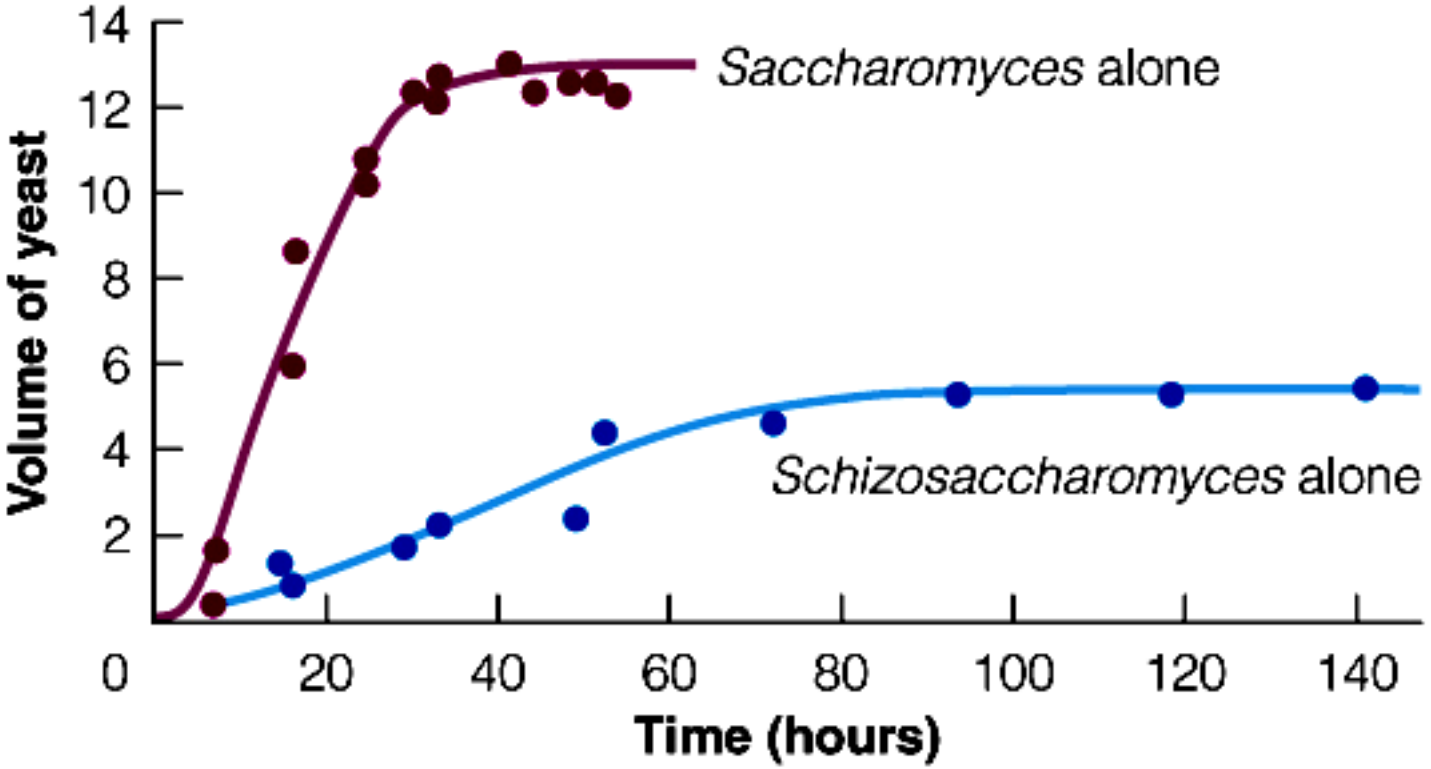
Evidence for Competition

Population growth in laboratory experiments carried out by the Russian scientist Gause on growth rates in two different yeast species

Each of the species has the same food – e.g., sugar

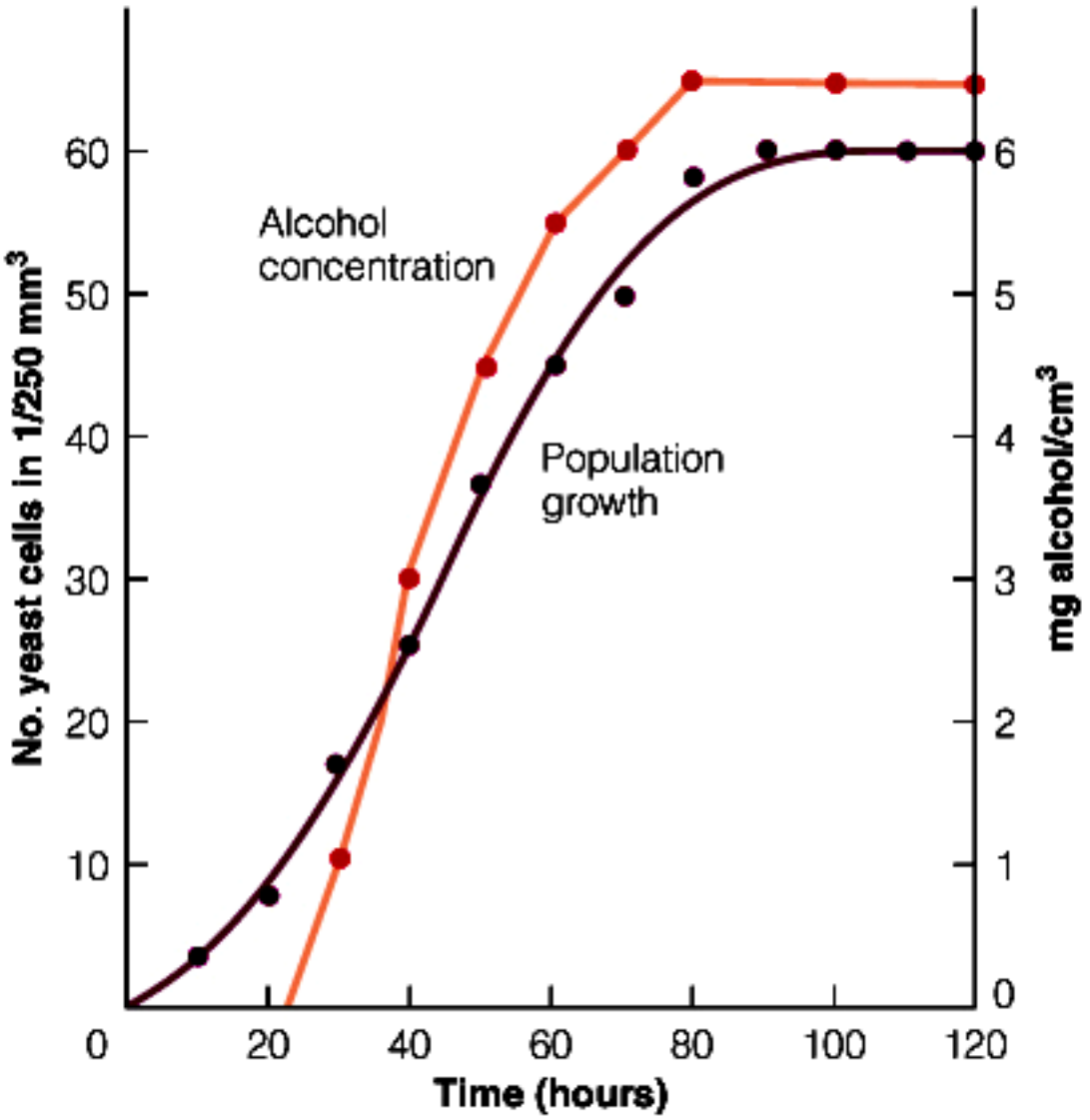
The plots in this curve were developed for populations growing separately

