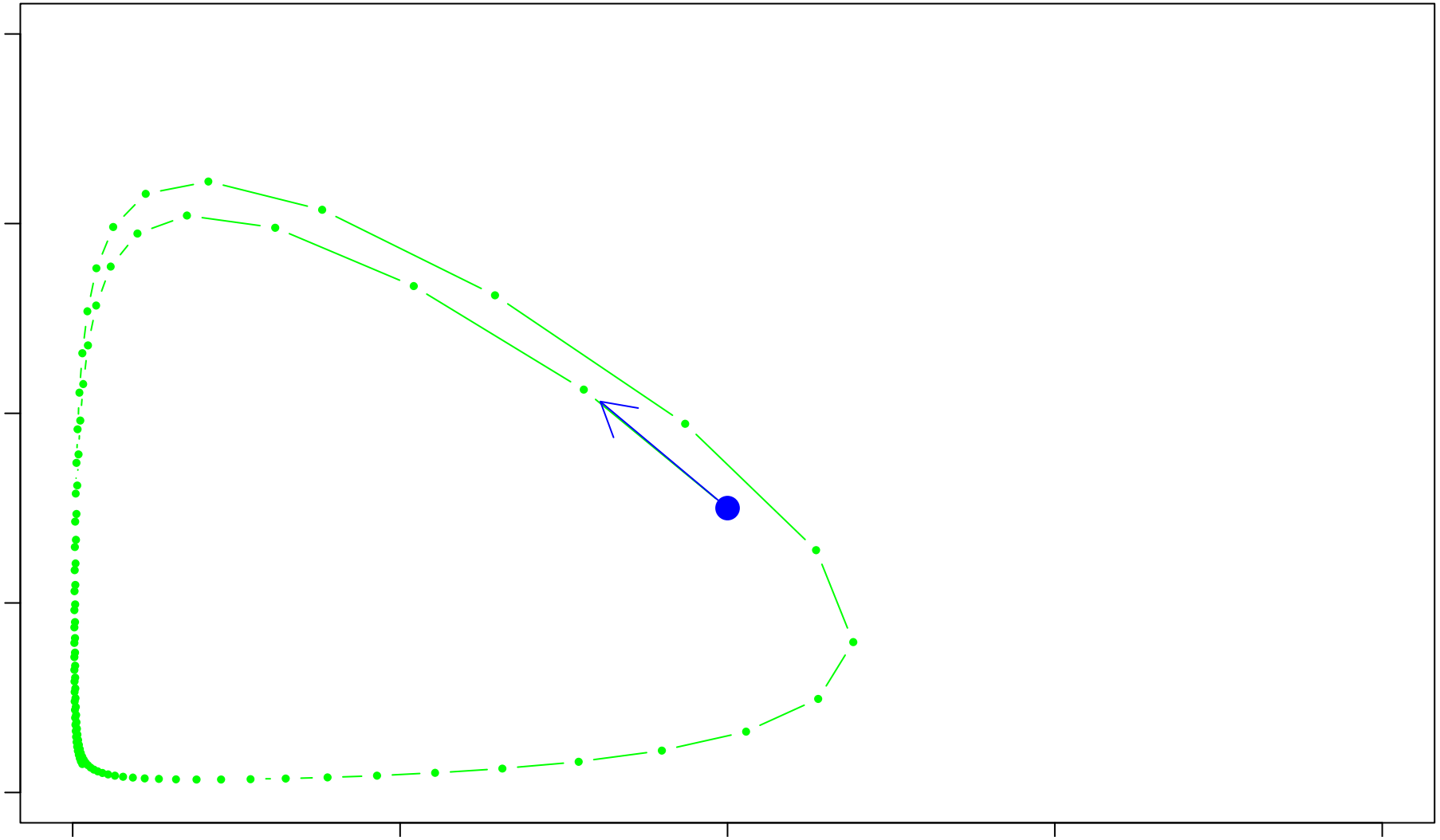
Predation and Herbivory



The ten principles of ecology

1. Evolution organizes ecological systems into hierarchies.
2. The sun is the ultimate source of energy for most ecosystems.
3. Organisms are chemical machines that run on energy.
4. Chemical nutrients cycle repeatedly while energy flows through an ecosystem.
5. dN/dt = B-X+I
6. dS/dt = D-X+I
7. Organisms interact – do things to each other - in ways that influence their abundance.
8. Ecosystems are organized into webs of interactions.
9. Human populations have an outsized role in competing with, preying upon, and helping other organisms.
10. Ecosystems provide essential services to human populations.

