SANGKALAN

Beberapa bagian dari salindia perkuliahan ini merupakan materi yang dilindungi oleh HAK CIPTA, dan penggunaannya dalam perkuliahan ini berdasarkan prinsip penggunaan wajar (*FAIR USE*) untuk keperluan edukasi.

Oleh karena itu, mohon untuk membatasi penyebarluasan materi ini secara daring; materi ini hanya untuk penggunaan pribadi mahasiswa peserta mata kuliah ini.

EKOLOGI KOMUNITAS

COMPETITION

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01

DEFINITION AND BASIC CONCEPT

Competition

- Competition is use of a resource by one organism that reduces the availability of that resource to other organisms.
  - Is ubiquitous in nature as agent of natural selection and a factor structuring communities.
- For competition to occur:
  - Both organisms must rely on a common resource.
  - That resource must be finite.

Resource

- Any substance or factor in the environment that determines growth, survivorship, or reproduction of individuals in the population.

- Depletion of this resource decreases growth, survivorship, or reproduction.

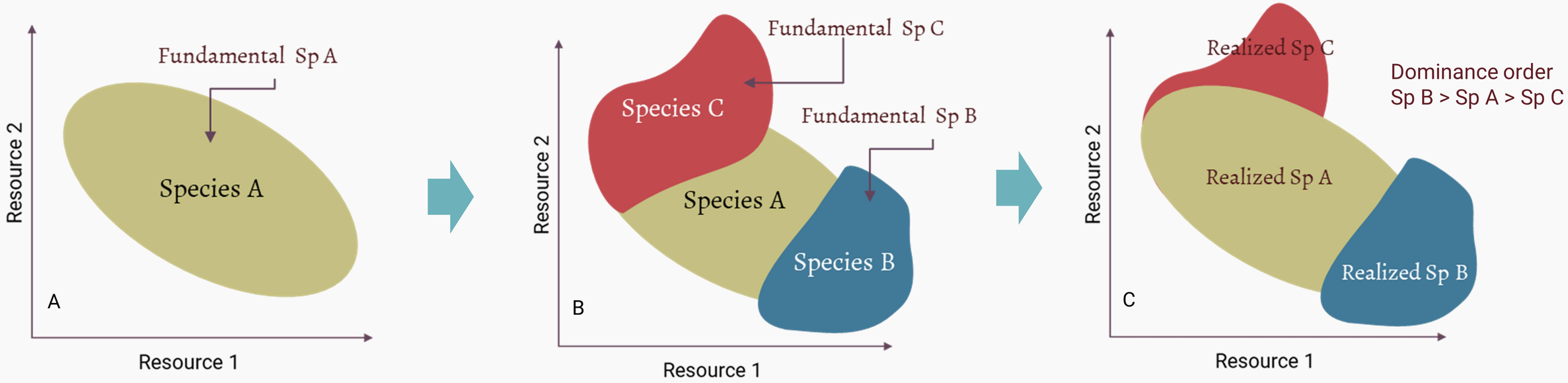
Limiting resources

- For plants:
  - Light, water, nutrients, pollinators.
- For animals:
  - Prey, nesting sites, territories, water, host, mates.
- Space can also be a limiting resource.
- Not a limiting resource, examples:
  - Oxygen in terrestrial environments.
  - Water in an aquatic environment.

Habitat vs niche

- **Habitat**: the location that a species is found in an ecosystem (“address”).
- **Niche**: the ecological role of a species in an ecosystem (“occupation”).
- Three components of a niche:
  - Environmental conditions;
  - Resources for survival;
  - Interactions with other niches.

Fundamental & realized niches



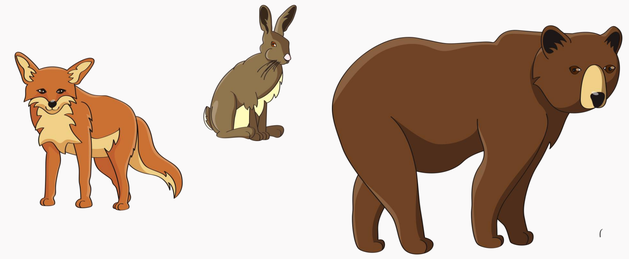
Fundamental niche

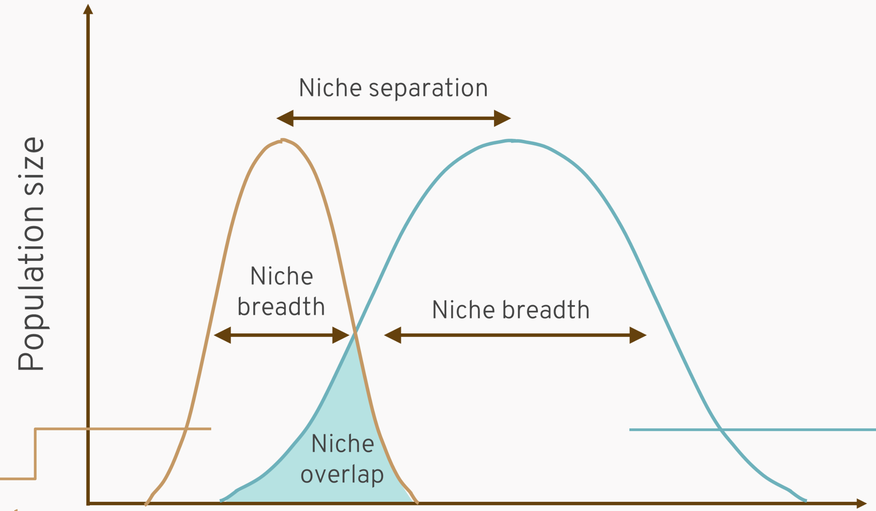
Theoretical niche: set of resources a species can utilize in the absence of competition and other biotic interactions.

Realized niche

Niche a species actually occupies; observed resource use of a species in the presence of competition.

Niche breadth





SPECIALIST
SPECIES

Narrow niche

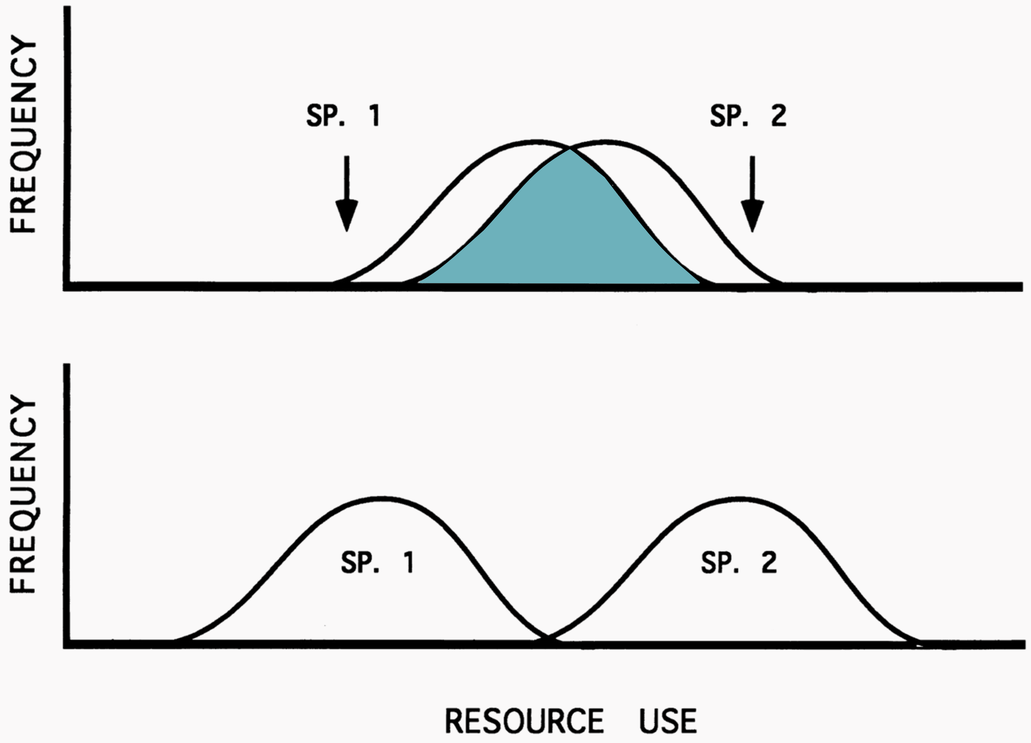
Broad niche

GENERALIST
SPECIES

- Smaller range of tolerant
- Less adaptable to new conditions
- More prone to extinction
- Specific food requirements

- Larger range of tolerant
- Highly adaptable to new conditions
- More likely to be invasive
- Broad food requirements

Reducing competition in an overlapping niche



- Two sympatric species with broadly overlapping distributions of resource use.
- Natural selection favor individuals with traits that allow each of them to use the resource not used by the other species (arrows).
- Result: the species diverge in trait value and resource use, minimizing competition for resources.

