0.4$ offspring per lotus per year.

B. Death Rate (Mortality)

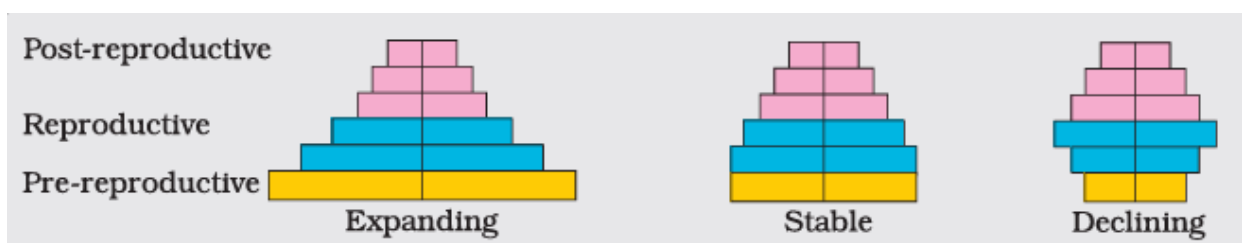
- Number of deaths **per unit population** per unit time.
- Example:
 - 40 fruit flies in a lab population.
 - Deaths in one week: 4.
 - Death rate = $4 \div 40 = 0.1$ per fruit fly per week.

C. Sex Ratio

- Proportion of males and females in a population.
- Example: 60% females : 40% males.

D. Age Structure (Age Pyramid)

- Distribution of individuals in different age groups.
- Shape of age pyramid indicates growth status:
 - **Expanding (Growing)** – Broad base.
 - **Stable** – Uniform width.
 - **Declining** – Narrow base.



Representation of age pyramids for human population

Population Size and Density

- **Population size** gives an idea of its **status** in a habitat.
- Size varies greatly in nature:
 - **Low:** <10 Siberian cranes at Bharatpur.
 - **High:** Millions of *Chlamydomonas* in a pond.
- Population density (N) = number of individuals per unit area/volume.

Measures of Density:

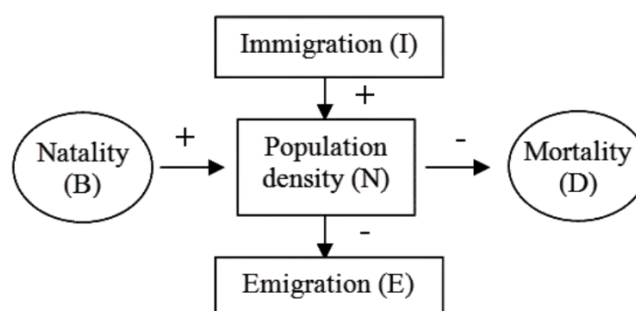
1. Number count (most common).
2. **Percent cover** or **biomass** – used when number alone is misleading (e.g., one huge banyan tree vs. many small plants).
3. **Relative density** – when absolute numbers are not needed (e.g., fish caught per trap).
4. **Indirect estimation** – using signs (e.g., tiger pugmarks, droppings).

Population Growth

- The size of a population is **not static**.
- It changes over time due to several biotic and abiotic factors such as food availability, predation pressure, and climatic conditions.
- By studying these changes in **population density**, we can understand whether a population is flourishing or declining.

Factors Causing Changes in Population Size

- Population size changes due to **four basic processes**:
- Two factors increase population density, and two decrease it.
 1. **Natality (B):** Number of births during a given period, adding to the initial population.
 2. **Mortality (D):** Number of deaths during a given period, reducing population size.
 3. **Immigration (I):** Number of individuals entering a habitat from elsewhere.
 4. **Emigration (E):** Number of individuals leaving a habitat to live elsewhere.



Population Change Equation:

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

- If $B + I > D + E$, population density increases.
- Under normal conditions, **births and deaths** are the primary factors affecting population size.
- Immigration and emigration become significant in special cases (e.g., colonisation of a new habitat).

Growth Models

Population growth models describe how population size changes over time under different resource conditions, revealing distinct growth patterns.

1. Exponential Growth (J-shaped curve)

Definition

- Occurs when **resources are unlimited** (food, space, etc.), allowing a species to fully realise its reproductive potential.

Mathematical Model

- If:
 - N = Population size at time t
 - b = Per capita birth rate
 - d = Per capita death rate
 - $r = b - d$ = Intrinsic rate of natural increase

- Then:

$$\frac{dN}{dt} = rN$$

- r is a key parameter used to assess the impact of biotic and abiotic factors on growth.

Example r Values:

- Norway rat: **0.015**
- Flour beetle: **0.12**
- Human population in India (1981): **0.0205**

Integral Form:

$$N_t = N_0 e^{rt}$$

- Where:
 - N_t = Population at time t

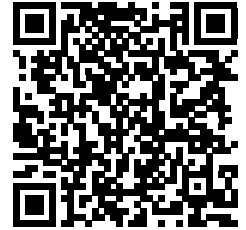


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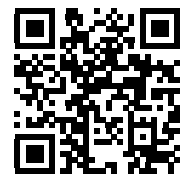


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