Topics for today

- Predation
  - Characteristics of predators in comparison to other natural enemies
  - Predation and population growth
  - Application in Lotka-Volterra models
  - Predator and Prey (antipredator) adaptations
- Herbivory
  - Plant defense strategies
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Interspecific interactions: Predation





Predation (+/–) occurs between species in which one species, the predator, kills and eats the other, the prey

Characteristics of predation

Table 1. Variations in life history traits along a parasite-predator continuum reflecting an increase in body-size, population growth rate, and host-fatality from microparasite through predator.

Trait	Microparasite	Macroparasite	Parasitoid	Predator
Body Size	Microscopic	Smaller than host	Similar in size (e.g. wasp and moth)	Often larger than prey unless social hunter
Intrinsic rate of population growth	Rapid	Faster than hosts	Comparable to host	Comparable to but often slightly slower than that of prey
Number per host	One host usually supports populations of several different species	One host supports a few to many individuals of different species	One host usually supports one, but can support many, individuals	Each predator eats many prey individuals
Fatality to host	Mild to severe	Usually mild	Eventually fatal	Immediately fatal
Stability of the interaction with the host	Intermediate	High	Intermediate	Usually low
Ability to regulate host population	Moderate to high	Low	Moderate to high	High

How does predation affect population growth?

Predation has a high potential to regulate prey populations

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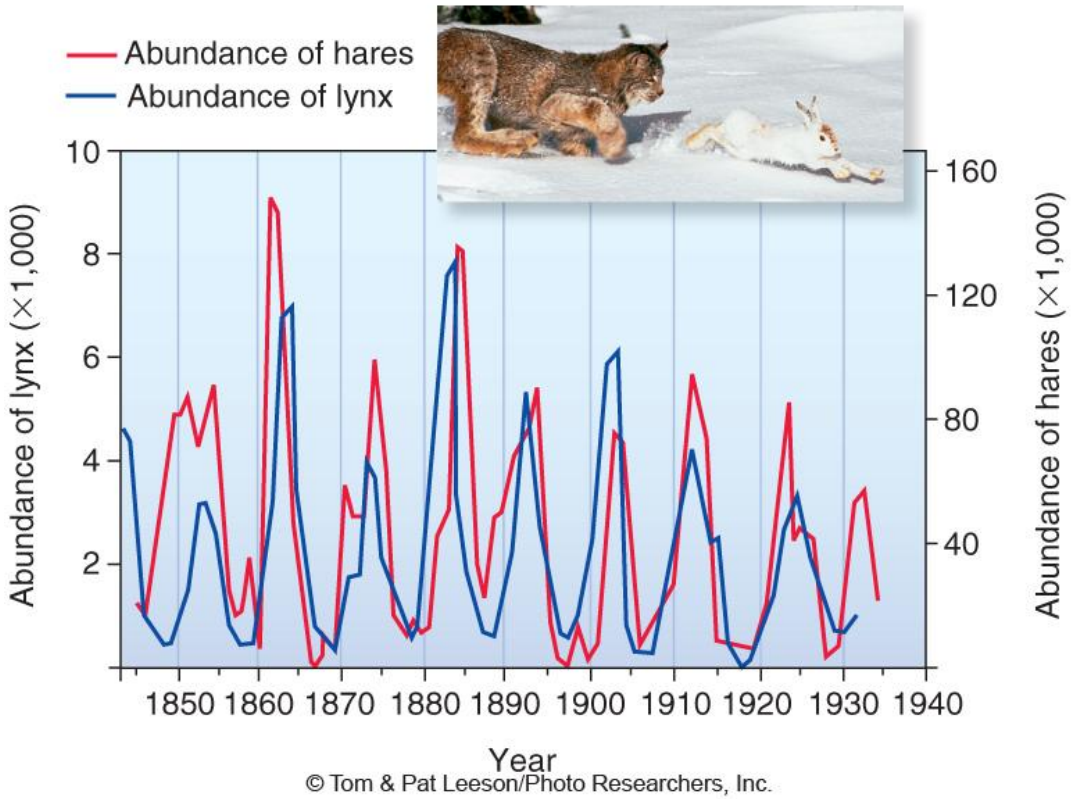
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How does predation affect population growth?

