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POPULATION ECOLOGY

INTRODUCTION

This chapter introduces the principles by which biologists study populations of a species. It is important as you progress through the chapter that you distinguish between the many terms associated with describing populations, such as size, density, and structure. The final sections of the chapter apply the knowledge of population structure to humans, and discuss some of the challenges facing human population growth.

FOCAL POINTS

- Figure 45.5 [p.804] and Figure 45.8 [p.807] together illustrate a key concept, the difference between exponential and logistic population growth models.
- Figure 45.11 [p.809] explains the differences between the three forms of survivorship curves.
- Figure 45.17 [p.815] illustrates the different forms of age structure in populations based on their rate of growth.

Interactive Exercises

The Numbers Game [pp.800–801]

45.1. CHARACTERISTICS OF POPULATIONS [p.802]

45.2. ELUSIVE HEADS TO COUNT [p.803]

45.3. POPULATION SIZE AND EXPONENTIAL GROWTH [pp.804–805]

Selected Words: *pre-reproductive*, *reproductive*, and *post-reproductive* ages [p.802], *habitat* [p.802], *crude density* [p.802], *interspecific* interactions [p.802], *capita* [p.804]

Boldfaced, Page-Referenced Terms

[p.801] ecology _____

[p.802] demographics _____

[p.802] population size _____

[p.802] age structure _____

[p.802] reproductive base _____

[p.802] population density _____

[p.802] population distribution _____

[p.803] quadrats _____

[p.803] capture-recapture methods _____

[p.804] immigration _____

[p.804] emigration _____

[p.804] migration _____

[p.804] zero population growth _____

[p.804] per capita _____

[p.804] net reproduction per individual per unit time (r) _____

[p.805] exponential growth _____

[p.805] doubling time _____

[p.805] biotic potential _____

Matching

Choose the most appropriate statement for each term. [p.802]

- | | |
|--|---|
| 1. _____ demographics | A. Includes pre-reproductive and reproductive age categories |
| 2. _____ population size | B. The general pattern in which the individuals of the population are dispersed through a specified area |
| 3. _____ population density | C. When individuals of a population are more evenly spaced than they would be by chance alone |
| 4. _____ habitat | D. The number of individuals in some specified area or volume of a habitat |
| 5. _____ population distribution | E. Occurs only when individuals of a population neither attract nor avoid one another when conditions are fairly uniform through the habitat, and when resources are available all the time |
| 6. _____ age structure | F. The number of individuals in each of several to many age categories |
| 7. _____ reproductive base | G. The measured number of individuals in a specified area |
| 8. _____ crude density | H. The number of individuals that contribute to a population's gene pool |
| 9. _____ pre-reproductive, reproductive, and post-reproductive | I. The type of place where a species normally lives |
| 10. _____ clumped dispersion | J. Categories of a population's age structure |
| 11. _____ nearly uniform dispersion | K. The vital statistics of a population |
| 12. _____ random dispersion | L. Individuals of a population form aggregations at specific habitat sites; most common dispersion pattern |

Short Answer

13. A zoologist wishes to estimate the population size of a species of salamander. Initially, 10 salamanders are caught and marked with an orange, waterproof dye. After six months the scientist returns and captures 5 marked salamanders out of a total catch of 50. What is the population size of the salamanders? [p.803]

14. List three variables that may have caused error in the above estimate of population size. [p.803]

Matching

Match each of the following statements to the correct term. [pp.804–805]

- | | |
|---|---------------------------|
| 15. _____ Growth at a proportional rate, such as a fixed percentage of the population per year. | A. per capita rates |
| 16. _____ The departure of individuals from a population | B. r |
| 17. _____ Net reproduction per individual per unit time | C. zero population growth |
| 18. _____ A balanced number of births and deaths | D. biotic potential |
| 19. _____ Rates per individual | E. doubling time |
| 20. _____ The arrival of new individuals from other populations | F. exponential growth |
| 21. _____ The maximum rate of increase per individual under ideal conditions | G. emigration |
| 22. _____ The time it takes for a population to double its size | H. immigration |

Problems

23. Consider the equation $G = rN$, where G = the population growth rate per unit time, r = the net population growth rate per individual per unit time, and N = the number of individuals in the population. Assume that r remains constant at 0.2. [p.805]

a. As the value of G increases, what happens to the value of N ?

b. If the value of G is negative, what happens to the value of N ?