Losos JB. 2000. PNAS 97(11): 5693-5695. https://doi.org/10.1073/pnas.97.11.5693. Used under a Fair Use rationale.

Types of competition in a community

Intraspecific competition

- Individuals of the **same** species interfere with each other either directly or through preemptive use of resources.
- Population level.
- Helps nature keep the population under control

Interspecific competition

- Individuals of **different** species interfere with each other either directly or through preemptive use of resources.
- Community level.
- Usually less critical than intraspecific competition.

Effect of a competition

- The ultimate effect: a decrease in fitness.
  - Decrease in reproduction and survival.
- Reciprocally negative interaction.
  - All individuals may lose energy and/or time that they could have invested in their own growth, survivorship or reproduction.
- Competition for one resource affects competition for other resources.
  - Plants competing for light end up competing for nutrients as well.
- Which competitor wins is not predictable
  - Depends on initial conditions (e.g. starting densities).

Consequences of a competition

If two or more species with similar characteristics compete…

Hypothetical situation; no evolution

↓

Extinction or extirpation

↓

COMPETITIVE EXCLUSION

Real life

↓

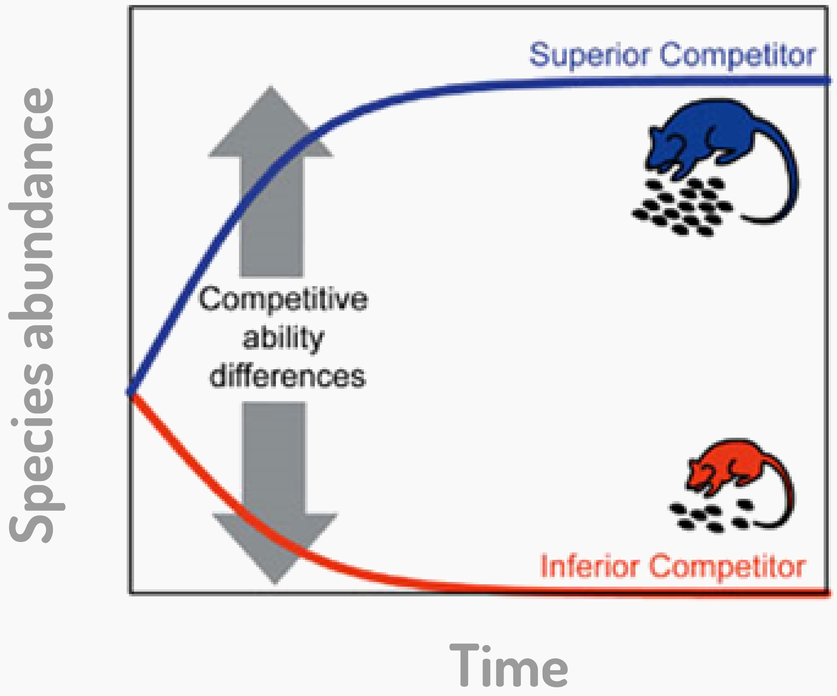
Character displacement or niche differentiation.

↓

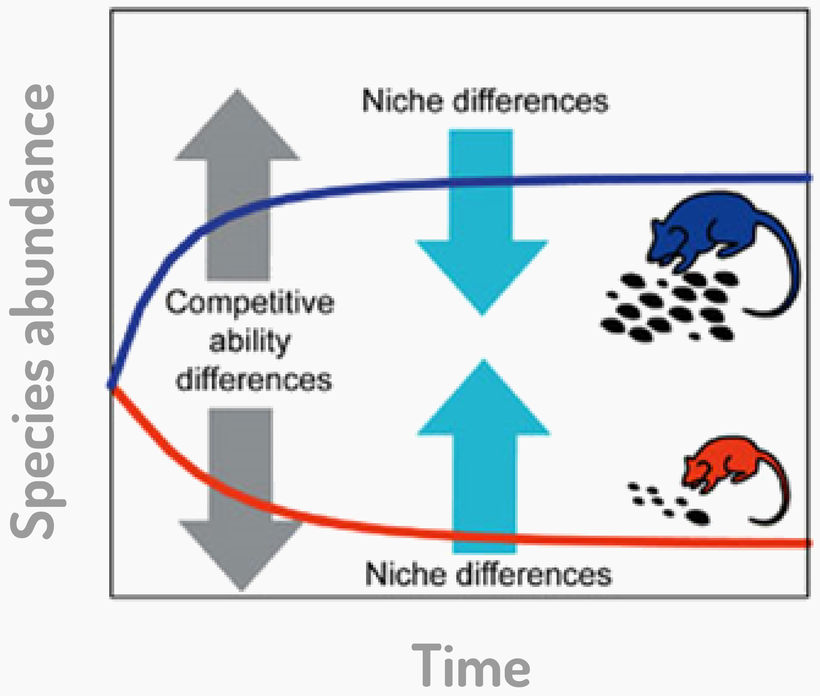
COEXISTENCE

Consequences of a competition

EXCLUSION



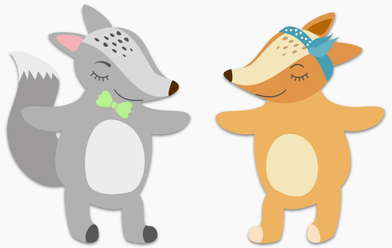
COEXISTENCE



Levine JM & HilleRisLambers J. 2010. Nature Education Knowledge 3(10):59. Used under a Fair Use rationale.

Two species that compete for the exact same resources cannot coexist indefinitely.

—GAUSE'S PRINCIPLE OF COMPETITIVE EXCLUSION

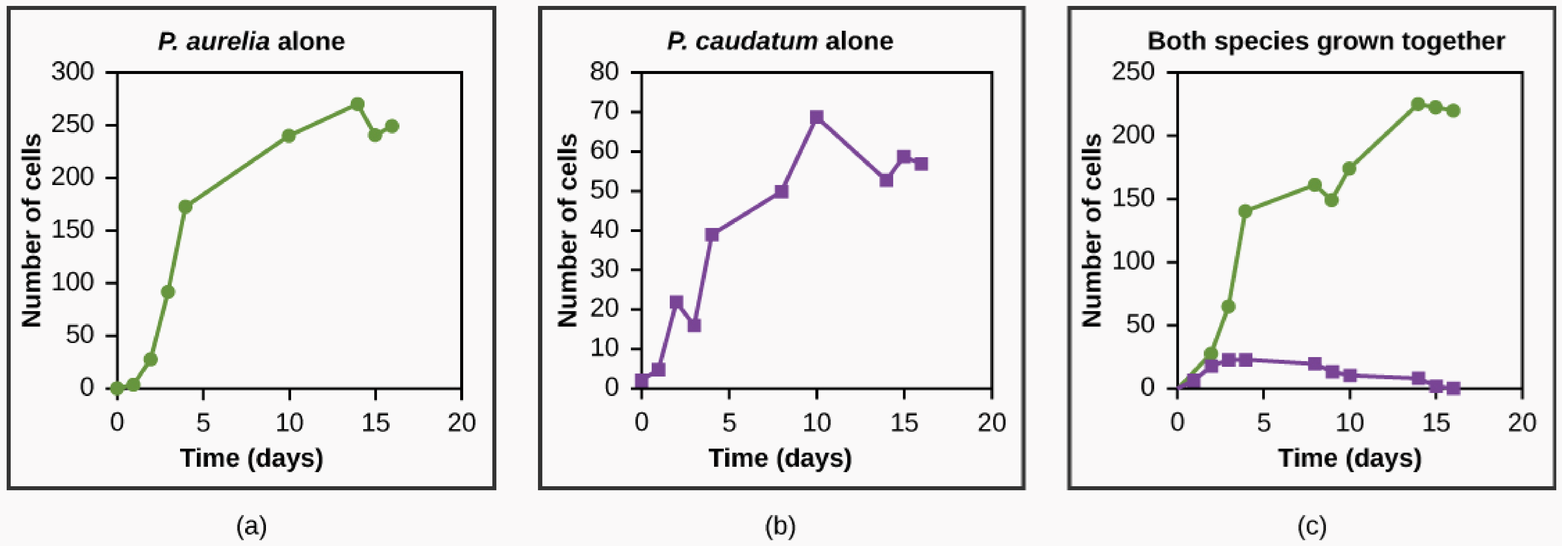


Competitive exclusion

- Complete competitors cannot coexist.
  - One species must be displaced or go to extinction.
- Does **not** occur when:
  - Environment is unstable.
  - No competition for resources.
  - Environment fluctuates or reverses direction before extinction is possible.
  - Species coexist.

Examples of competitive exclusion

- Fire ants (*Solenopsis invictus*) have replaced most species of native ants in Southeastern United States.
- *Paramaecium aurelia* vs *P. caudatum* experiment.
- Grey squirrel vs red squirrel in UK.