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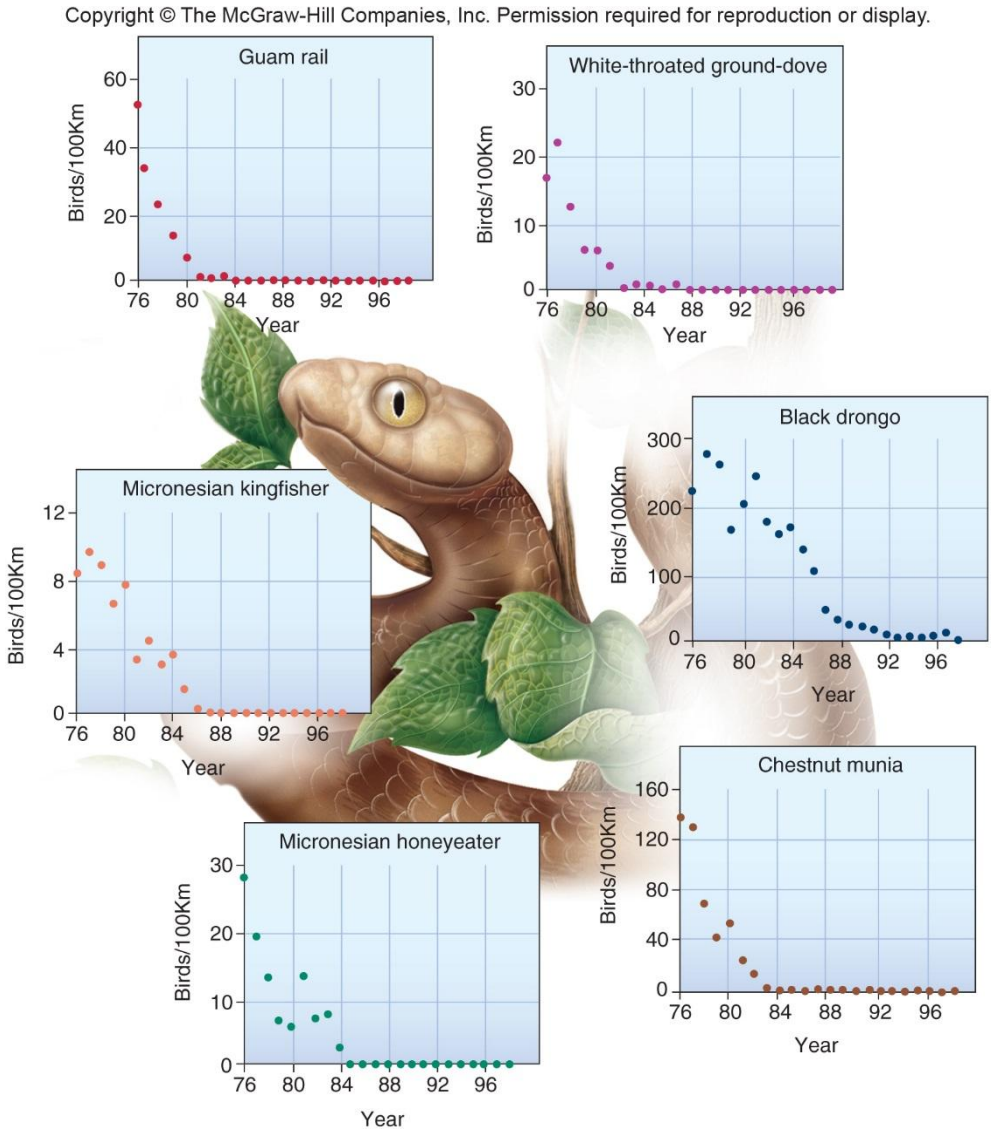
Figure 13.8 Coupled predator-prey oscillations.

The 9- to 11-year coupled oscillations of the abundance of the snowshoe hare, *Lepus americanus*, and the Canada lynx, *Lynx canadensis*, were revealed from pelt trading records of the Hudson's Bay Company.

We often observe a lag in the growth of the predator population compared to their prey (the predator population can't begin to increase until its food source begins to increase).

Introduction of non-native predators can cause extinction (prey not adapted to predator)

Brown tree snake (*Boiga irregularis)* introduced to the island of Guam



Text, Fig. 13.10, p. 273

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Predator-Prey Interactions

We begin with geometric increase of prey population:

$$N_{t+1} = R_0 N_t$$

Predator-Prey Interactions

We then add on the effects of predation

- We need to know the **searching efficiency**, or attack rates, of the predators, called ***s***.
- The actual number of prey attacked will also depend on the number of prey present (*N*) and the numbers of predators present (*P*).
- The consumption of prey is thus equivalent to the combination of these three features, sPN.

If *s* is very high (like an introduced predator), then extinction of prey could occur

$$N_{t+1} = R_0 N_t - sP_t N_t$$

Prey removal by predators.

Note that the term for number of prey (N) is on both the positive and negative portion of the equation

Predator-Prey Interactions

How does the predator population grow?

- Predator birth-rate depends on the value *sPN* and on how efficient predators are at turning food into new predators, a value we can term *e.*

$$P_{t+1} = esP_tN_t$$

Predator-Prey Interactions

We know there is predator mortality, too.