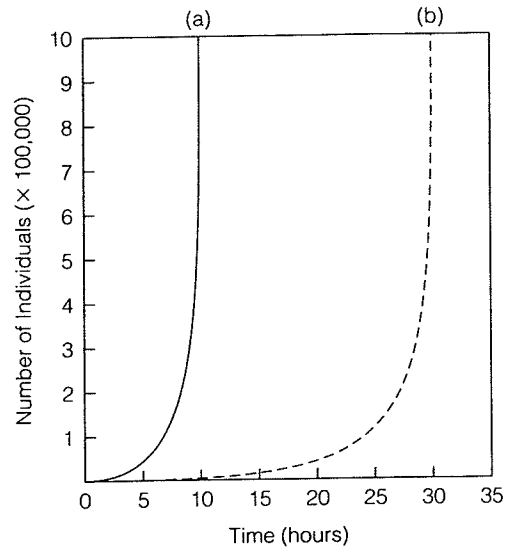
c. If the net reproduction per individual stays the same and the population grows faster, then what must happen to the number of individuals in the population?

24. Look at line (a) in the accompanying graph. After seven hours have elapsed, approximately how many individuals are in the population? [p.805]

25. Look at line (b) in the same graph.

a. After 24 hours have elapsed, approximately how many individuals are in the population? [p.805]

b. After 28 hours have elapsed, approximately how many individuals are in the population? [p.805]



45.4. LIMITS ON THE GROWTH OF POPULATIONS [pp.806–807]

45.5. LIFE HISTORY PATTERNS [pp.808–809]

45.6. NATURAL SELECTION AND LIFE HISTORIES [pp.810–811]

Selected Words: sustainable supply of resources [p.806], “survivorship” [p.808], Type I curves [p.809], Type II curves [p.809], Type III curves [p.809]

Boldfaced, Page-Referenced Terms

[p.806] limiting factor _____

[p.806] carrying capacity _____

[p.806] logistic growth _____

[p.807] density-dependent controls _____

[p.807] density-independent factors _____

[p.808] life history pattern _____

[p.808] cohort _____

[p.809] survivorship curve _____

Matching

Match each of the following terms to the most appropriate statement.

- | | |
|---|--|
| 1. _____ limiting factor [p.806] | A. An essential resource that is in short supply. |
| 2. _____ life history patterns [p.808] | B. The maximum number of individuals of a population that the environment can sustain. |
| 3. _____ carrying capacity [p.806] | C. A set of adaptations that influence survival, fertility, and age at first reproduction. |
| 4. _____ survivorship curve [p.809] | D. A small population that initially grows slowly, then rapidly, and then the numbers level off. |
| 5. _____ logistic growth [p.806] | E. Graph line of the age-specific survival of a cohort in a habitat. |
| 6. _____ density-dependent control [p.807] | F. Biotic or abiotic factors that reduce the odds for individual survival during overcrowding. |
| 7. _____ density-independent factor [p.807] | G. Causes changes in population size regardless of density. |

Choice

Choose the most appropriate form of survivorship curve for each of the following descriptions. [p.809]

- a. Type I b. Type II c. Type III

- 8. ____ Constant death rate at all ages.
- 9. ____ Highest death rate at an early age.
- 10. ____ High survivorship until late in life.
- 11. ____ Most human populations follow this survivorship curve.
- 12. ____ The survivorship of sea stars is an example.
- 13. ____ Lizards and small mammals follow this pattern.

45.7. HUMAN POPULATION GROWTH [pp.812–813]

45.8. FERTILITY RATES AND AGE STRUCTURE [pp.814–815]

45.9. POPULATION GROWTH AND ECONOMIC EFFECTS [pp.816–817]

45.10. SOCIAL IMPACT OF NO GROWTH [p.817]

Selected Words: preindustrial stage [p.816], transitional stage [p.816], industrial stage [p.816], postindustrial stage [p.816], postpone [p.817]

Boldfaced, Page-Referenced Terms

[p.814] total fertility rate (TFR) _____

[p.816] demographic transition model _____

Fill-in-the-Blanks

Early humans evolved in (1) _____ [p.812], then in savannas. They were (2) _____ [p.812], mostly, but they also scavenged bits of meat. Bands of hunter-gatherers moved out of Africa about (3) _____ [p.812] million years ago. By 40,000 years ago, their descendants were established in much of the world.