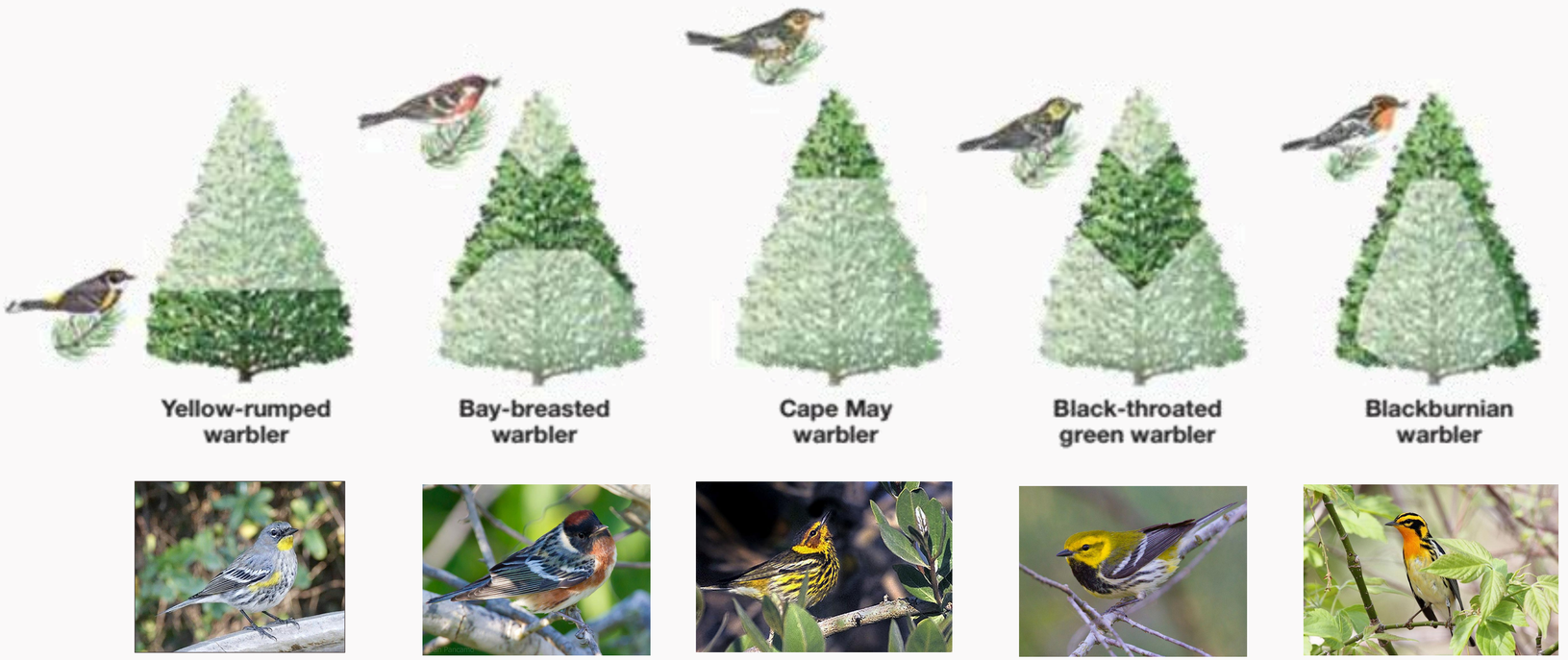


[Fig 19.19. *Paramaecium* competition], Fowler et al., https://openstax.org/books/concepts-biology/pages/19-4-community-ecology, CC BY 4.0.

Classical coexistence theories

- Each species inhabits a particular niche, where it outcompetes the rest of the species in the local pool.
  - Grinnell's niche, Gause's niche.
- Niche overlap causes exclusion of weakest competitors from a community.
- Species coexist by being **functionally different** and by exploiting **different niches**.

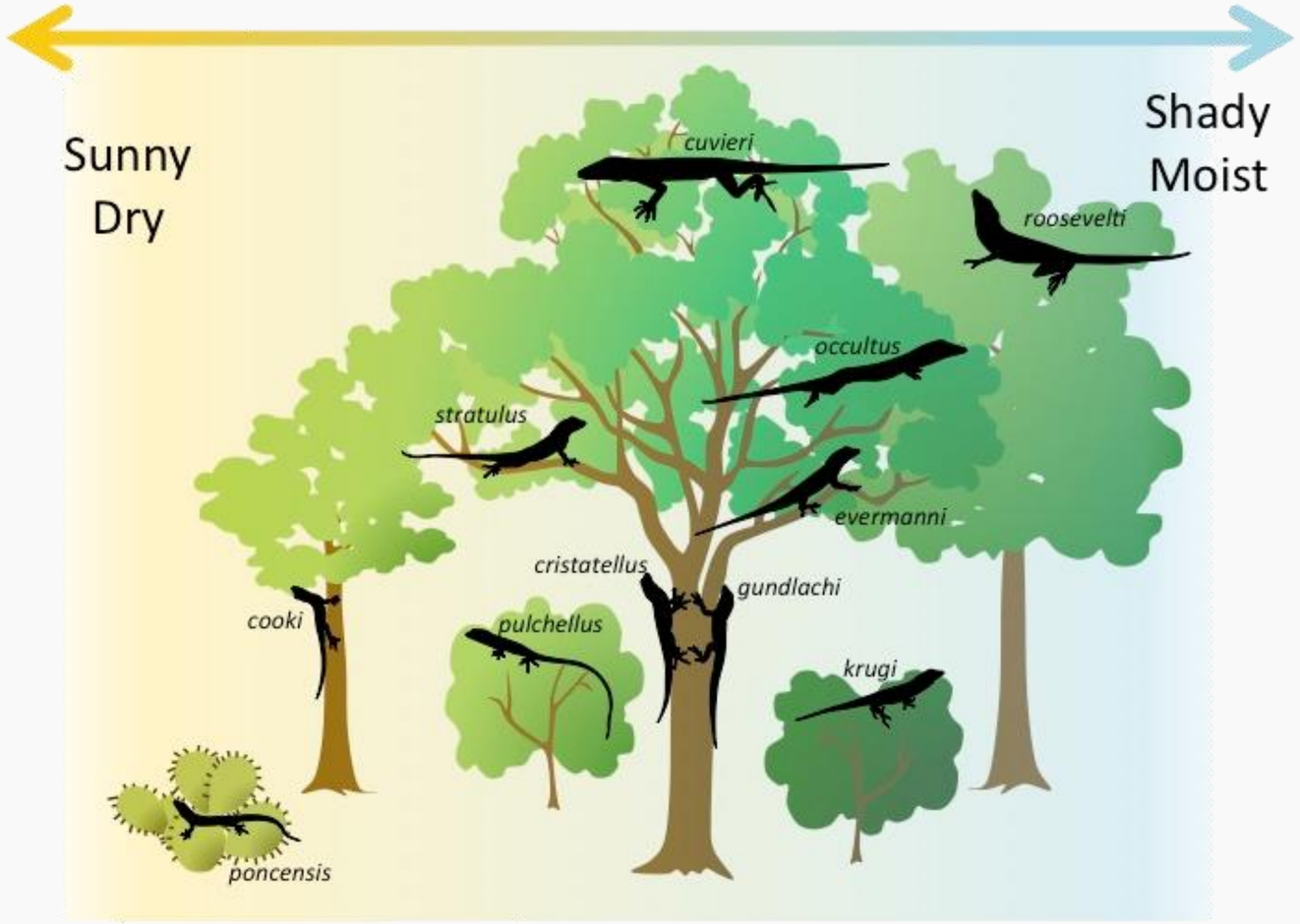
Coexistence of North American warblers



[Figure 28.2. Resource partitioning], Audesirk et al. 2017. Biology: Life on earth with physiology. 11th edition. Used under a Fair Use rationale.

- Five North American warblers all nest and hunt for insects in spruce trees.
- The warblers have evolved behaviors that reduce the overlap of their niches, thereby reducing interspecific competition, "**resource partitioning**".

Coexistence of anoles in Puerto Rico



Modified by Eva Horne, http://cnx.org/contents/db89c8f8-a27c-4685-ad2a-19d11a2a7e2e@24.18, CC BY 4.0.

- Each species occupies a different type or elevation of vegetation.
- The habitat is further partitioned by the amount of sunlight and moisture available.

