Solution Manual for Animal Diversity 7th Edition Hickman Roberts Keen Larson Eisenhour 0073524255 9780073524252

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CHAPTER 2 ANIMAL ECOLOGY

CHAPTER OUTLINE

2.1 Every Species Has Its Niche
  A. Definitions and Levels of Study
   1. The hierarchy of study includes organism, population, community, and an ecosystem.
   2. **Ecology** is the study of the relationship of organisms to their environment.
   3. Ecology is studied as a hierarchy of biological systems.
   4. It is necessary to understand the physiological and behavioral mechanisms of **organisms** to understand their ecological relationships
   5. When organisms live together with others of their species, this **population** has properties that cannot be discovered by studying individuals alone.
   6. Populations of many species occur together in complex **communities**.
      a. Variation and evenness of distribution within a community is measured as species diversity.
      b. Many species have relationships such as predator-prey and parasite-host associations.
      c. Competition occurs when food or space becomes limited.
      d. Mutualism occurs when both members of a pair benefit from their interactions.
   7. Larger units or **ecosystems** allow study of the community and the physical environment.
  B. Environment and the Niche
   1. An animal's environment is composed of all conditions that directly affect its chances of survival and reproduction.
   2. Physical, or abiotic, factors include space, energy forms including sunlight, heat, wind and water currents, and the soil, air, water and chemicals (Figure 2.1).
   3. Biotic factors include other organisms as food, or competitors, predators, hosts or parasites.
   4. **Resources** include space or food utilized directly by the animal.
   5. Some resources are expendable; food, once eaten, is no longer available and must be continuously replenished.
   6. Space is not consumed by being used and is therefore nonexpendable.
   7. The **habitat** is the physical space where an animal lives and is defined by the animal's normal activity.
   8. **Niche** (See Page 40)
      a. The life requirements of an organism define its niche.
      b. A niche includes the animal's limits of temperature, moisture, food and other factors.
      c. These limitations for living and reproducing can be graphed.
      d. Addition of important factors such as salinity or pH describes a complex multidimensional niche (Figure 2.2).
   9. Some animals are generalists with wide niches; they can tolerate a wide range of salinity or eat a wide range of foods.
   10. Other animals are specialists and have narrow dietary requirements (Figure 18.16, p.379) or limited tolerance to temperature changes, etc.
   11. The **fundamental niche** describes its potential to live within a wider range of conditions.
   12. The **realized niche** is the narrower subset of suitable environments where it actually occurs (Figure 2.3).

C. Populations

1. Population Factors
   a. A **population** is a potentially reproductively interactive group of animals of the same species.
   b. Local disjunct populations that do actually interbreed are **demes** and they share a gene pool.
   c. A **metapopulation** refers to a population subdivided into multiple genetically interacting demes.
   d. Migration among demes provides some evolutionary cohesion among this species.
   e. **Demography** is the study of the age structure, sex ratio, and growth rate of a population.
   f. Sponges, corals, and bryozoans are **modular**, consisting of colonies of identical organisms, often through **asexual cloning.**

g. It is easier to count and measure individual or unitary animals than colonial organisms.

h. Some **unitary** organisms such as the praying mantis reproduce by **parthenogenesis**.

i. Most metazoans are biparental; reproduction begins a **cohort** of individuals born at the same time.

j. **Survivorship** defines the age pattern of a population from birth to death of the last member (Figure 2.4).
   1) Curve I, where all individuals die at the same time, occurs rarely in nature.
   2) Curve II, where rate of mortality as a proportion of survivors is constant across ages, is characteristic of birds that care for their young; humans fall between a and b.
   3) Curve III represents many species that produce huge numbers of young but experience rapid and sustained mortality; this explains the need for high reproductive output of many animals.
   4) Populations of temperate insects may reproduce once a year, only leaving eggs to over winter.
   5) Populations that reproduce while their parents are still alive and reproducing contain multiple cohorts and have an **age structure** (Figure 2.5).
   6) **Semelpatity** is a condition in which an organism reproduces only once during its life history.
   7) **Iteroparity** denotes the occurrence of more than one reproductive cycle in an organism's life history.