Both populations exhibited the classic sigmoid growth curve

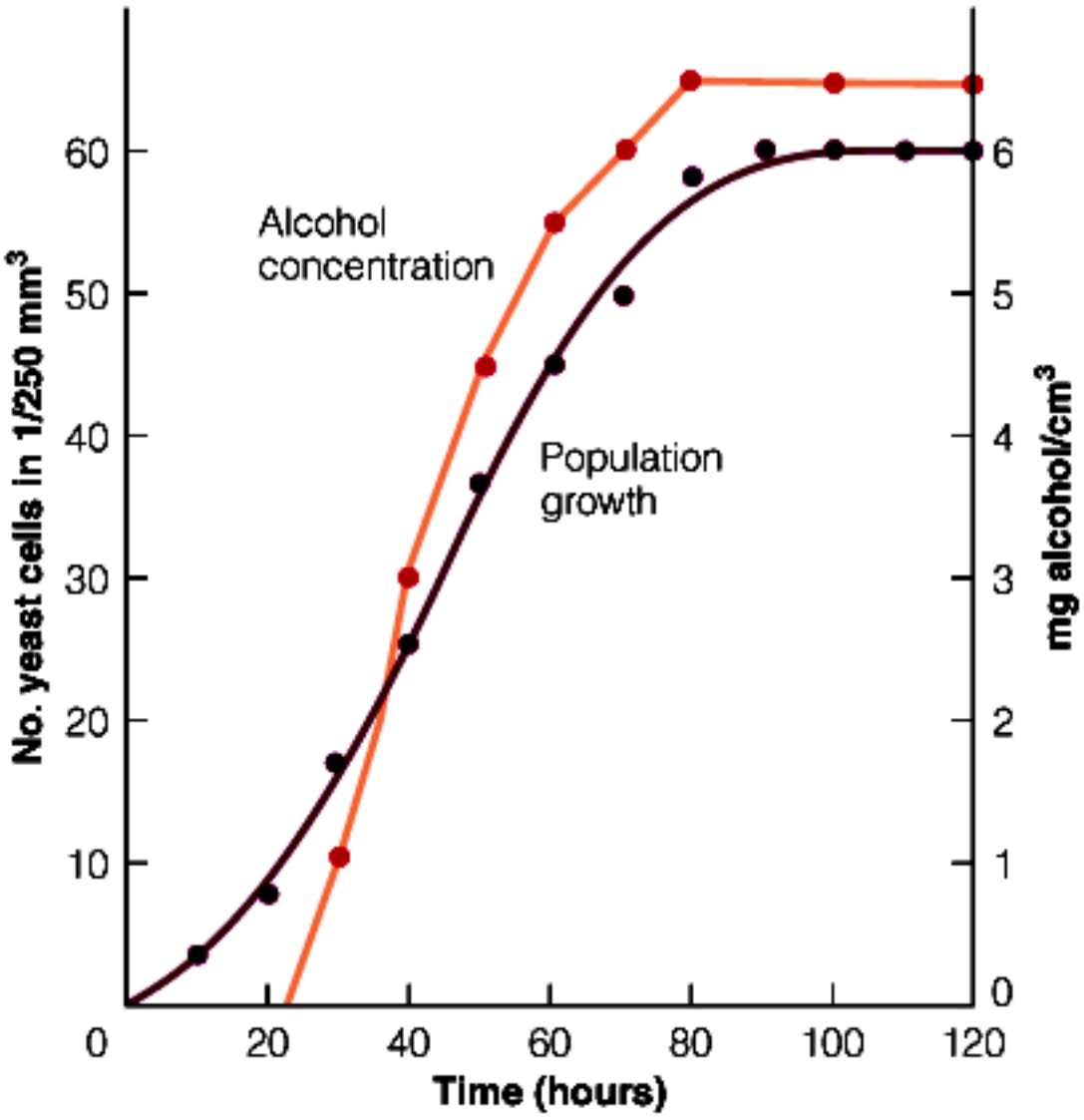


Growth decreased prior to the point where food or energy were exhausted in each case.

Why?



Concentration of alcohol limits growth - a side-product when yeast consumes sugar under anaerobic conditions
Alcohol has a toxic effect on the yeast populations. High alcohol concentrations kill young yeast buds as they break off from their mothers

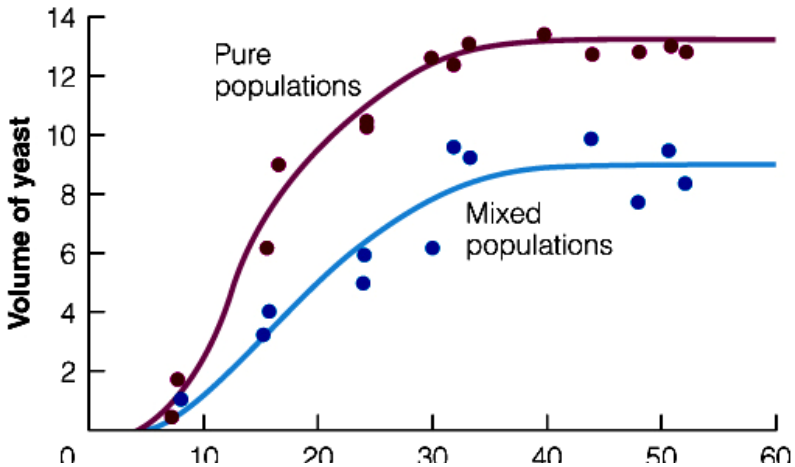


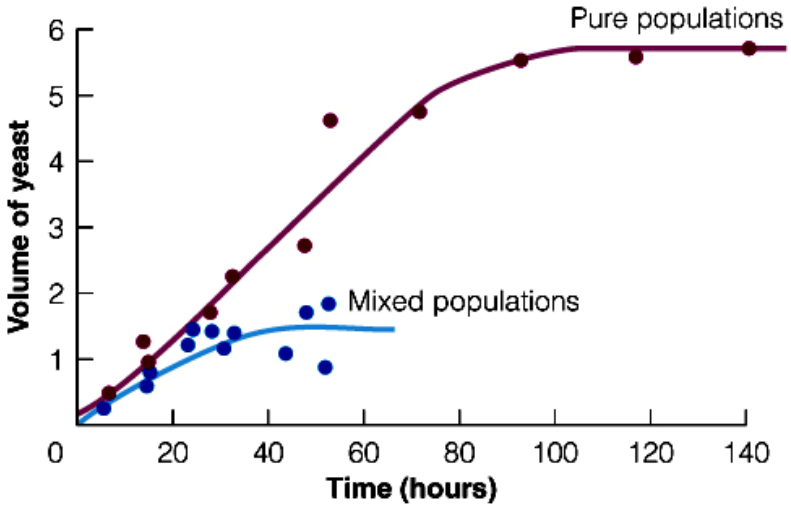
Gause conducted experiments on the growth of the two yeast species together, competing for the same food source.