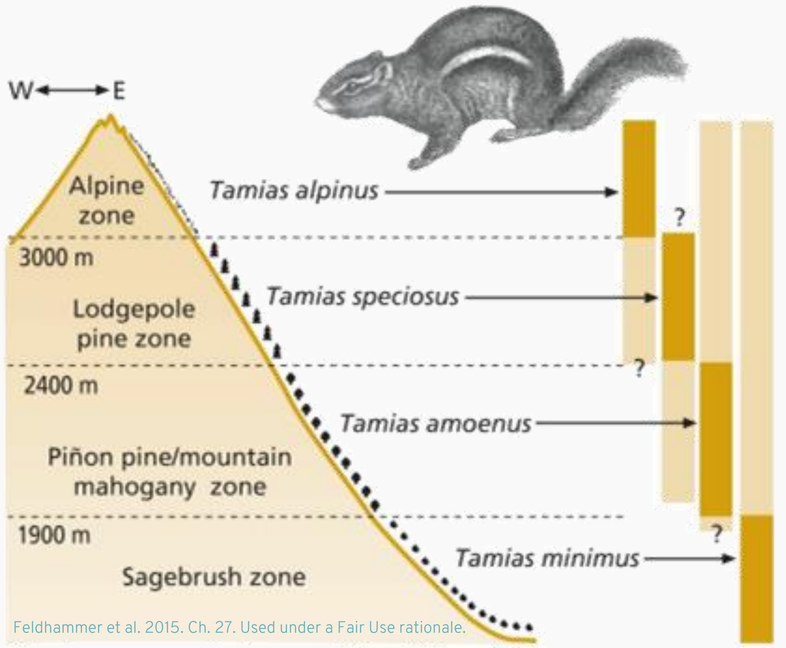
Mechanisms of coexistence

- Competing species can coexist, even if they utilize the same resources.
- Specialization: species evolve different adaptations.
- This can be through:
  1. Niche differentiation/segregation (resource partitioning, predator partitioning, conditional differentiation).
  2. Character displacement.

1. Niche differentiation

- Interspecific competition increases niche separation (reduce overlap.
  - Niche compression.

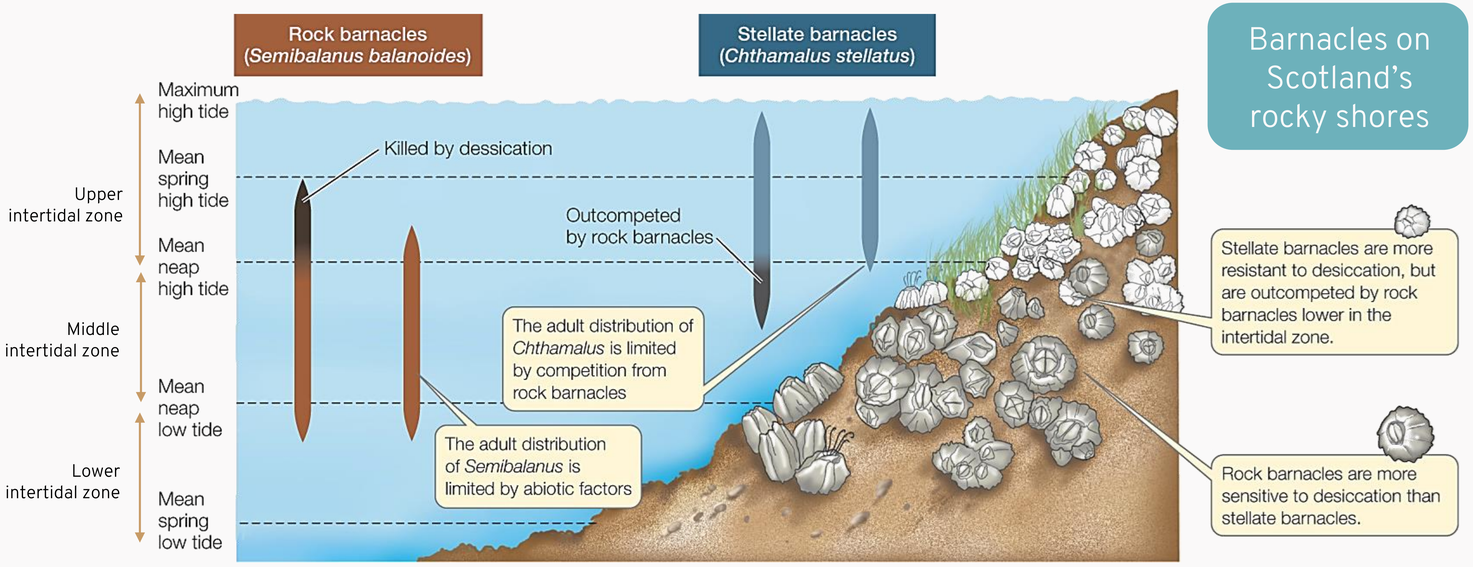
Chipmunks in Sierra Nevada



Feldhammer et al. 2015. Ch. 27. Used under a Fair Use rationale.

Figure 27.6 Distribution of four species of chipmunk on the eastern slope of the Sierra Nevada, California. Dark portions of bars denote realized niches; entire bars show fundamental niches. *Data from M. A. Chappell (1978).*

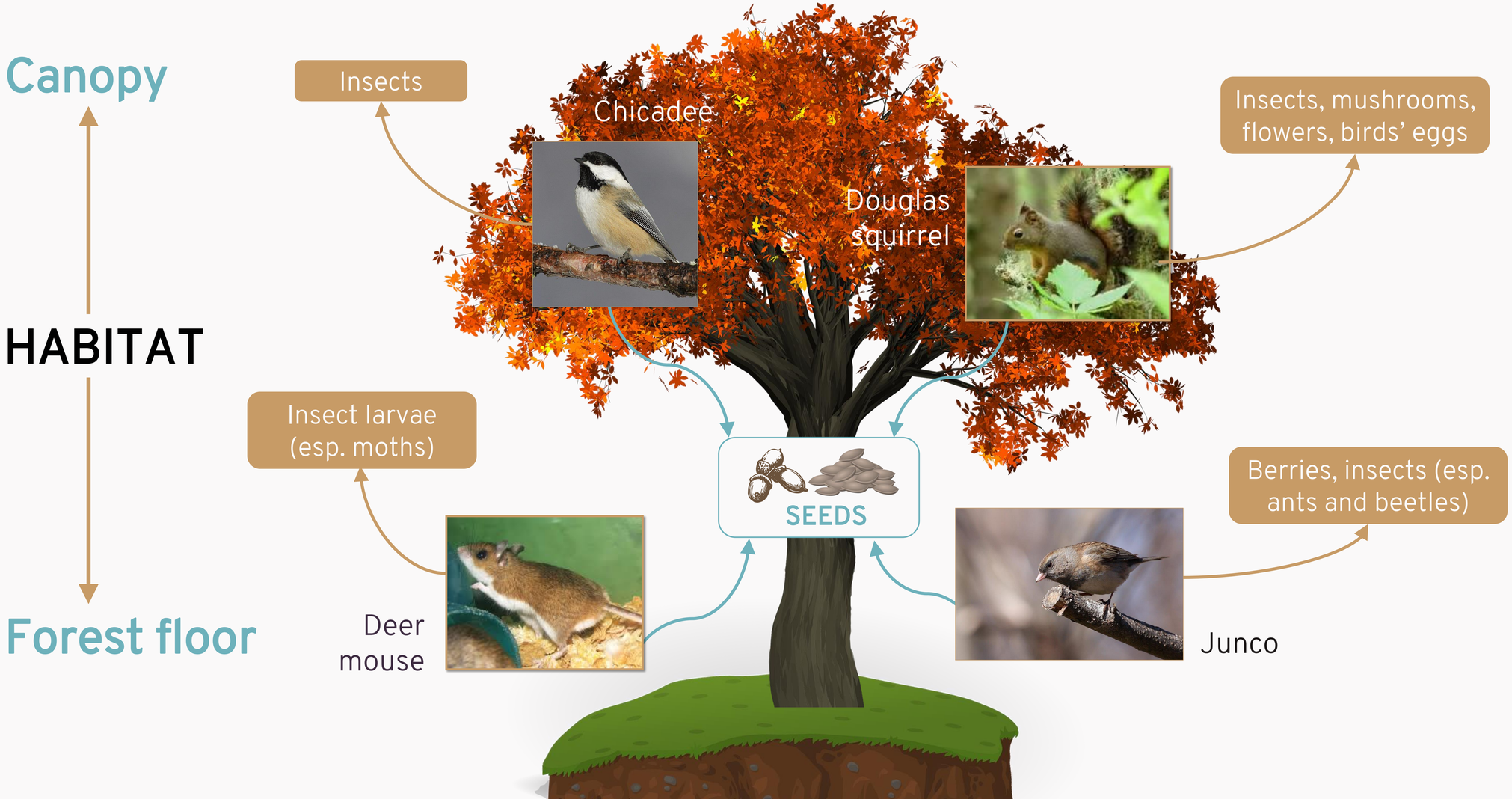
Barnacles on Scotland's rocky shores



Interspecific barnacles competition, https://www.macmillanhighered.com/BrainHoney/Resource/6716/digital_first_content/trunk/test/hillis2e/asset/img_ch43/c43_fig04.html, used under a Fair Use rationale., with modifications.

Figure 43.4: Interspecific Competition Can Restrict Distributions. Competition with rock barnacles restricts stellate barnacles to a smaller portion of the intertidal zone than they could otherwise occupy.