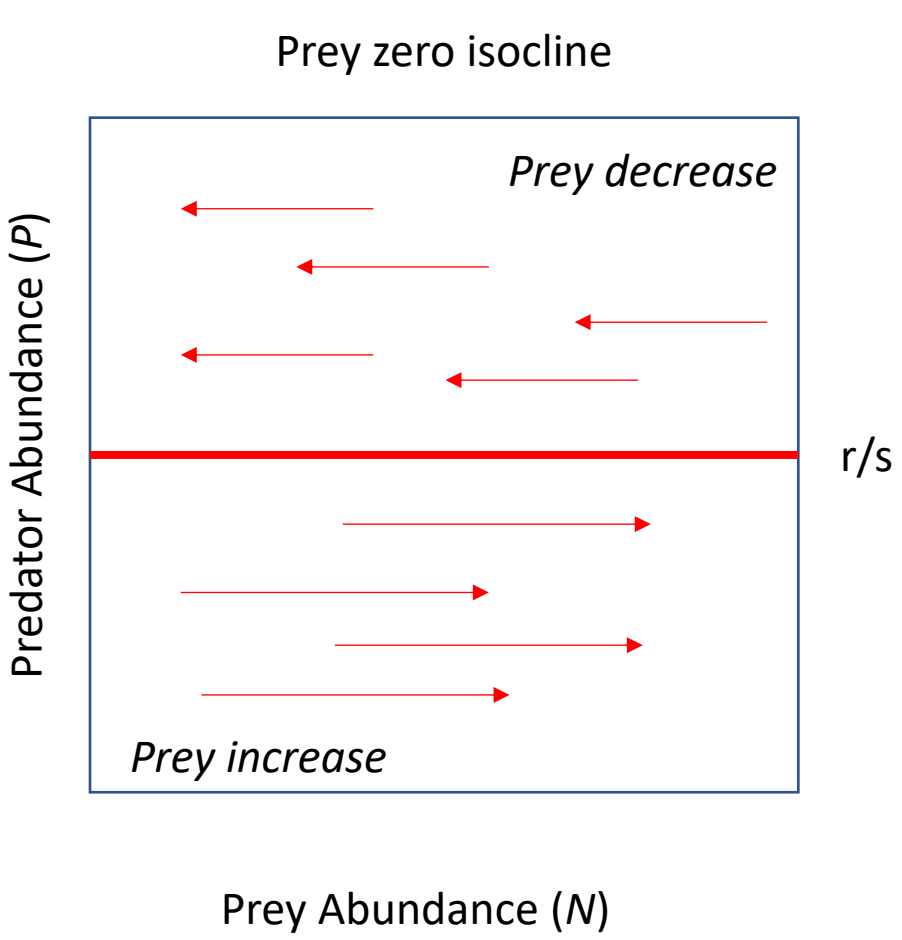
- Not withstanding the effects of prey, the predator death rate is dependent upon a mortality rate, *m* and the number of predators, *P*