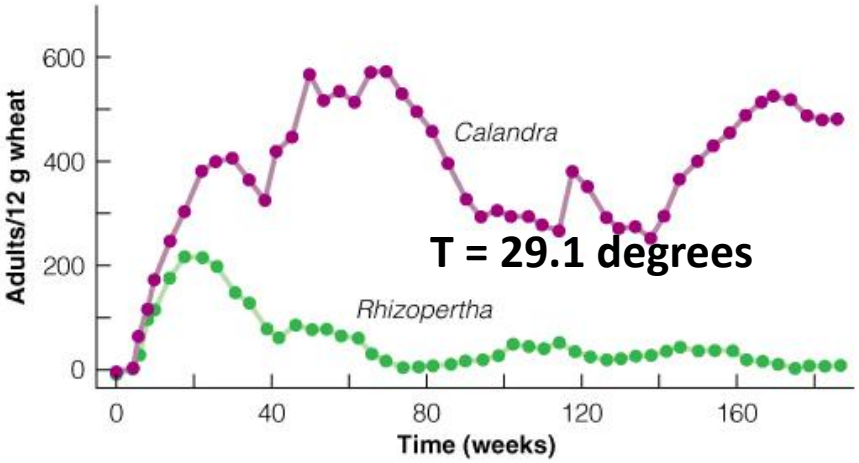
Each grow less when in competition.

Presence of alcohol
limits growth. When one species produces alcohol, it limits the growth of both.Thus the carrying capacity of both are reduced

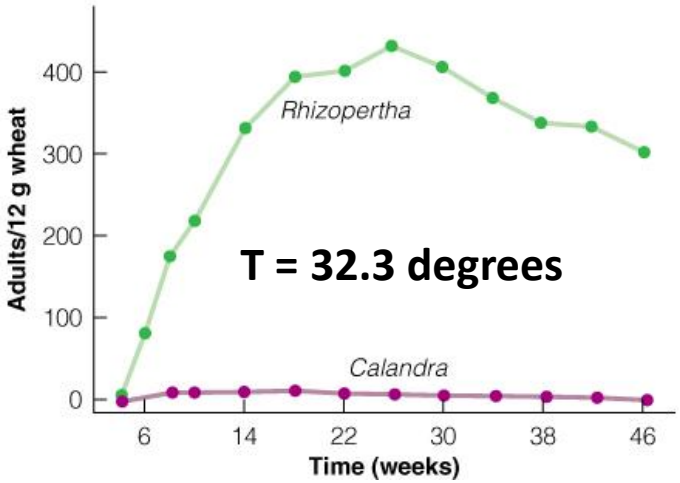
Alpha and beta for competition between the species estimated and the Lotka-Volterra model described the results well







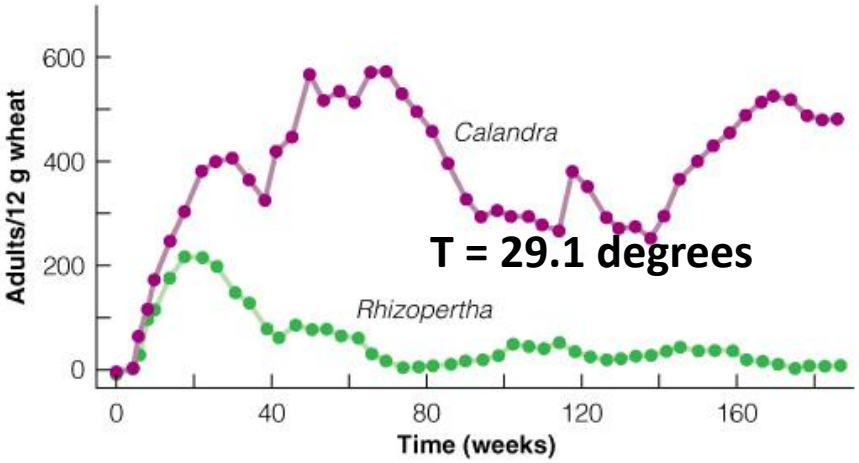
Calandra oryzae



Rhizopertha dominica

Research by Birch on grain beetles represent a situation where competition leads to extinction of one species or the other

In his study, Birch showed that one species went extinct in the face of competition when the temp was 29 degrees, but by changing the temperature by 3 degrees, the other species then went extinct