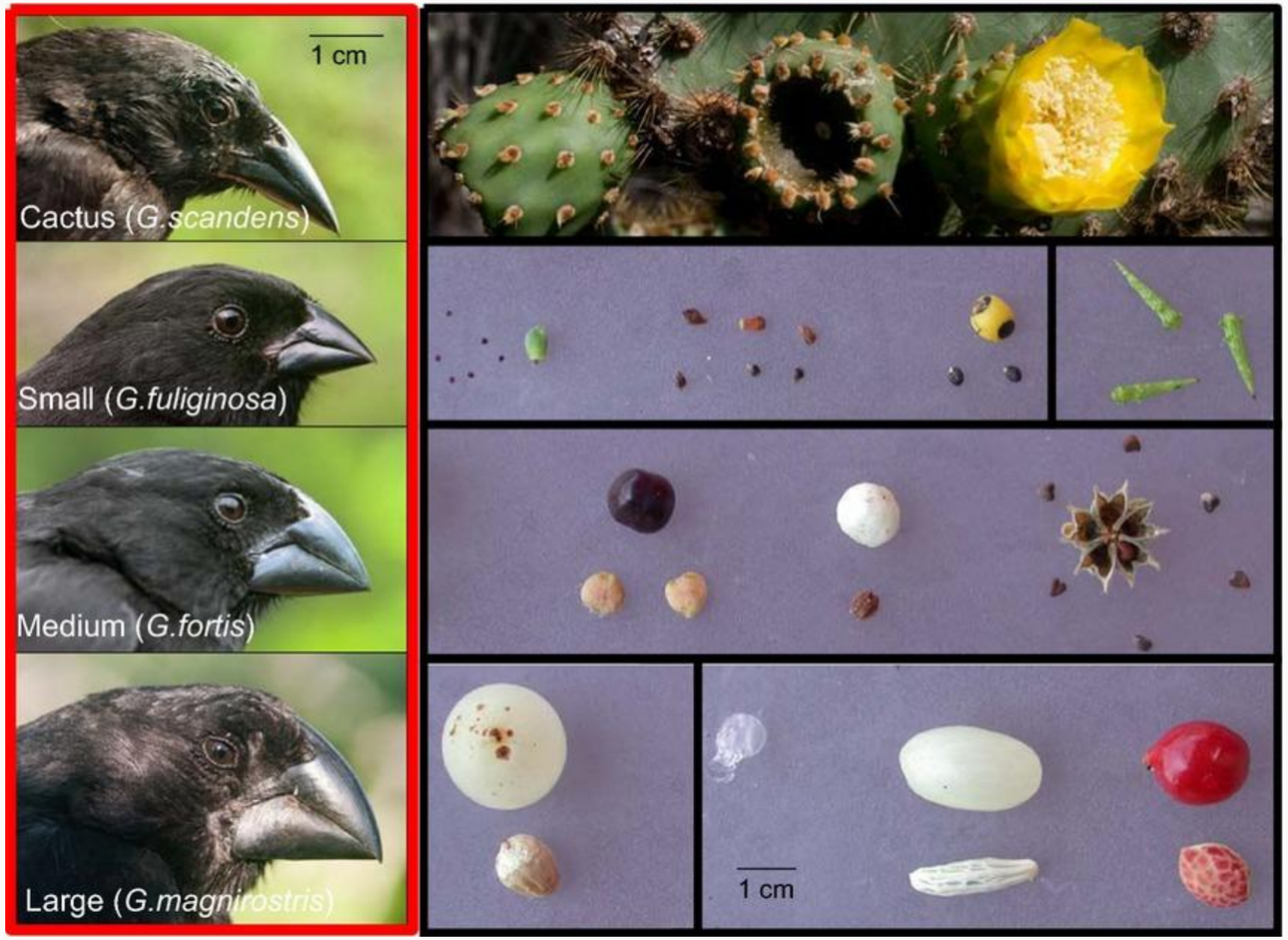
Diet segregation among granivores



2. Character displacement

- An evolutionary response to interspecific competition.
- Competing species can evolve to be different in their resource utilization.
  - E.g. size differences between closely related sympatric species.
  - Finches of Galapagos Islands.
- Allows each species to exploit different habitats/resources.

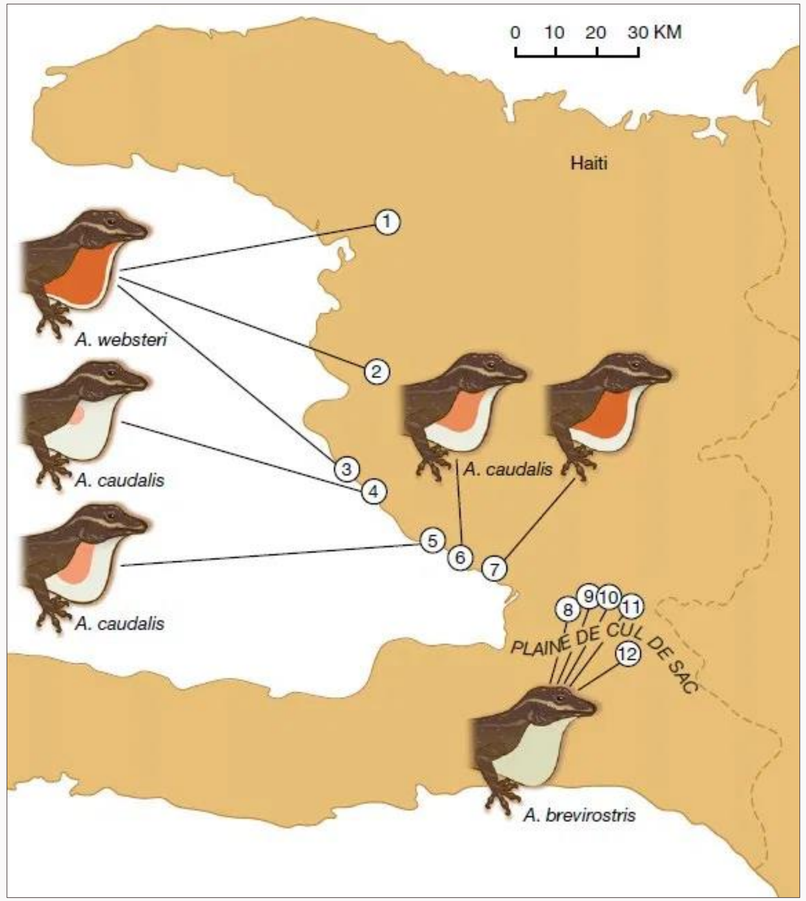
Darwin's finches' beaks character displacement