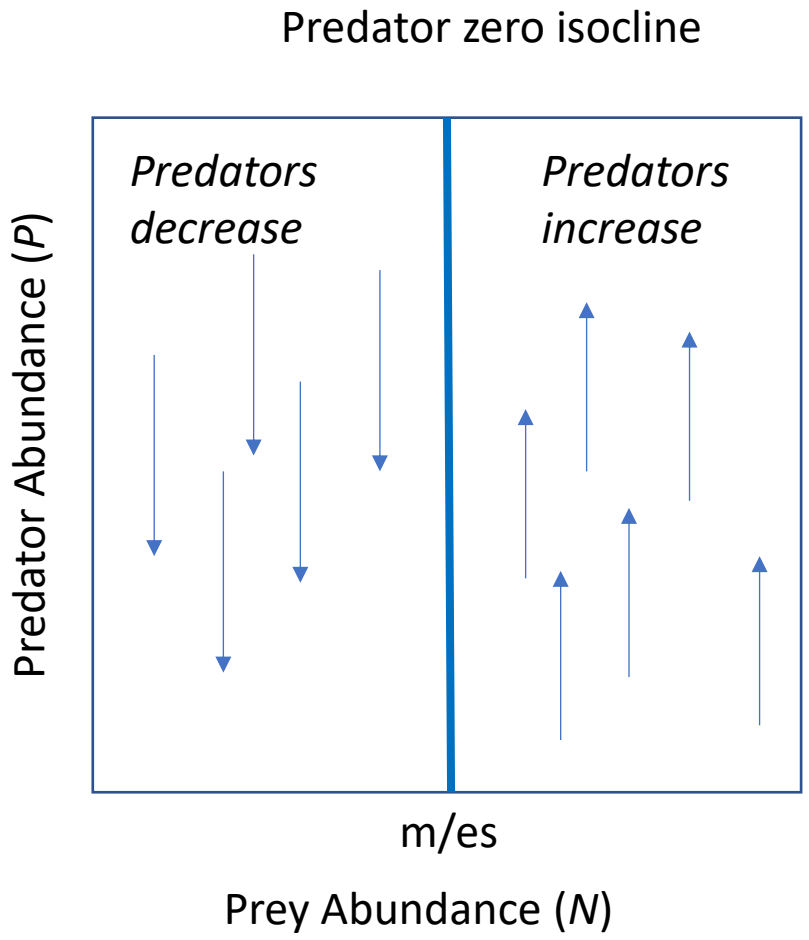
$$P_{t+1} = esP_tN_t - mP_t$$

Predator death.

Predator growth rate.

Predator-Prey Interactions





Predator-Prey Interactions

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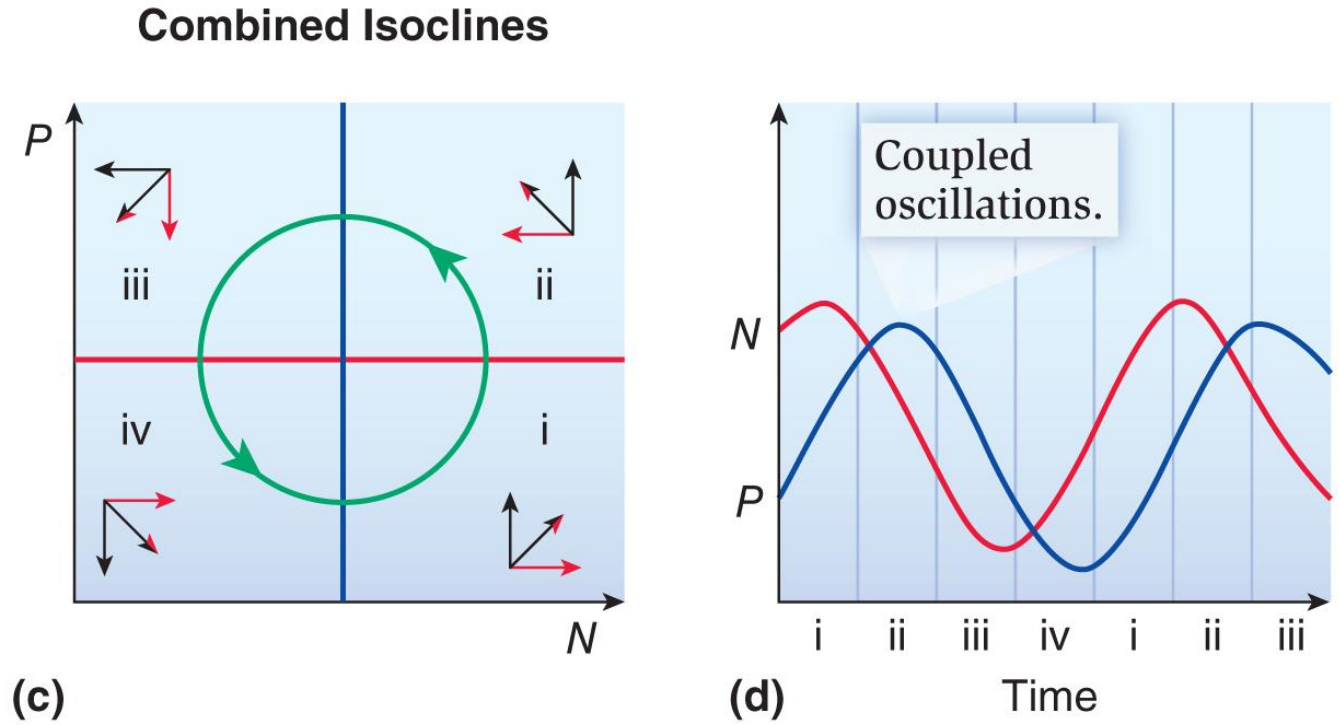


Figure 13.6 The basic Lotka-Volterra predator-prey model.