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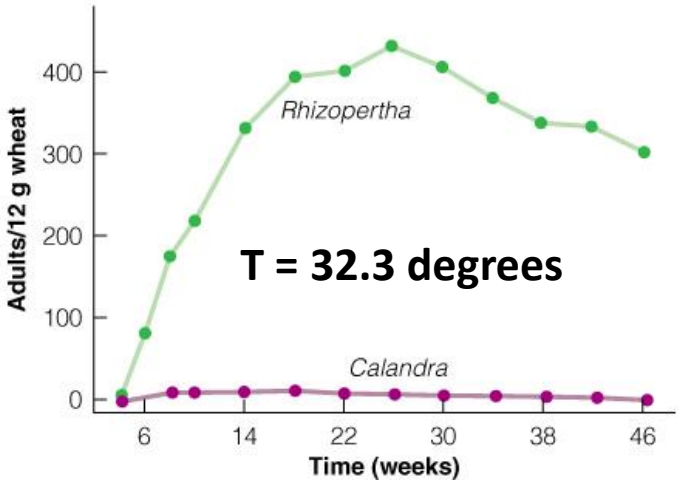
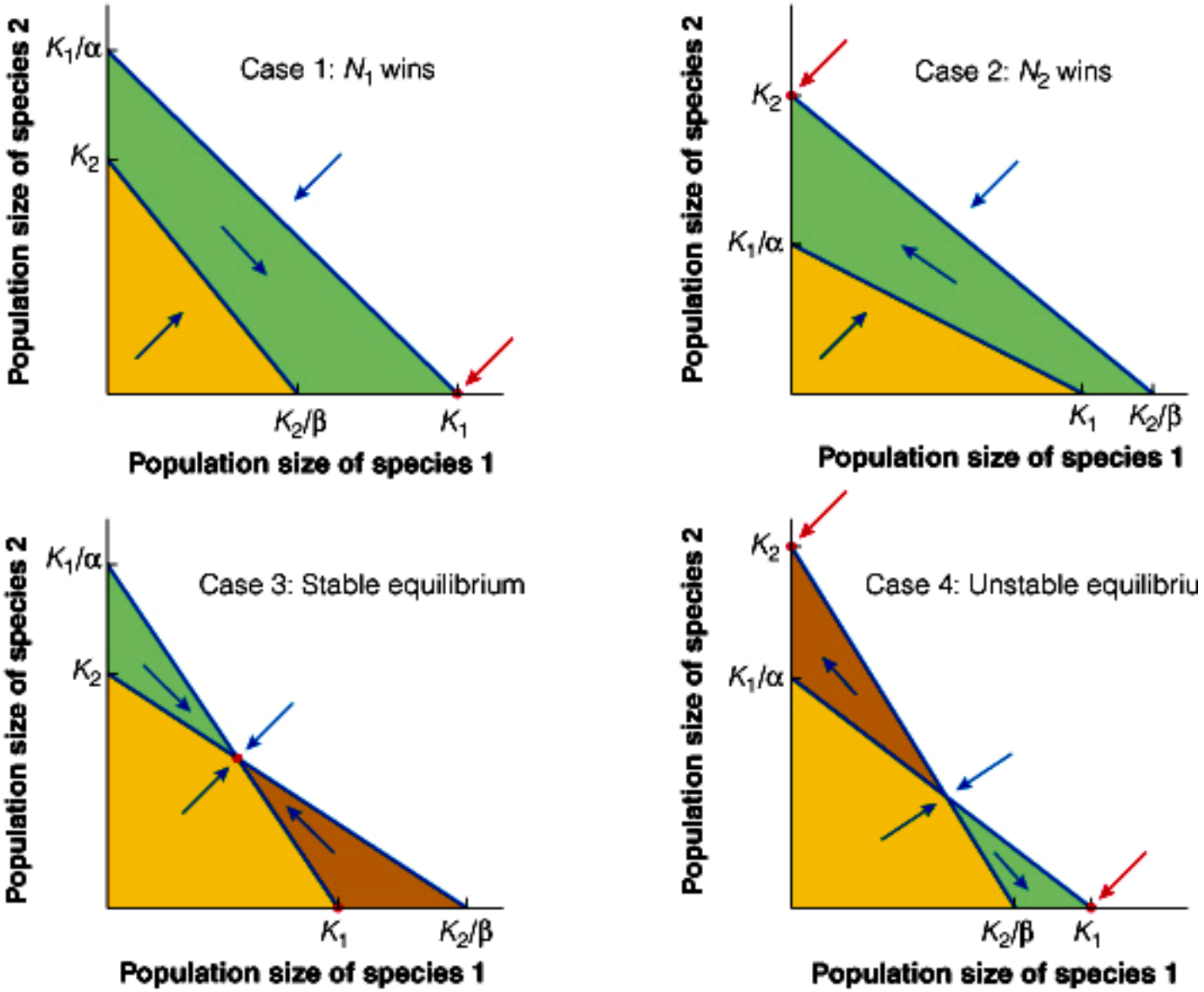


Rhizopertha dominica

Temperature influences the metabolic pathways of the species differently, so variations in temperature influence the relative fitness of the individuals and so competition between species is dependent on ambient environmental conditions

Consistent with Lotka-Volterra model



The 29 degree case equals Case 1, e.g., species 1 out competes species 2

The 32 degree case equals Case 2, e.g., species 2 out competes species 1

Competition in Natural Populations

- **Gause's hypothesis – Two species with a similar ecology cannot live together in the same place**
- **Competitive exclusion principle -Complete competitors cannot co-exist**

Coexistence-The Paradox of Competition

- **How does the theory of competitive exclusion and the observation of extinction of closely related species in laboratories reconcile itself with the observation that a large number of similar species can actually co-exist in nature**

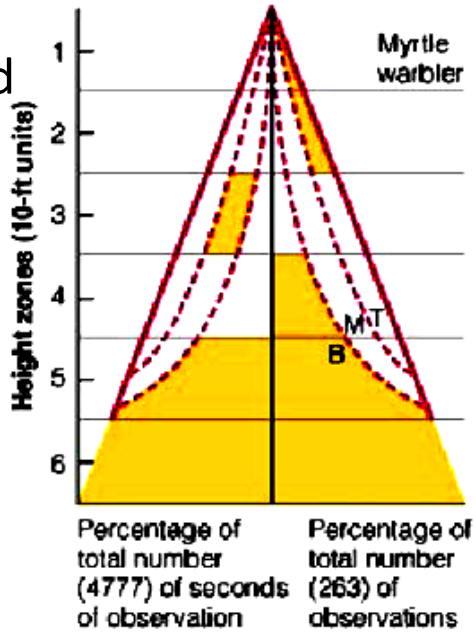
Explanation 1- situations exist where competition is not expected

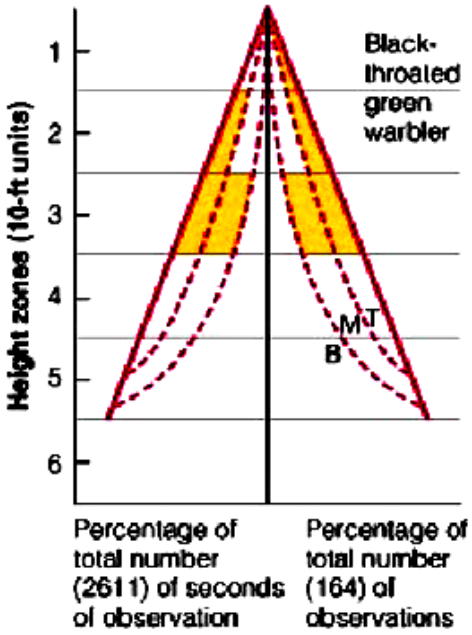
- **Resources are not limiting, ample for all**
- **Unstable, fluctuating environments exist, that reverse direction of competition before extinction is possible**