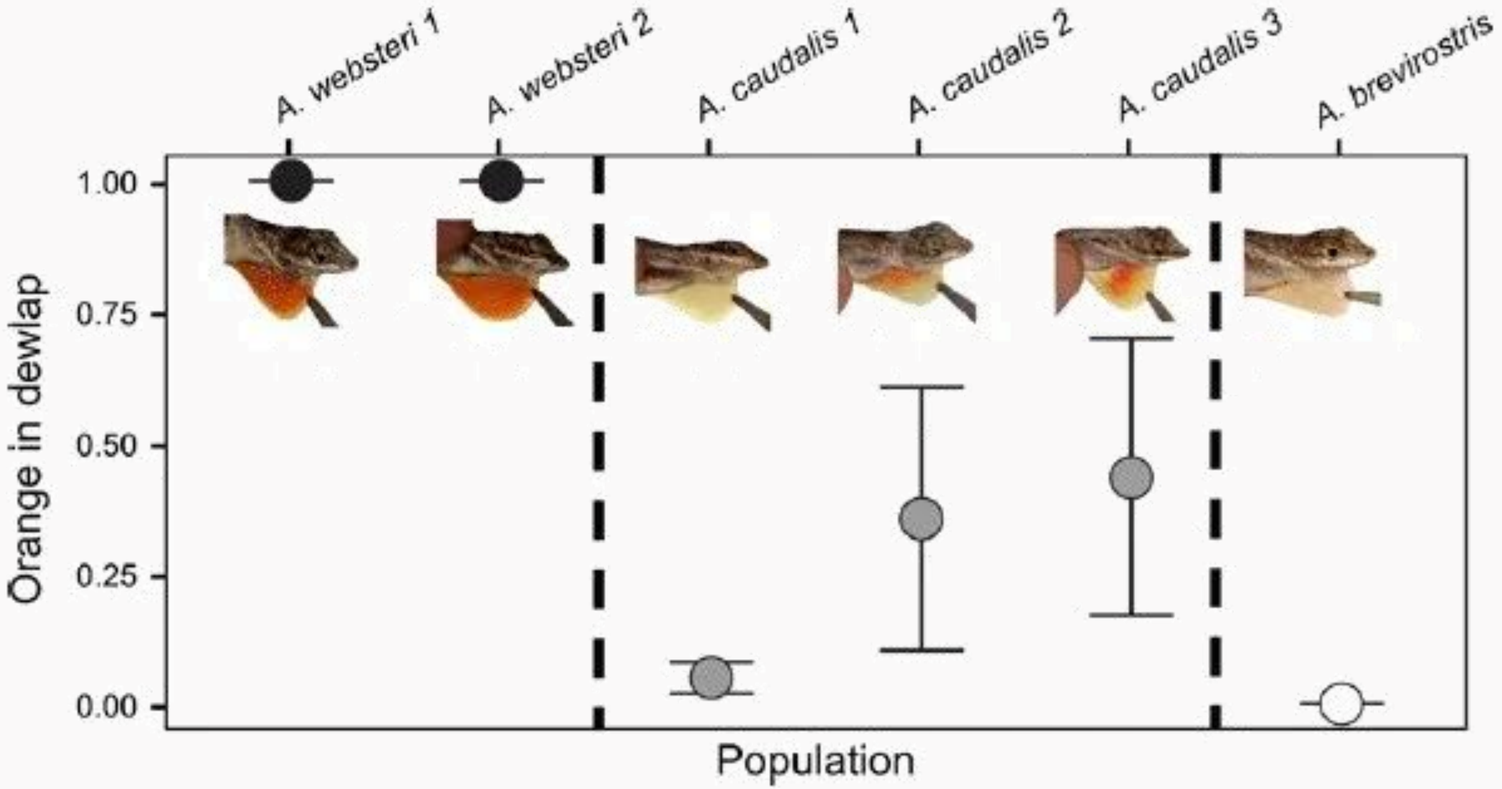


De León et al. 2014. J Evol Biol 27:1093-1104. DOI: 10.1111/jeb.12383. Used under a Fair Use rationale.

- Darwin's ground finches and some of the foods they often feed on.
  - *Geospiza scandens*: cactus flowers and fruit.
  - *G. fuliginosa*: small-sized fruit and seeds.
  - *G. fortis*: medium-sized fruit and seeds.
  - *G. magnirostris*: large-sized fruit and seeds.

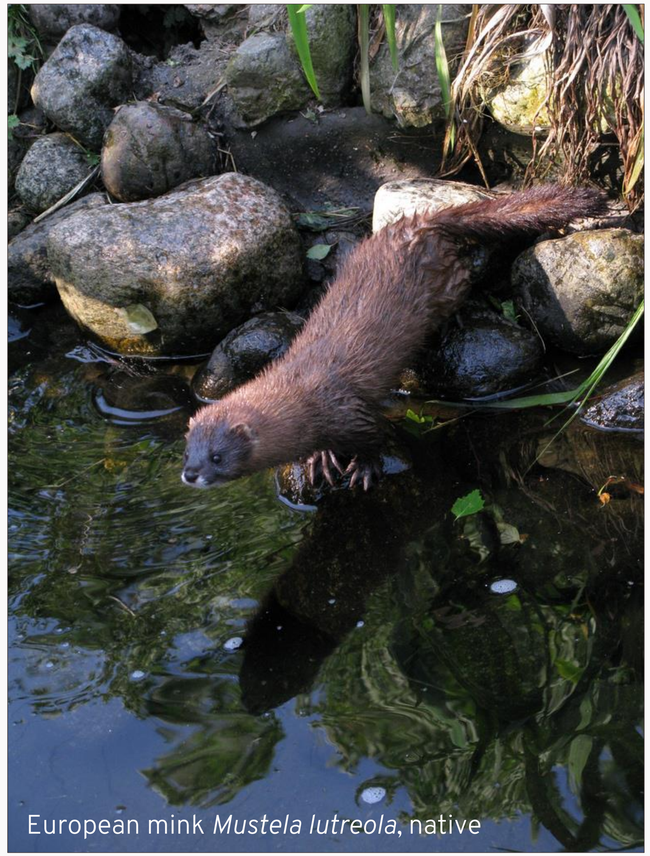
Dewlap color in Haitian anoles





Losos J. 2013. https://www.anoleannals.org/2013/08/12/reproductive-character-displacement-and-dewlap-color-in-haitian-anoles/. Used under a Fair Use rationale.

Character displacement in minks in Belarus



European mink *Mustela lutreola*, native

- American mink were introduced in north-eastern Belarus,
- The native European mink increased in size, and the introduced mink decreased in size.

American mink *Mustela vision*, introduced

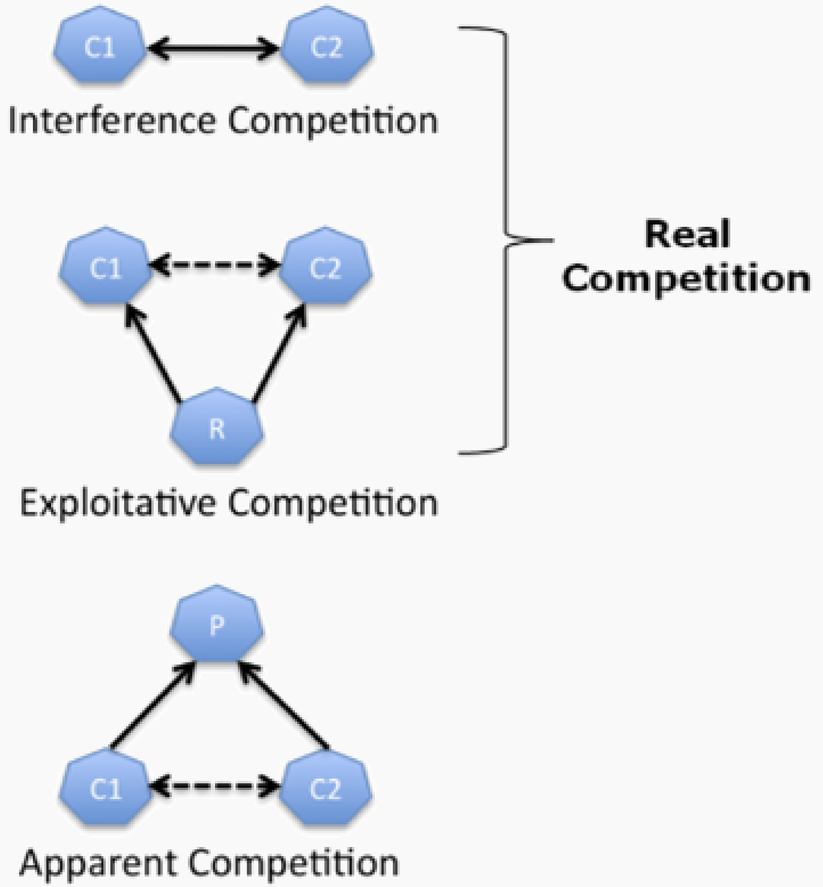
- Demonstrating a rapid evolutionary change.

02

INTERSPECIFIC COMPETITION

Major forms of competition

1. Exploitative (scramble) competition.
2. Interference (direct or contest) competition.
3. Apparent competition



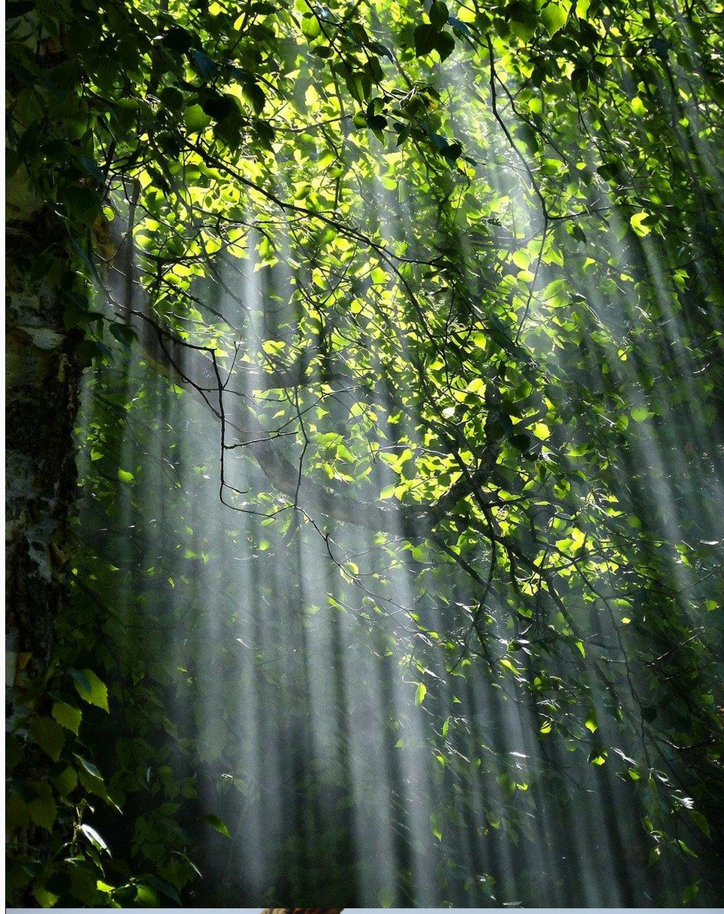
[Figure 1], Lang & Benbow. (2013), Species Interactions and Competition. Nature Education Knowledge 4(4):8

Alternative classification of competition

- Proposed by Schoener (1983), six mechanisms of competition:
  1. Consumption
  2. Pre-emption
  3. Overgrowth
  4. Chemical interactions (allelopathy)
  5. Territoriality
  6. Encounter competition

1. Exploitation competition

- Occurs through a common limiting resource which acts as an intermediate.
  - One species denies another access to a resource by consuming it first.
  - No direct interaction.
- All individuals get equal share of resources.
  - However, resources are limited.



and sometimes the two species coexisted

Exploitation competition between diatoms

- Two species of freshwater diatom: competing on silicate and phosphate.
- Exclusion or coexistence depended upon the ratio of two essential nutrients.
  - High ratio silicate to phosphate, *Asteriolla* dominates.
  - Lower ratio silicate to phosphate, coexist.
  - Lowest ratio silicate to phosphate, *Cyclotella* dominates.