2. **Population Growth and Intrinsic Regulation** (Figure 2.6)
   a. Population growth is the difference between rates of birth and death.
   b. Populations have the ability to grow **exponentially** at the **intrinsic rate of increase**, symbol **(r).**
   c. This forms a steeply rising curve.
   d. Unrestricted growth cannot occur unchecked for either bacteria or field mice.
   e. A growing population eventually exhausts food or space; planktonic blooms and locusts outbreaks both stop when resources are exhausted.
   f. Among many resources, one will be depleted first; this is the **limiting resource**.
   g. The largest population that can be supported by the limited resource is the **carrying capacity (K).**
   h. A population slows its growth rate in response to diminishing resources.
   i. Sigmoid growth occurs when there is negative feedback between growth rate and density.
   j. The Logistic Growth Curve
      1) *N* represents the number of organism, *t* represents time, and *r* is the intrinsic rate of increase, measured as the difference between birth and death rates at any instant.
      2) The letter *d* is used to indicate change, and is read as "delta."
      3) The growth rate of a population is $dN/dt = rN$.
      4) When the population approaches carrying capacity, the growth slows down.
      5) The unutilized freedom for growth enters a new term: $dN/dt = rN([K-N]/K)$.
      6) The addition of "K-N" adds a multiplier that approaches zero and flattens the curve.
      7) Experimental populations of protozoa fit the growth curve closely.
      8) Sheep introduced to Tasmania oscillated slightly around a carrying capacity of 1.7 million (Figure 2.7A).
      9) Ring-necked pheasants on an island had wider oscillations (Figure 2.7B).
   k. Oscillations
      1) As the carrying capacity of an environment changes over time, a population must change its density to track the limiting resource.
      2) Animals experience a lag between the time that a resource becomes limiting and the population responds by reducing its rate of growth.
      3) **Extrinsic** factors may limit a population's growth below carrying capacity.
   l. Carrying Capacity of the Human Species
      1) Humans have the longest record of exponential population growth (Figure 2.7C).
      2) Human population was about 5 million around 8000 BC before the Agricultural Revolution.
      3) Human population rose to 500 million by 1650, 1 billion by 1850, 2 billion by 1927,

4 billion by 1974, 6 billion by October 1999 and will reach 8.9 billion by 2040.
4) Estimates of carrying capacity for humans must consider the quality of life, and whether food production can keep pace with population growth.

    3. Extrinsic Limits to Growth
      a. Density-independent Factors
1) Abiotic factors reduce populations by floods, fires, storms and severe climate fluctuations.
2) These agents kill young or other members of a population regardless of the size of population.
3) They cannot truly regulate population growth because they are unrelated to population size.

      b. Density-dependent Factors
1) These are biotic factors that do respond to the density of the population.
2) Such factors include predators, parasites and diseases.
3) As a population increases and individuals live closer together, the effects of parasites and disease are more severe.
4) Competition between species for a common limiting resource lowers the effective carrying capacity for each species.
5) Populations may be kept below carrying capacity by extrinsic factors and not by resource limitations.

2.3   Community Ecology
   A. Interactions Among Populations in Communities
1. In a **community**, populations of different species interact.
2. The number of species that share a habitat is known as **species diversity**.
3. Species interactions may benefit or harm the species involved.
   a. In a **predator-prey** interaction, the predator is benefited and the prey is harmed.
   b. **Herbivory** benefits the animal and harms the plant.
   c. **Parasitism** benefits the parasite and harms the host.
   d. In **commensalism**, one species is benefited and the other is neither benefited nor harmed (Figure 2.8).
   e. Commensalism may grade into **mutualism** (Figure 2.8) where both species are benefited.
   f. Some mutualistic relationships become obligate; neither can survive without the other (Figure 2.9).
   g. Competition between two species reduces the fitness of both; **asymmetric competition** affects one species less than the other species.

   B. Competition and Resource Partitioning
1. Competition occurs when two or more species share a **limiting resource**.
2. However, if the resource is not in short supply, sharing the resource does not produce competition.
3. **Niche overlap** is the portion of the niche's resources that are shared by two or more species.
4. **Competitive exclusion** is the principle that no two species will occupy the same niche for a long time; eventually one will exclude the other.
5. To coexist, two species can specialize by partitioning a shared resource and using different portions.
6. This specialization involves **resource partitioning**; the morphology or behavior of a species shifts; they do not compete with each other directly (Figure 2.10).
7. Where two species coexisted, competition between them led to evolutionary displacement to diminish the competition; the absence of competition today is "the ghost of competition past."
8. When two or more species reduce niche overlap to share the same general resources, they form a **guild** (Figure 2.11).