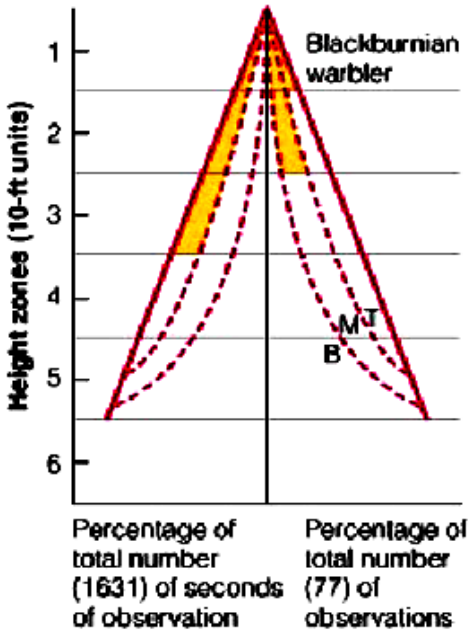
- **Explanation 2 - Since in many cases, resources are not limiting, competition is actually rare – there really is no competition**

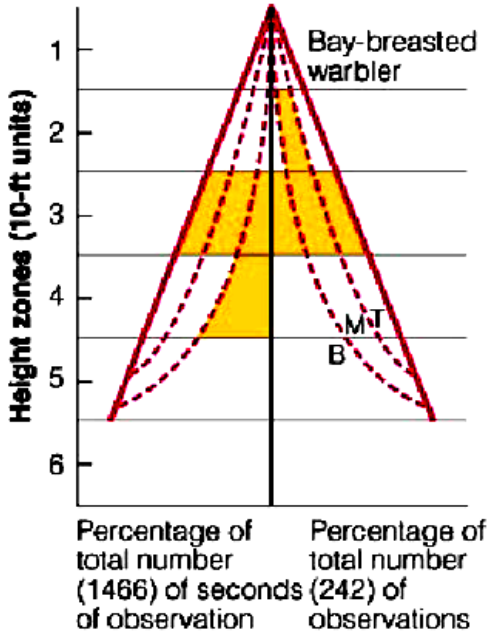
- **Explanation 3 – Competition is not rare, but is common – has resulted in adaptations and natural selection that serve to limit competition – so it only appears to be rare**

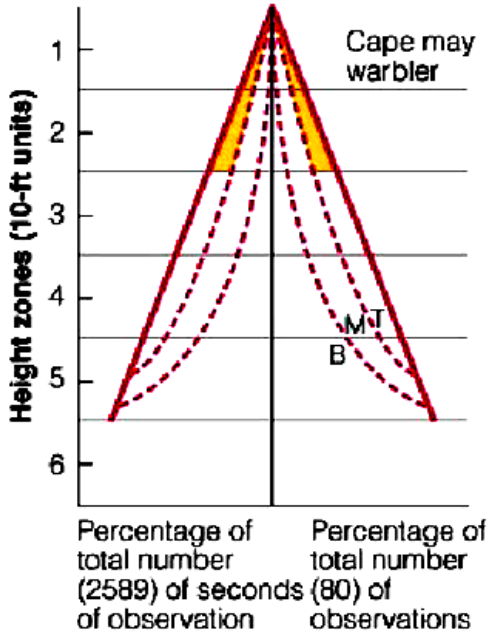
MacArthur asked Why does 1 species not out-compete the others?