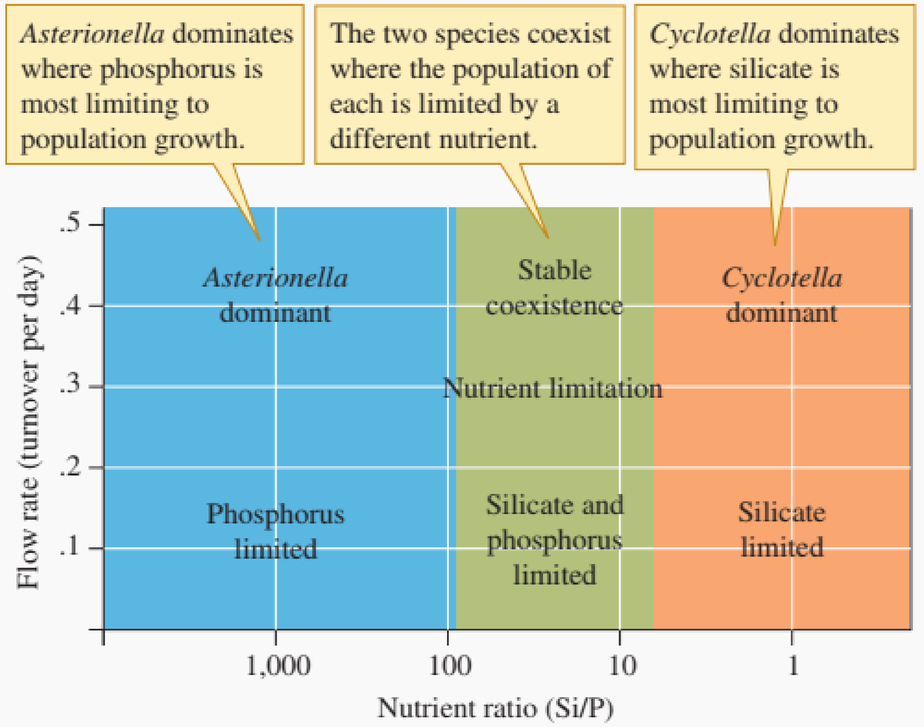


Figure 16.11 The ratio of silicate (SiO_2^{2-}) to phosphate (PO_4^{3-}) and competition between the diatoms *Asterionella formosa* and *Cyclotella meneghiniana* (data from Tilman 1977).

[Fig. 16.11. Tilman's experiment on competition between diatoms], Molles Jr, 2016, Ecology: concepts and applications, used under a Fair Use rationale.

2. Interference competition

- Some confrontation occurs.
- A few “winners” get all the resources, the remaining individuals get nothing.
- One species actively inhibits the foraging, survival, or reproduction of the other species.
- A classic example: competition between barnacles *Balanus* & *Chthamalus*.

Interference competition through allelopathy

- Production/release of chemical substances by one species that inhibits the growth of another.
- Chemicals produced by plants that seem to have no direct use in metabolism.

Interference competition in *Tribolium* beetles

- Confused flour beetle (*T. confusum*) and red flour beetle (*T. castaneum*).
  - Interferes with the survival of competitors.
- In experiments, one species always excluded the other.
- Which species won depended on:
  - Environmental conditions.
  - Random chance.
  - Density of each species at the start of the experiment.

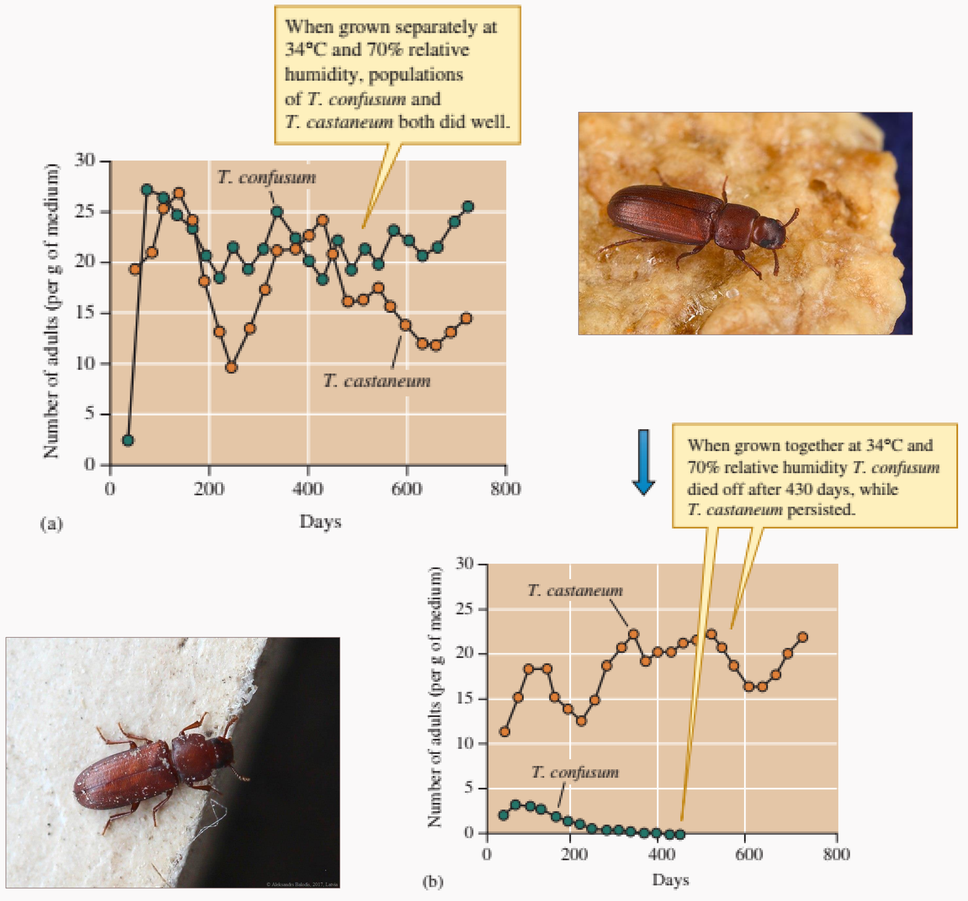
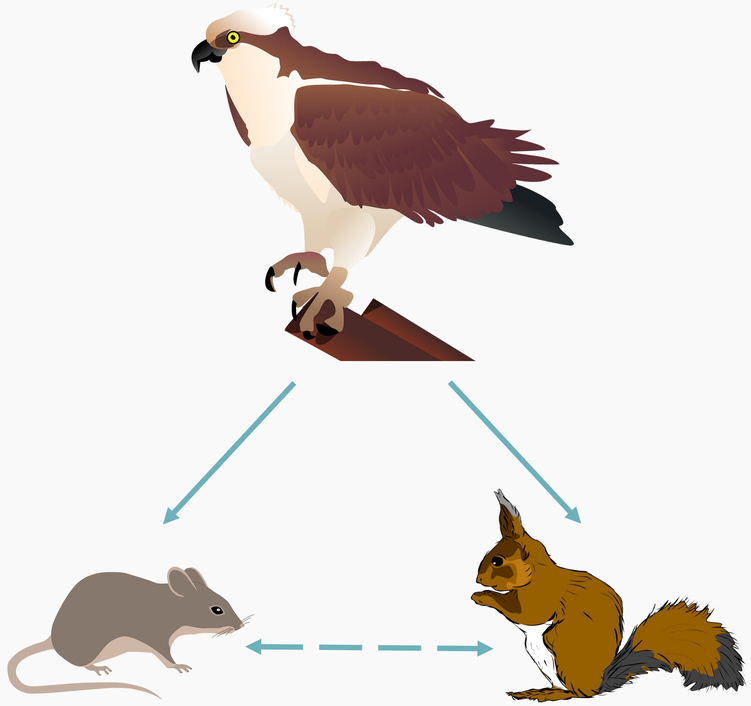


Figure 13.16 Populations of *Tribolium confusum* and *T. castaneum* grown separately (*a*) and together (*b*) under hot-wet conditions (data from Park 1954).