(c) When prey and predator isoclines are combined, coupled oscillations result, which are expressed in **(d)** as numbers of prey and predators through time. (Modified from Begon, et al. 1986)

Lotka-Volterra can also be used for parasitoid – host or herbivore – plant if attack increases death

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Red queen hypothesis

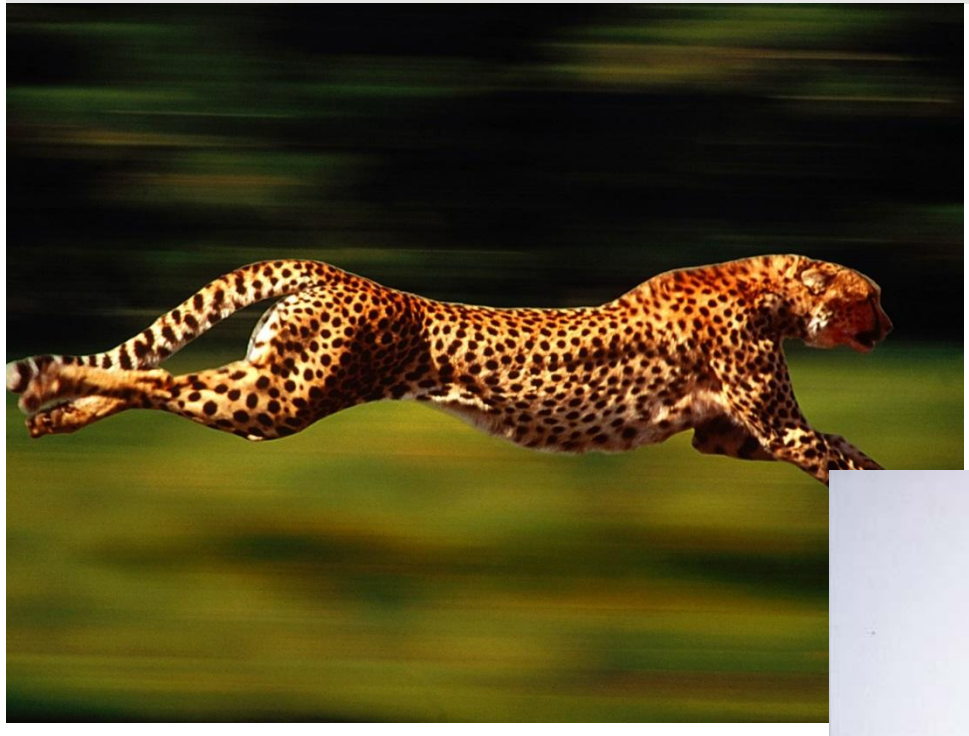


Now, *here*, you see, it takes all the running you can do, to keep in the same place.

“Through the Looking-Glass”



Cheetah / gazelle are classic example of support for red queen hypothesis



They both became faster and faster, but any gains in the speed of one was generally matched by gains in the speed of the other species



Adaptations of predators

-Coloration as an adaptation









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Antipredator Adaptations

Adaptation	Description
Cryptic colorations	• An aspect of camouflage, the blending of an organism with the background of its habitat. • Cryptic coloration is a common method of avoiding detection by predators • Cryptic coloration is prevalent in the vertebrate world.
Mimicry	• The resemblance of a species (the mimic) to another species (the model) also secures protection from predators. There are two major types of mimicry.
Batesian mimicry	• Named after English naturalist Henry Bates. • The mimicry of an unpalatable species (the model) by a palatable one the (mimic).
Müllerian mimicry	• Named after the German biologist Fritz Müller. • Many noxious species converge to look the same, thus reinforcing the basic distasteful design.
Physical defenses	• Armor, claws, stingers, horns.
Predation satiation	• The synchronous production of many progeny by all individuals in a population to satiate predators and thereby allow some progeny to survive.

Antipredator Adaptations

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Figure 13.2 Cryptic coloration and camouflage.

(a,b) This Indian leaf butterfly*, Kallima paralekta*, mimics the leaves on which it rests. **(c)** This Pygmy seahorse, *Hippocampus bargibanti*, from Bali, blends in with its background.