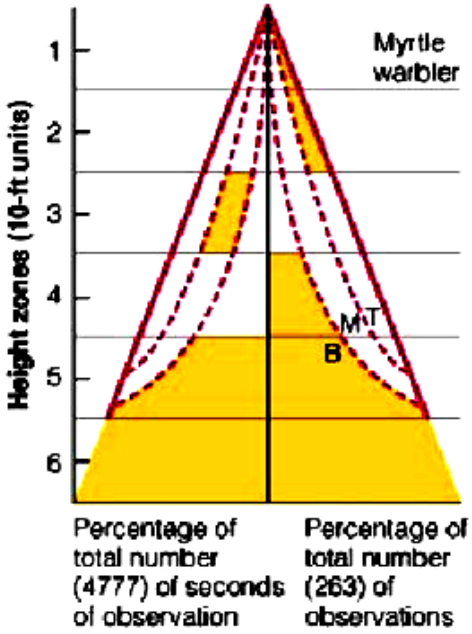


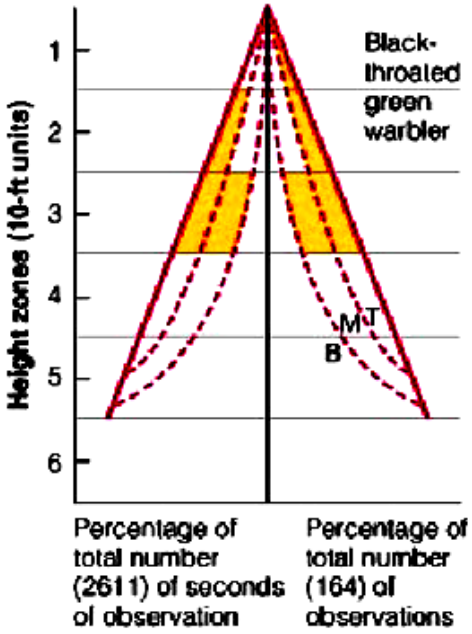


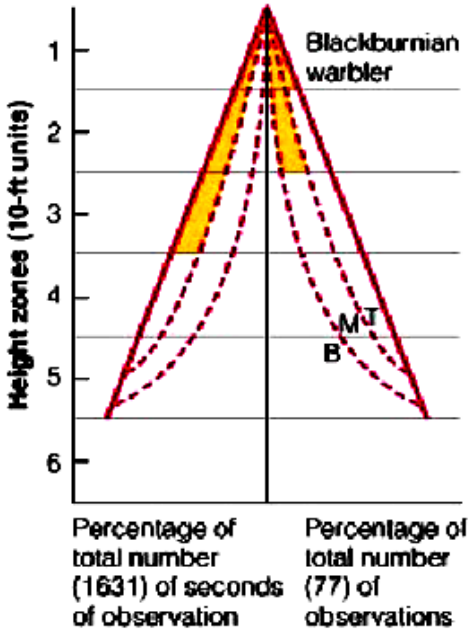


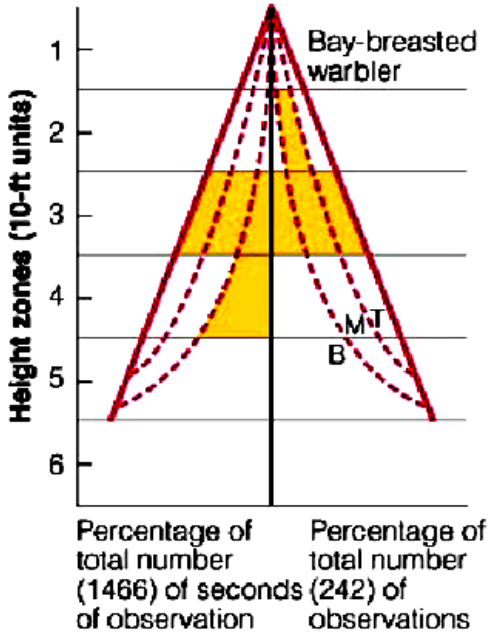


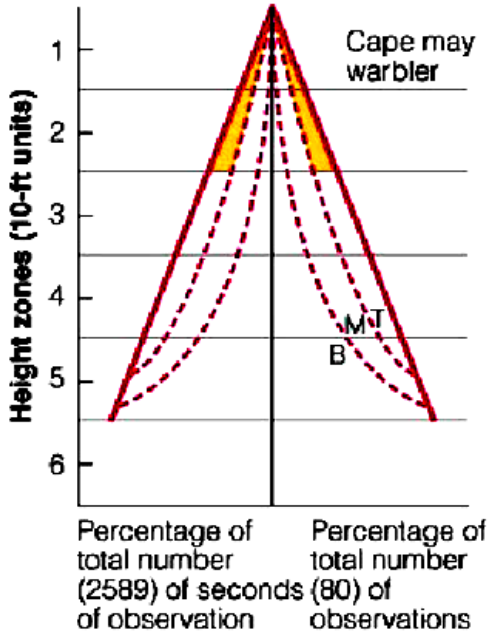
Where competition was thought to exist, in fact the species under study were occupying different niches

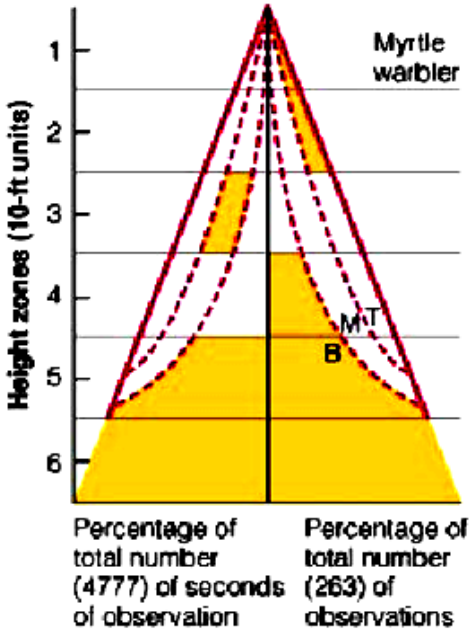


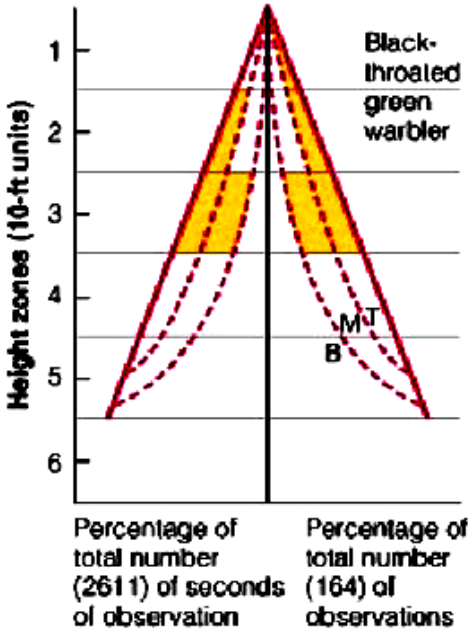


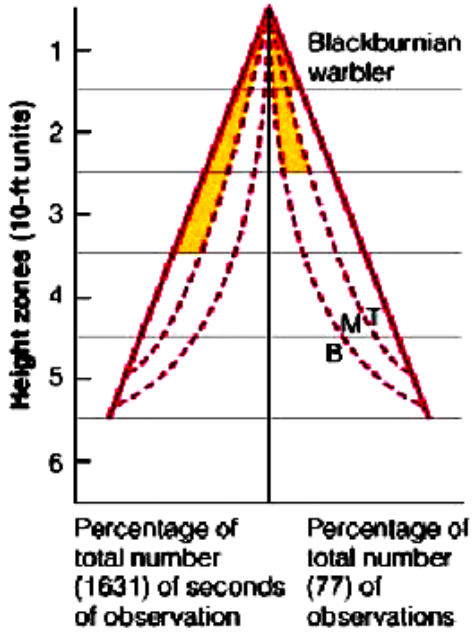




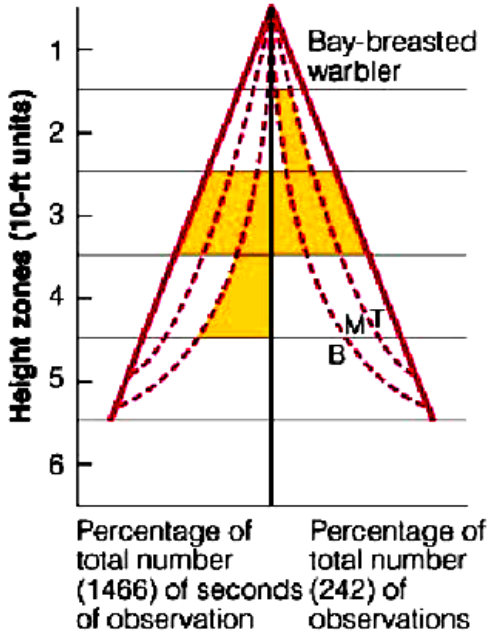


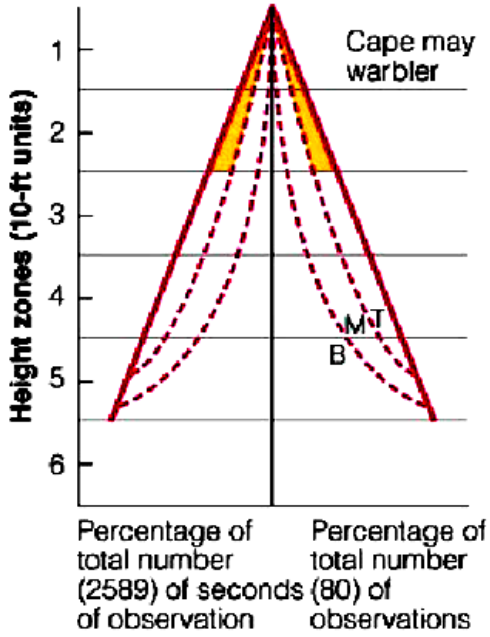






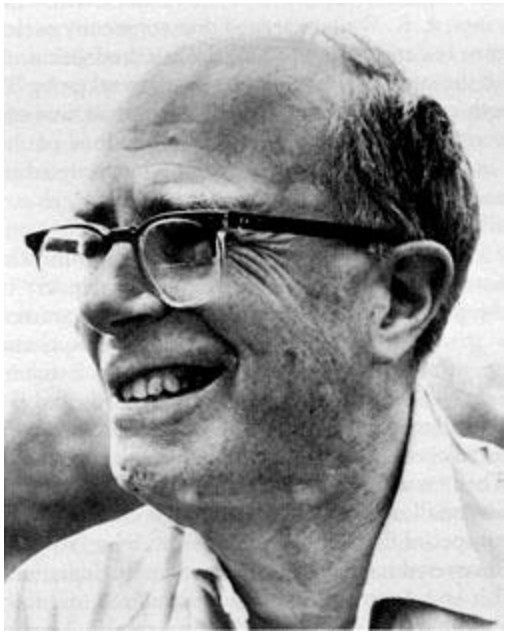
Feeding positions of warblers found in coniferous forests occupy different parts of the canopy, and therefore exploit different resources. Hence no competition.