Starting about 11,000 years ago or so, many hunter-gatherer bands shifted to (4) _____ [p.812]. Instead of simply following (5) _____ [p.812] game herds, they settled in fertile valleys and other regions that favored seasonal harvesting of fruits and (6) _____ [p.812]. In this way, they developed a more dependable basis for life. A pivotal factor was the domestication of wild (7) _____ [p.812], including species ancestral to modern (8) _____ [p.812] and (9) _____ [p.812]. People harvested, stored, and planted seeds in one place. They domesticated

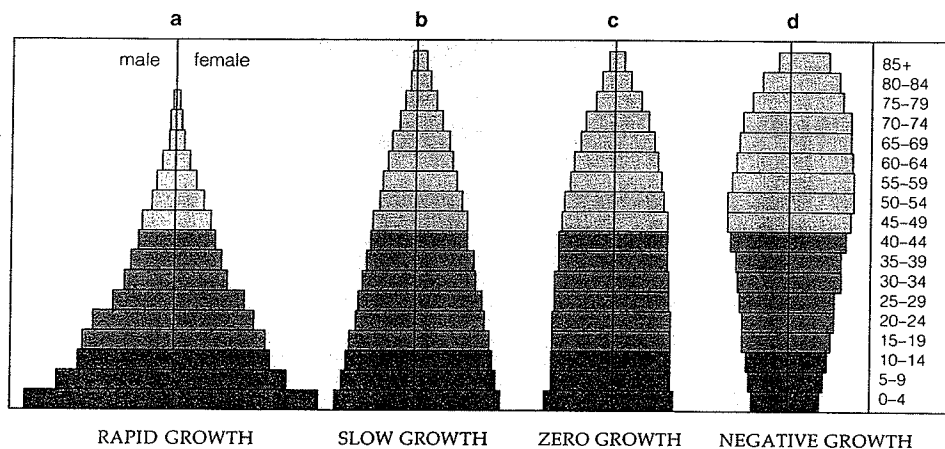
(10) _____ [p.812] for food and pulling plows. They dug (11) _____ [p.812] ditches to divert water to croplands.

Until about 300 years ago, poor (12) _____ [p.812], malnutrition, and infectious (13) _____ [p.813] kept death rates high enough to more or less balance (14) _____ [p.813] rates. Infectious diseases became density-(15) _____ [p.813] controls. Epidemics swept through overcrowded settlements and cities were infested with fleas and (16) _____ [p.813]. Then came plumbing and new methods of (17) _____ [p.813] treatment. Over time, vaccines, (18) _____ [p.813], and other drugs were developed as weapons against pathogens. The (19) _____ [p.813] rates dropped sharply. Birth rates began to exceed death rates—and rapid population growth was under way.

Choice

For each of the following, choose the appropriate age structure diagram from the accompanying figure. [p.815]

20. _____ United States
21. _____ China
22. _____ Canada
23. _____ Mexico
24. _____ Australia
25. _____ India



Sequence

Arrange the following stages of the demographic transition model in correct chronological sequence. Write the letter of the first step next to 26, the letter of the second step next to 27, and so on. [p.816]

26. _____
 27. _____
 28. _____
 29. _____
- A. *Industrial stage*: population growth slows and industrialization is in full swing
 - B. *Preindustrial stage*: harsh living conditions, high birth and death rates, slow population growth
 - C. *Postindustrial stage*: zero population growth is reached; then birth rate falls below death rate, and population size slowly decreases
 - D. *Transitional stage*: industrialization begins, food production rises, and health care improves; death rates drop, birth rates remain high, resulting in rapid population growth

