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Evolution, Biodiversity, and Population Ecology

Chapter Objectives

This chapter will help students:

Explain the process of natural selection and cite evidence for this process

Describe the ways in which evolution influences biodiversity

Discuss reasons for species extinction and mass extinction events

List the levels of ecological organization

Outline the characteristics of populations that help predict population growth

Assess logistic growth, carrying capacity, limiting factors, and other fundamental concepts in population ecology

Identify efforts and challenges involved in the conservation of biodiversity

Lecture Outline

- I. Central Case: Striking Gold in a Costa Rican Cloud Forest**
 - A. Local residents in Costa Rica's mountainous Monteverde region told of an elusive golden toad that appeared only in the early rainy season.
 - B. In 1964, Dr. Jay M. Savage and his colleagues encountered hundreds of golden toads during an expedition.
 - C. The newly discovered species went extinct 25 years later when global climate change caused drying of the forest.

- II. Evolution as the Wellspring of Earth's Biodiversity**
 - A. Natural selection shapes organisms and diversity.
 1. Biological **evolution** consists of genetic change in organisms across generations.

2. **Natural selection** is the process by which traits that enhance survival and reproduction are passed on more frequently to future generations, altering the genetic makeup of populations through time.
 3. In 1858, **Charles Darwin** and **Alfred Russell Wallace** each independently proposed the concept of natural selection as a mechanism for evolution and as a way to explain the great variety of living things.
 - a. Individuals of the same species vary in their characteristics.
 - b. Organisms produce more offspring than can possibly survive.
 - c. Some offspring may be more likely than others to survive and reproduce.
 - d. Characteristics that give certain individuals an advantage in surviving and reproducing might be inherited by their offspring.
 - e. These characteristics would tend to become more prevalent in the population in future generations.
 4. A trait that promotes success is called an **adaptive trait**, or an **adaptation**.
- B. Natural selection acts on genetic variation.
1. Accidental changes in DNA are called **mutations** and can range from the addition, deletion, or substitution of single nucleotides to the insertion or deletion of large sections of DNA.
 2. Most mutations have little effect; some are deadly; a few are beneficial.
 3. Sexual reproduction generates variation as organisms reproduce through sex; they mix, or recombine, their genetic material so that a portion of each parent's genome is included in the genome of the offspring.
- C. Evidence of natural selection is all around us.
1. This process of selection conducted under human direction is termed **artificial selection**.
- D. Evolution generates biological diversity.
1. **Biological diversity**, or **biodiversity**, is the sum total of all organisms in an area, taking into account the diversity of species, the diversity of populations within a community, and the diversity of communities within an ecosystem.
 2. A **species** is a population whose members share certain characteristics and can freely breed with one another and produce fertile offspring.
- E. **Speciation** produces new types of organisms.
1. When populations of the same species are kept separate, their individuals no longer come in contact, so their genes no longer mix.
 2. If there is no contact, the mutations that occur in one population cannot spread to the other.
- F. Populations can be separated in many ways.
- G. Life's diversification results from numerous speciation events.
- H. Speciation and extinction together determine Earth's biodiversity.
- I. Some species are more vulnerable to extinction than others.

1. Generally, **extinction** occurs when environmental conditions change rapidly or severely enough that a species cannot genetically adapt to the change.
 2. Some species are vulnerable because they are **endemic**, occurring in only a single place on the planet.
- J. Earth has seen several episodes of mass extinction.
1. There have been five **mass extinction events** at widely spaced intervals in Earth's history that have wiped out anywhere from 50 to 95% of Earth's species each time.
- K. The sixth mass extinction is upon us.

III. Levels of Ecological Organization

- A. Ecology is studied at several levels.
1. Life occurs in a hierarchy of levels, from the atoms, molecules, and cells up through the **biosphere**, which is the cumulative total of living things on Earth and the areas they inhabit
 2. A group of organisms of the same species that live in the same area is a **population**, and species are often composed of multiple populations.
 3. **Communities** are made up of multiple interacting species that live in the same area.
 4. **Ecosystems** encompass communities and the abiotic (nonliving) material and forces with which their members interact.
 5. **Population ecology** investigates how individuals within a species interact with one another.
 6. **Community ecology** focuses on interactions among species.
 7. **Ecosystem ecology** studies living and nonliving components of systems.
- B. Habitat, niche, and degree of specialization are important in organismal ecology.
1. The specific environment in which an organism lives is its **habitat**.
 2. Each organism has patterns of **habitat use**.
 3. A species' **niche** reflects its use of resources and its functional role in a community.
 4. Species with very specific requirements are said to be **specialists**.
 5. Those with broad tolerances, able to use a wide array of habitats or resources, are **generalists**.

IV. Population Ecology

- A. Populations exhibit characteristics that help predict their dynamics.
1. **Population size** is the number of individual organisms present at a given time.
 2. **Population density** is the number of individuals in a population per unit area.
 3. **Population distribution**, or **population dispersion**, is the spatial arrangement of organisms within a particular area.
 4. A population's **sex ratio** is its proportion of males to females.

5. **Age distribution**, or **age structure**, describes the relative numbers of organisms of each age within a population.
 6. **Birth and death rates** measure the number of births and deaths per 1,000 individuals for a given time period. The likelihood of death varies with age; this can be graphically shown in **survivorship curves**.
- B. Populations may grow, shrink, or remain stable.
1. Population growth or decline is determined by births, deaths, **immigration** into an area, and **emigration** away from an area.
 2. The **growth rate** equals the crude birth rate plus the immigration rate minus the crude death rate plus the emigration rate.
- C. Unregulated populations increase by exponential growth.
1. When a population increases by a fixed percentage each year, it is said to undergo **exponential growth**.
- D. **Limiting factors** restrain population growth.
1. Every population is eventually contained by limiting factors, which are physical, chemical, and biological characteristics of the environment.
 2. The interaction of the limiting factors determines the **carrying capacity**.
 3. The **logistic growth curve** shows a population that increases sharply at first and then levels off as it is affected by limiting factors.
- E. Carrying capacities can change.
1. Limiting factors are diverse and complex, and help keep population levels below carrying capacity.
 2. Some organisms can alter their environment to reduce environmental resistance and increase carrying capacity.
 3. Humans have appropriated immense proportions of the planet's resources and in the process have reduced the carrying capacities for many other organisms.
- F. The influence of some factors on population depends on population density.
1. The influence of **density-dependent** factors waxes and wanes according to population density.
 2. **Density-independent** factors are not affected by population density.
- G. Biotic potential and reproductive strategies vary from species to species.
1. Species that devote large amounts of energy and resources to caring for a few offspring are said to be **K-selected**, because their populations tend to stabilize over time at or near their carrying capacity.
 2. Species that are **r-selected** have high biotic potential and devote their energy and resources to producing as many offspring as possible in a relatively short time.
 3. K is an abbreviation for carrying capacity, and species that are K-selected species are ones that tend to stabilize over time at or near the carrying capacity.
- H. Changes in populations influence the composition of communities.

V. The Conservation of Biodiversity

- A. Social and economic factors affect species and communities.
 - 1. Costa Rica took steps to protect its environment.
 - 2. Tourists now visit Costa Rica for **ecotourism**.

VI. Conclusion

- 1. Speciation and extinction help determine Earth's biodiversity.
- 2. Many human activities are playing a role in biodiversity loss.