David Lack suggested – These differences arose because of competition in the past.

“Ghost of competition past”



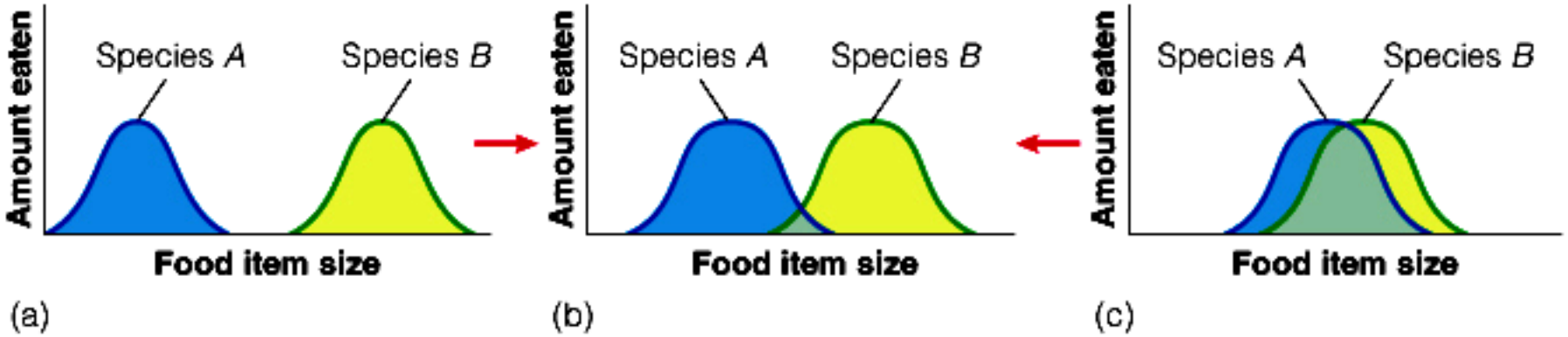
What evidence is used to deduce that competition has occurred in the past?

1. Niche separation
2. Habitat shift
3. Character displacement
4. Competitive exclusion
5. Competitive release

How does competition influence natural selection and the evolution of species? Three situations:

a. No – overlap
c. Significant overlap
b. Partial over-lap

Case A - If the curves are separate, natural selection and evolution indicates that a species that can capture the unused portion will have more fitness, therefore you should see a shift of both species towards the middle

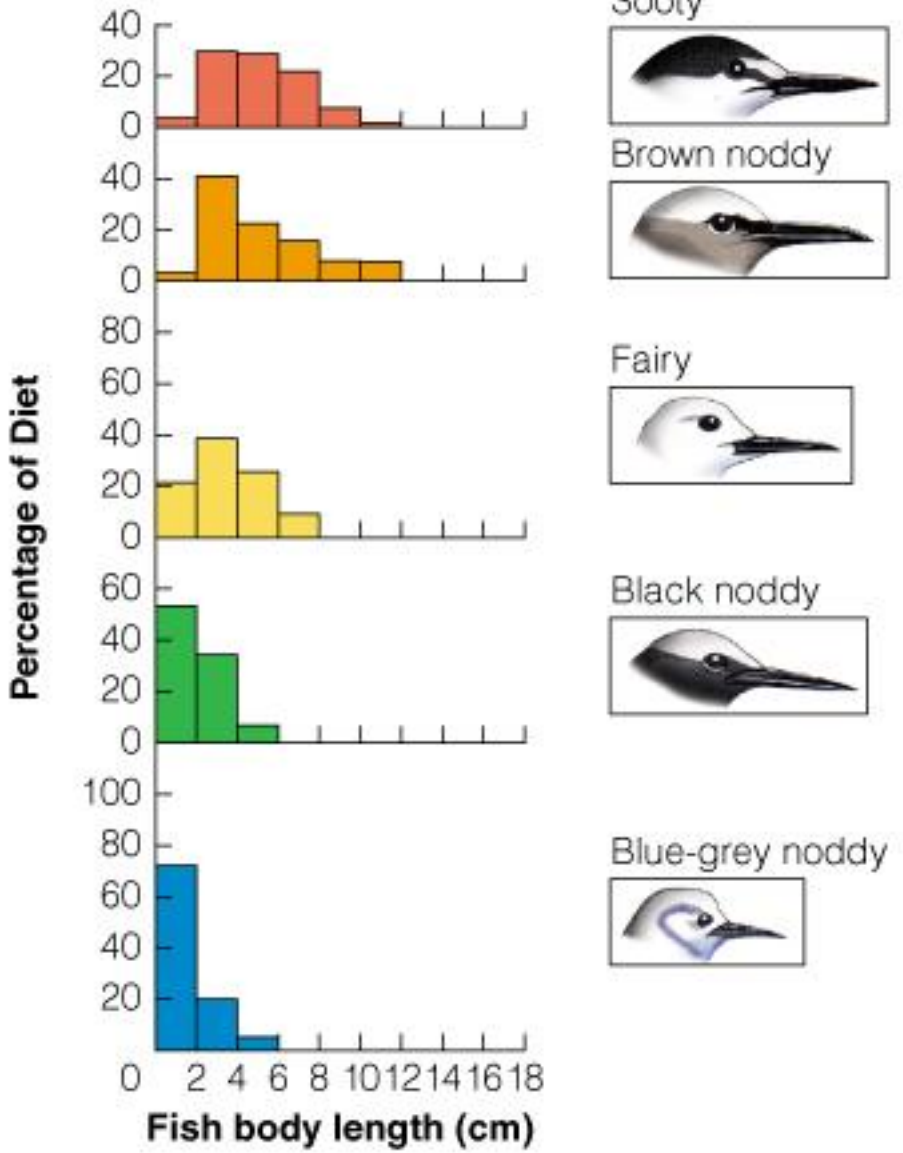


Niche separation via resource partitioning -

Example of food size for terns living in the same area (Christmas Island in the Pacific Ocean) that illustrates how selection and evolution work to create separate food niches.