Self-Quiz

- _____ 1. The number of individuals that contribute to a population's gene pool is _____. [p.802]
- the population density
 - the population growth
 - the population birth rate
 - the population size
- _____ 2. The number of individuals in a given area or volume of a habitat is _____. [p.802]
- the population density
 - the population growth
 - the population birth rate
 - the population size
- _____ 3. A population that is growing exponentially in the absence of limiting factors can be illustrated accurately by a(n) _____. [p.804]
- S-shaped curve
 - J-shaped curve
 - curve that terminates in a plateau phase
 - tolerance curve
- _____ 4. Assuming the birth rate and death rate remain constant, both can be combined into a single variable, r , or _____. [p.804]
- the per capita rate
 - the minus migration factor
 - exponential growth
 - the net reproduction per individual per unit time
- _____ 5. _____ is a way to express the growth rate of a given population. [p.805]
- Doubling time
 - Population density
 - Population size
 - Carrying capacity
- _____ 6. The maximum rate of increase per individual under ideal conditions is called the _____. [p.805]
- biotic potential
 - carrying capacity
 - doubling time
 - population size
- _____ 7. The maximum number of individuals of a population (or species) that a given environment can sustain indefinitely defines _____. [p.806]
- the carrying capacity of the environment
 - exponential growth
 - the doubling time of a population
 - density-independent factors
- _____ 8. Which of the following is *not* characteristic of logistic growth? [p.806]
- S-shaped curve
 - leveling off of growth as carrying capacity is reached
 - unrestricted growth
 - slow growth of a low-density population followed by rapid growth
- _____ 9. The beginning of industrialization, a rise in food production, improvement of health care, rising birth rates, and declining death rates describes the _____ stage of the demographic transition model. [p.816]
- preindustrial
 - transitional
 - industrial
 - postindustrial
- _____ 10. The survivorship curve typical of industrialized human populations is Type _____. [p.809]
- I
 - II
 - III
 - none of the above types

Chapter Objectives/Review Questions

1. Define the term *ecology*. [p.801]
2. Define the following terms: *demographics, habitat, population size, population density, population distribution, age structure, and reproductive base*. [p.802]
3. List and describe the three patterns of dispersion illustrated by populations in a habitat. [p.802]
4. Given data on a capture–recapture experiment, estimate the population size of the species. [p.803]
5. Distinguish immigration from emigration and define the term *migration*. [p.804]
6. Define *zero population growth* and describe how achieving it would affect population size. [p.804]
7. Explain how $G = rN$ can be used to predict population growth. [p.805]
8. Explain the relationship between exponential growth and doubling time. [p.805]
9. Explain what is meant by *biotic potential*. [p.805]
10. List several examples of limiting factors, and explain how they influence population curves. [p.806]
11. Explain what is meant by *carrying capacity*. [p.806]
12. Explain the meaning of the logistic growth equation. [p.806]
13. Compare logistic and exponential growth. [pp.805–806]
14. Define the term *density-dependent controls on growth* of populations; cite one example. [p.807]
15. Define the term *density-independent factors* and list two examples; indicate how such factors affect populations. [p.807]
16. Explain what is meant by a life history pattern. [p.808]
17. Explain the three survivorship curves. [p.809]
18. Guppy populations targeted by killifish tend to be larger, less streamlined, and more brightly colored, and guppy populations targeted by pike-cichlids tend to be smaller, more streamlined, and duller in color patterning. Other life history pattern differences exist between the two groups. After consideration of the research results obtained by Reznick and Endler, provide an explanation for these differences. [pp.810–811]
19. List three possible reasons why growth of the human population is out of control. [pp.812–813]
20. Define the term *total fertility rate*. [p.814]
21. Be able to analyze age structure diagrams to determine patterns of growth. [p.815]
22. List and describe the four stages of the demographic transition model. [p.816]

Integrating and Applying Key Concepts

1. Assume that the world has reached zero population growth. The year is 2110, and there are 10.5 billion individuals of *Homo pollutans* on Earth. You have seen stories on the community television screen about how people used to live 120 years ago. List the ways that life has changed, and comment on the events that no longer happen because of the enormous human population.
2. The capture–recapture method of estimating population is widely recognized as being inaccurate. If given the resources, how would you go about estimating the size of a population without counting every individual in the population?
3. How would changes in immigration laws in the United States influence the age structure diagrams? What are the long-term consequences of these decisions? Why would countries like Canada and Australia be actively increasing immigration?