   C.   Predators and Parasites
1. Many animals and plants are in co-evolutionary relationships; each is in a race with the other.
2. If a predator relies primarily on a single prey species, the populations cycle with each other.
3. The time lag between cycles is demonstrated by laboratory work with ciliates and the snowshoe hare and lynx (Figure 2.12).
4. The predator-prey relationship has led to development of **mimicry**, where harmless species mimic models that have toxins or stings.

5. Another mimicry complex consists of many different species, all with noxious or toxic factors, that evolve to resemble each other (Figure 2.13).
6. A **keystone species** is so critical to a community that its loss causes drastic changes in the community (Figure 2.14).
7. Keystone species reduce competition and allow more species to coexist on the same resource.
8. Periodic natural disturbances also allow more species to coexist in diverse communities.
9. **Ectoparasites** not only secure nutrition from their host but are also dispersed by the host.
10. **Endoparasites** have lost ability to choose habitats and must have tremendous reproductive output to ensure that some offspring will reach another host.
11. Generally, the parasite and host co-evolve toward a less virulent relationship because the death of the host also ends or shortens a parasite's life; exceptions occur when alternative hosts are available.

2.4 Ecosystems
A. Trophic Levels and Food Webs (Figure 2.15)
1. Energy flows through organisms and is used to construct and maintain organisms at several levels.
2. **Primary producers**, usually green plants, fix and store energy, usually from sunlight.
3. **Herbivores** are the first level of consumers that eat plants.
4. **Carnivores** eat herbivores (forming a second level of consumer) or eat carnivores forming higher trophic levels.
5. The most important consumers are **decomposers,** mainly bacteria and fungi, that break dead organic matter into mineral components, returning it to a soluble form that can be reused by plants to start the cycle over again.
6. Chemical cycle is endless through the system.
7. However, energy is lost as heat and must constantly be replenished; ecosystems are open systems.

B. Energy Flow
1. Every organism has an energy budget and must obtain enough energy to grow, reproduce, etc.
2. How energy is obtained by organisms establishes trophic levels. Trophic levels are then linked to form **food chains** and into larger **food webs**.
3. **Gross productivity** (P_g) is total energy assimilated or taken-in; some is used to maintain metabolism.
4. **Net productivity** (P_n) is energy stored in the animal's tissue as biomass; this energy is available for growth of the animal and for reproduction of other individuals.
5. Energy is limited and can be represented as $P_n = P_g - R$ where R is respiration.
6. The energy budget of every animal is finite; growth and reproduction can only occur after metabolism is accomplished.
7. Much energy is lost when it is transferred between trophic levels in food webs.
8. More than 90% of the energy in an animal's food is lost as heat; less than 10% is stored as biomass.
9. Each succeeding trophic level contains only 10% of the energy of the next lower trophic level.
10. This 90% loss of energy between trophic levels produces **ecological pyramids.**
11. The **Eltonian pyramid**(Figure 2.16A) is based on numbers of individuals at each trophic level; however, many small insects may feed on one large plant.
12. A pyramid of **biomass**(Figure 2.16B) can be built on the mass of organisms at one point in time.
12. Biomass is usually pyramidal and solves the small insect—large plant dilemma.
14. A biomass pyramid may still be inverted due to food stored in a consumer over time as well as failure to measure the rapid productivity of some producers.
15. Energy pyramids encompassing the lifespan of all organisms involved show a pyramid relationship (Figure 2.16C).

C. Life without the Sun (BOX: DeepSea Vent Ecosystem)
1. From 1977 to 1979, dense communities were first discovered on sea floor thermal vents.
2. The producers in these vent communities are chemoautotrophic bacteria that oxidize hydrogen sulfide.
3. The tubeworms and bivalve molluscs form trophic communities that rely on this non-photosynthetic source of nutrients

D. Nutrient Cycles
1. Decomposers feed on the remains of animals and plants and return substances to the ecosystem.
2. **Biogeochemical cycles** involve exchanges between living organisms, rocks, air and water.
3. The continuous input of energy from the sun keeps nutrients flowing and the ecosystem functioning (Figure 2.17).
4. Water, carbon, phosphorus, and nitrogen are important biochemical cycles.
5. Synthetic compounds such as pesticides are not degraded by decomposers.
6. Pesticides accumulate in top carnivores, kill nontarget species, and persist in the environment.