Each species has a unique region of fish sizes that it feeds on, therefore, they are avoiding competition

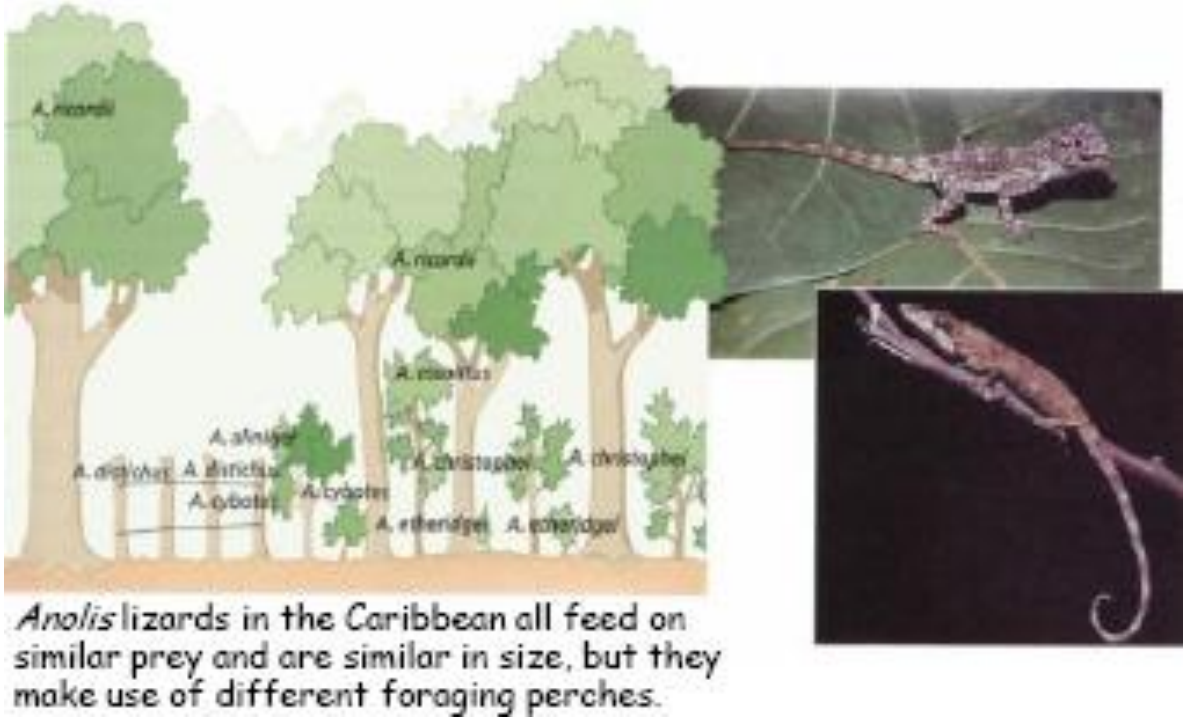
With respect to the sooty and brown noddy, even though their food sizes are similar, they actually feed in different regions, so they are not in competition



Habitat shift -

Use of habitat often changes depending on presence or absence of closely related species.

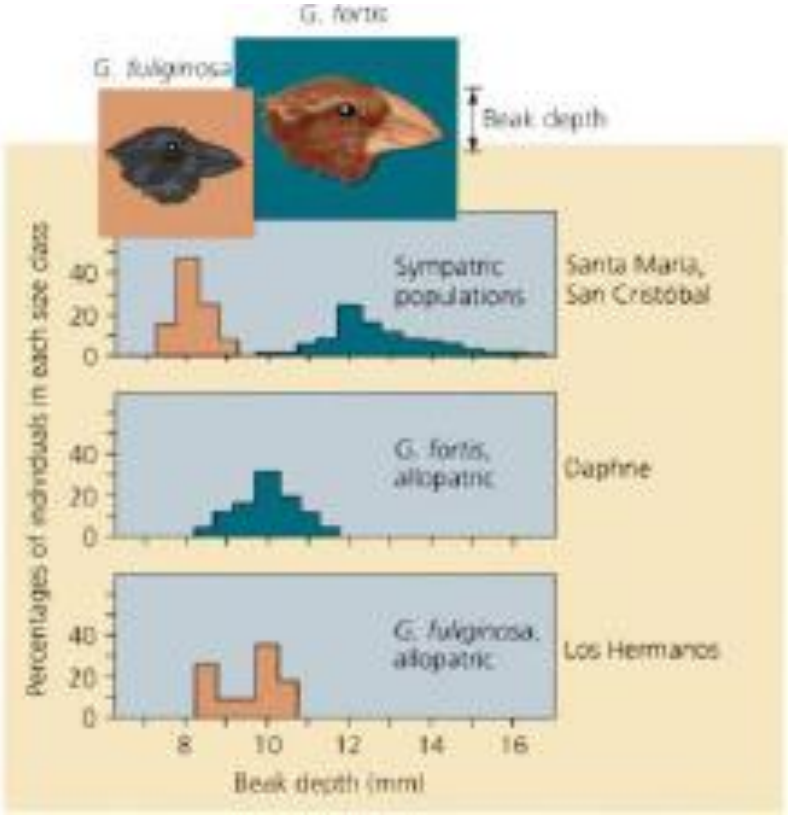
Expand habitat when others are absent.



Anolis lizards in the Caribbean all feed on similar prey and are similar in size, but they make use of different foraging perches.

Character displacement -

Morphological traits and food selection of species shift depending on presence or absence of closely related species



Competitive exclusion

Red squirrel vs. Grey squirrel

Competitive release:

Densities of organisms often increased when densities of competing species are reduced.

- Baleen whales: 1 million 100 years ago, now 200,000
- Eat Antarctic krill
- Other krill-dependent predators (seals, penguins) have been found to be at much greater densities.

Criteria for establishing that competition exists

Reynoldson and Bellamy 1970

Weak

Suggestive

Strong & Convincing

1. Distribution and relative abundance of 2 species should be amenable to explanation based on competition.
2. Necessary to show that species are using a common resource.
3. Evidence that intraspecific competition is occurring.
4. Evidence that resource use by 1 species reduces availability to another.
5. Manipulation indicates 1 or more species is negatively affected.
6. Events following introduction or removal of species consistent with competition hypothesis

How common is competition?

Schoener 1983 – Am Nat 122:240
Connell 1983 – Am Nat 122:661

- Reviewed evidence from field studies
  - S. 90% of studies, 76% of species, resource competition is prevalent, if not then certainly not rare.
  - C. 40% of studies, 50% of species, not as extensive of review
- Problem with review?

How common is competition?

Schoener 1983 – Am Nat 122:240
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- Problem with review
  - Tend not to look for competition when we don't expect it
  - Tend not to publish negative results

How common is competition?

Schoener 1983 – Am Nat 122:240
Connell 1983 – Am Nat 122:661

- Areas of agreement
  - Competition found where investigators think they should look for it
    - Don't look where it isn't likely
    - Don't publish negative results
  - Competition often asymmetrical (often reverses year to year)
  - Competition most common within some systems (marine environments, plants, other aquatic systems)
  - Results are variable in time