Antipredator Adaptations

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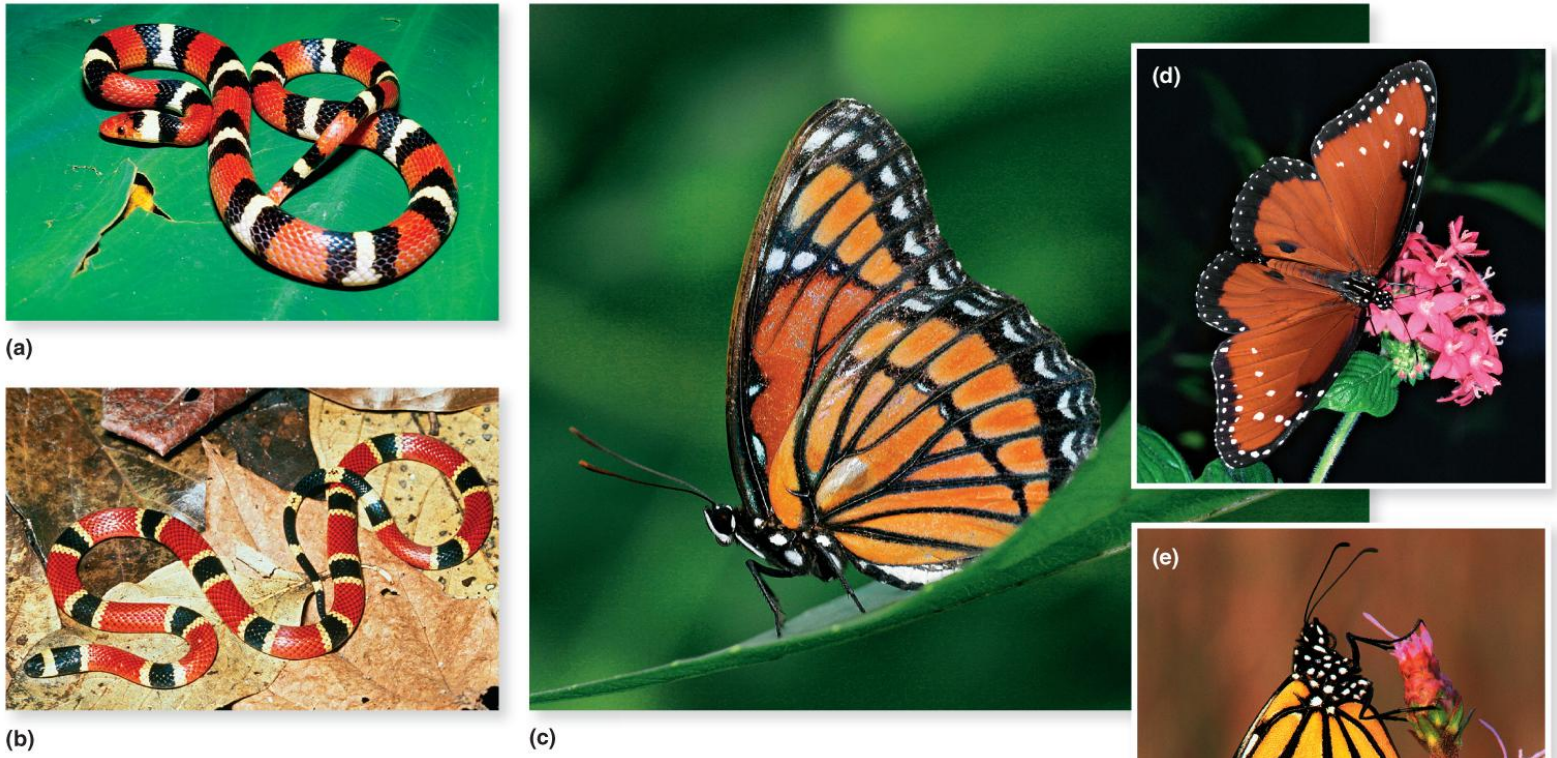


Figure 13.3 Mimicry

(a) Batesian mimicry: An innocuous scarlet king snake, *Lampropeltis triangulum* **(a),** mimics the poisonous coral snake, *Micrurus nigrocinctus* **(b)**. **Mullerian mimicry**: These viceroy **(c)**, queen **(d)** and monarch **(e)** butterflies have the same basic warning coloration and all three are toxic to birds.

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Antipredator Adaptations

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(a) (b)

a. © Design Pics Inc./agefotostock RF; b. © Digital Vision/Getty Images RF

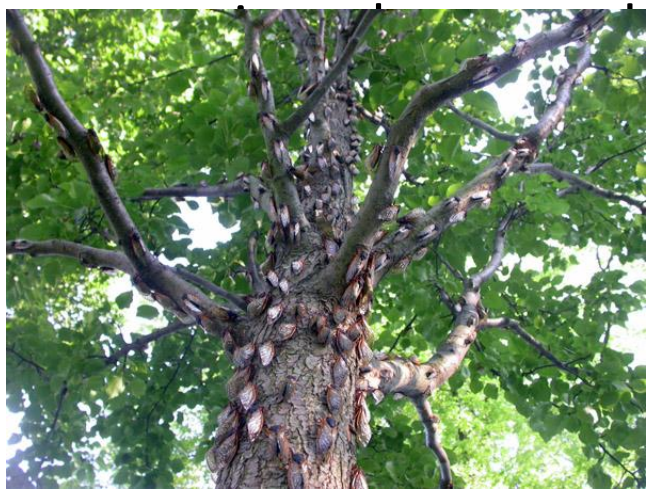
Figure 13.4 Intimidation and armor.