E. Biodiversity and Extinction
1. The number of species that thrive on earth is biodiversity; this number could be as high as 10 million.
2. Approximately 99% of all species that have lived are extinct. Extinction events have occurred at varying rates throughout earth's evolutionary history.
3. At rates unprecedented in human history, we are losing biodiversity, genetic diversity, and habitat diversity.
4. Habitat fragmentation and invasive species introductions are leading causes of decreased biodiversity.

Lecture Enrichment

1. The mathematics of population growth is a traditional area of difficulty for biology students more accustomed to hands-on organisms than abstract mathematics. Mathematics is also not a regular part of everyday biology lectures and requires a systematic presentation with close association with real examples. Growth curves are a form of "story problem" in math that some students dread; use of concrete examples will defuse some of this anxiety.
2. In enzootic diseases such as bubonic plague, the wild rodents of southeast Asia are more immune to the disease than are rodents in India, and rodents in Europe and the Americas are most susceptible. This provides a way to reconstruct the evolutionary history because the longer the parasitic relationship remains stable, the more benign the effect because the more resistant hosts have greater survivorship.
3. It is important not to extend food chain economy to political conclusions not justified by real conditions. The example of eating beef versus eating the grain that could be fed to beef to produce the biomass of meat is a useful teaching example. However, it is not possible to feed pure grain alone to a cow (it would kill it) nor are most cattle fed primarily on grain. Indeed, much beef is produced on grasslands that cannot be plowed for grain production. Indeed, the meat produced in China is virtually all produced on marginal resources and ending meat consumption there would result in no grain savings and would drop national nutrition levels dramatically.
4. The annual sunlight that strikes the earth and the proportion that enters the food chain via photosynthesis limit the energy budget for the earth. Therefore, it is possible to calculate the theoretical maximum of plant tissue, and therefore animal tissue, that the earth can support. As the human population grows, we must "re-budget" this energy consumption from wildlife to us and, contrary to non-science business pronouncements, there is an absolute limit to the amount of life that can be supported on earth.

Commentary

Background: Many ecological terms have definitions distinct from everyday usage; "population" is fairly close to our common usage, but "community" and "competition" and other terms have distinct and often mathematically defined meanings. Rural students may recognize putting up hay as harvesting biomass; any student who has mowed a lawn has likewise harvested biomass although both cases fail to account for the substantial belowground root biomass. Concepts of energy and mass may be very limited by the limited amount of physics in the U.S. curriculum and some time may have to be spent reviewing basic physics concepts about energy and the laws of thermodynamics, remembering that these were briefly explained early in this text.

Misconceptions: Students may have difficulty imaging the energy in sunlight as the related to the energy in chemical bonds in plant and animal tissue; the explanation of the measurement of a calorie in a calorimeter may help students see that this is one continuous phenomenon. The inverted pyramid found in intertidal areas often appears as a contradiction of the loss of energy as we move up the food chain; it is important to work through the values *over time* to show that they do indeed conform to the laws of physics.

Schedule: More time will be needed if illustrations are given of nutrient cycles or time is used to develop the mathematics of the logistic growth curve or energy flow through food webs.

ADVANCED CLASS QUESTIONS:
1. Why is a "perfect predator," that can efficiently hunt and kill any prey it seeks, not found?
2. Why would predators not all move toward specializing on one species of prey; what are the benefits of retaining some level of generalist feeding? Then why aren't all predators generalists, able to take any animal smaller animal as prey; what are the benefits of specialization?
3. Why would a mimicry complex where a harmless species evolves to resemble a noxious species have limitations on the size of the mimic population? In a mimicry complex where both species are noxious, would there be a limitation on the size of the mimic population?
4. In a small district in Africa, we might find that the biomass of elephants exceeded the biomass of the plants they ate over a short period of time, forming an "inverted pyramid." Explain why this is not a contradiction of the second law of thermodynamics.