3. Apparent competition

- Indirect competition.
- Two individuals affect each other indirectly by being prey for the same predator.
- Difficult to identify in nature
  - The complexity of indirect interactions.
  - The changing environmental conditions.



03

COMPETITION MODELS

Competition models

- Lotka-Volterra model.
  - Examines changes in abundance of one species while in competition with another species.
- Tilman’s model.
  - Specifies consumer-resource dynamics.

Lotka-Volterra competition model

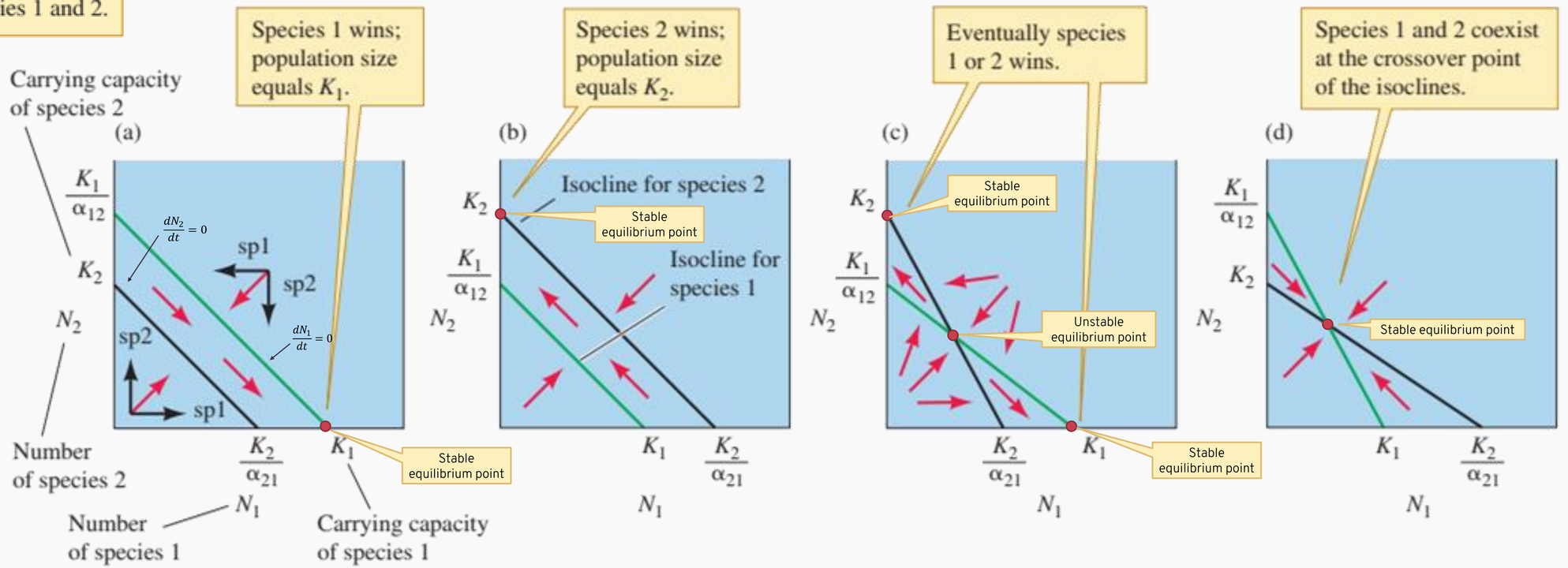


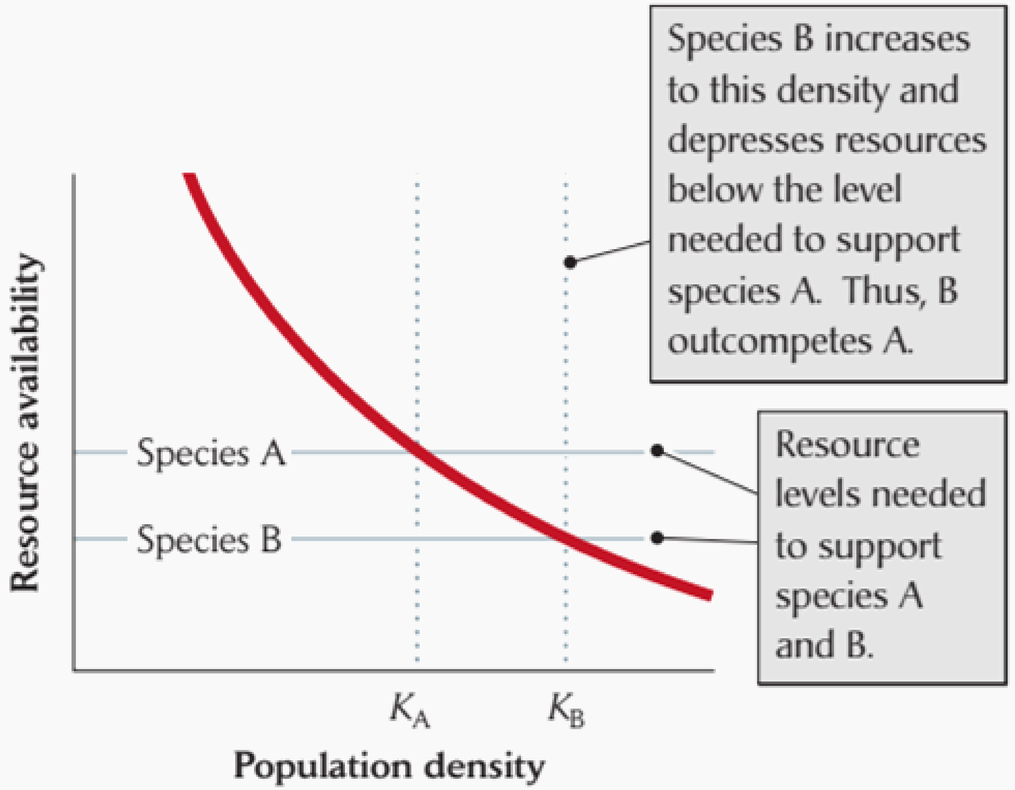
Figure 13.14 The orientation of isoclines for zero population growth and the outcome of competition according to the Lotka-Volterra competition model.

[Fig. 13.14. Lotka-Volterra competition model], Molles Jr, 2016, Ecology: concepts and applications, used under a Fair Use rationale.

Lotka-Volterra model

- Based on this model, there are 4 possible outcomes of interspecies competition:
  - Species 1 is stronger competitor, so 1 wins (“trivial equilibrium”).
  - Species 2 is stronger competitor, so 2 wins (“trivial equilibrium”).
  - Both species are stronger competitors on each other than on themselves, so may exist in unstable coexistence (“unstable equilibrium”).
  - Both species are weak competitors, so exist in stable coexistence (“stable equilibrium”).

Tilman's competition model



- Suggests that species that is more efficient at exploiting sparse resources will be more successful.
  - i.e. superior competitors can survive with fewer resources.

FIGURE 16.2 Superior competitors can persist at lower resource levels. As resources are consumed, they decline to levels that no longer support the further growth of the consumer population, and the population may reach an equilibrium size (K). If species A can continue to grow at a resource level that curtails the growth of species B, species A will outcompete, and will eventually replace, species B.

[Tilman's competition model], Ricklefs RE. 2008. The Economy of Nature 6th ed. Used under a Fair Use rationale..

Credits

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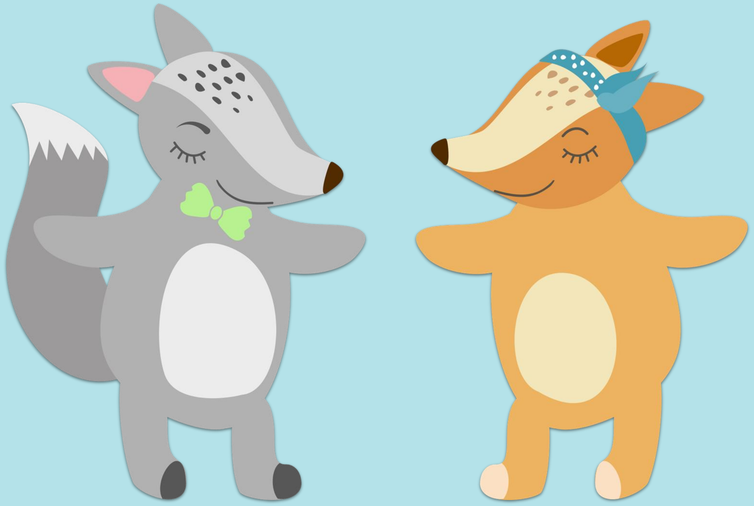

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