(a) This juvenile ornate box turtle, *Terrapene ornata*, has a strong shell that can deter predators much larger than itself. **(b)** In a display of intimidation, this porcupine fish, *Diodon holocanthus*, puffs itself up to look threatening to its predators.

Antipredator Adaptations

Predator satiation is the synchronous production of many progeny by all individuals in a population to satiate predators and thereby allow some individuals to survive.

- Example: 13- and 17-year periodical cicadas, *Magicicada* spp.
- Predators can't increase their population size quickly enough to eat a large percentage of cicadas before cicadas finish their life cycle and the "grubs" burrow back





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Herbivory

- Predation of plants or algae
  - Herbivores: includes organisms that feed on flowers, seeds, leaves, nectar, roots, wood, bark, and sap (Fig. 14.1, p. 286)



Goldenrod Gall Fly



Cow pea beetle





Leaf chewers like grasshoppers

Termites consume wood



Galago, eats sap



Plant defense strategies

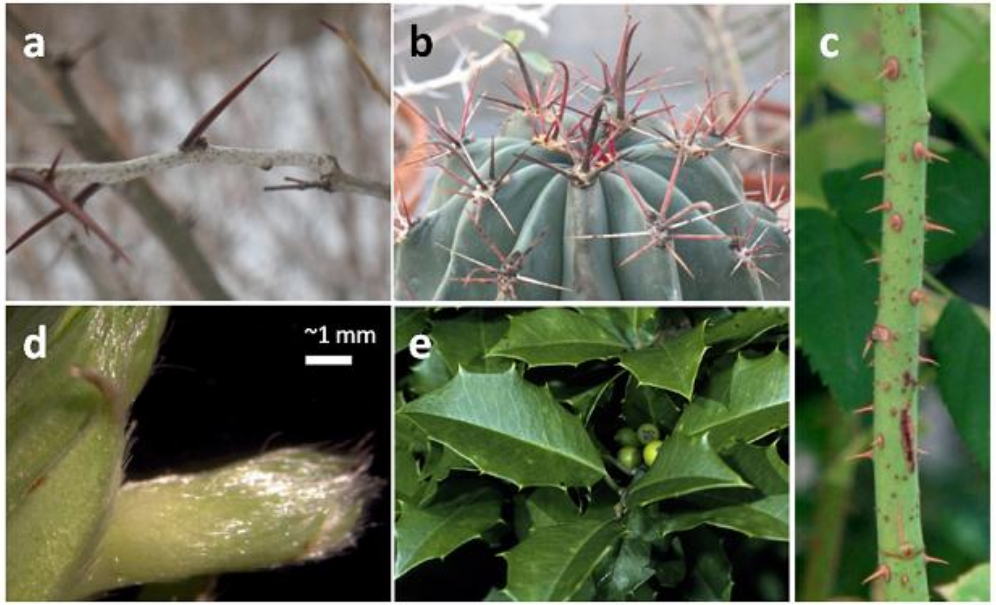
- Observation: we live in a “green” world; why is more plant material not eaten?
  - One art of the hypothesized answer is plant defenses
  - Defenses may be mechanical, chemical, mutualisms, associational resistance, mimicry



Plant defense strategies

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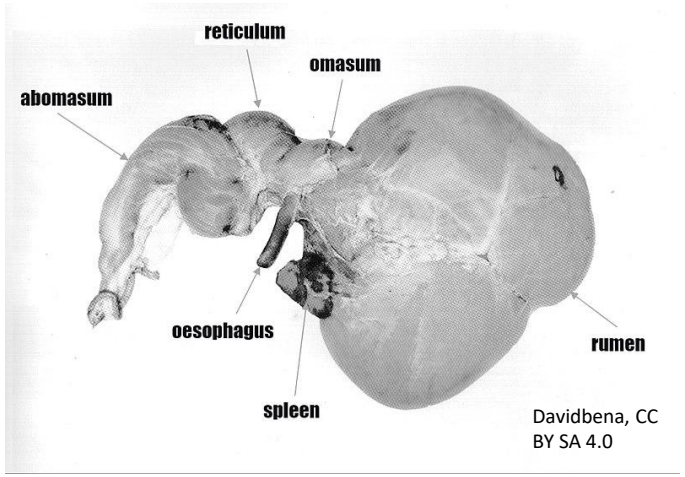




Plant defense strategies

- Much like the Red-queen hypothesis, plants and herbivores are often in an evolutionary arms race
  - Herbivores adapt via mechanical, behavioral, digestive, or symbiotic means, or host manipulation


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Shetlar and Andon

Herbivore adaptations such as flattened teeth, gut microorganisms, and gall formation