Observations (pattern) consistent with predictions.

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Altitudinal gradients in tropical forest composition, structure, and diversity in the Sierra de Manantlán

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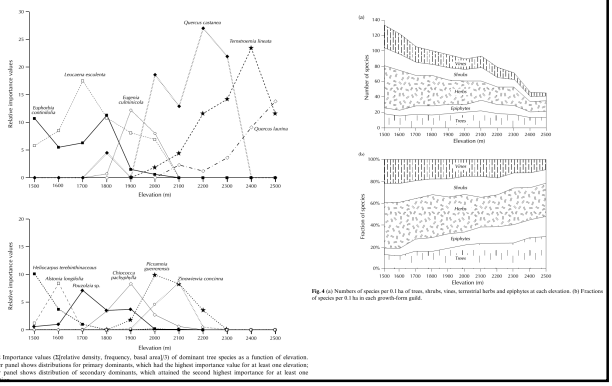
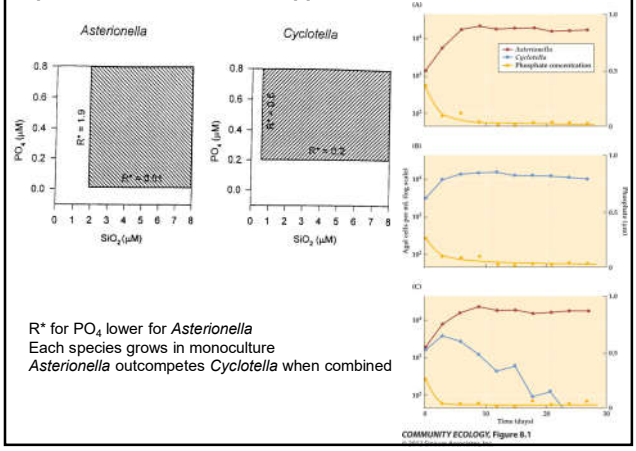


Fig. 2 Importance values (%)(relative density, frequency, basal area)/3) of dominant tree species as a function of elevation. Upper panel shows distributions for primary dominants, which had the highest importance value for at least one elevation; lower panel shows distribution of secondary dominants, which attained the second highest importance for at least one

Fig. 4 (a) Numbers of species per 0.1 ha of trees, shrubs, vines, terrestrial herbs and epiphytes at each elevation. (b) Fractions of species per 0.1 ha in each growth-form guild.

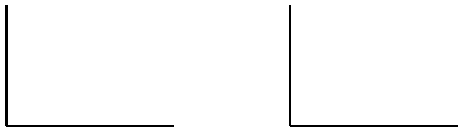
Experimental evidence in support of R* model

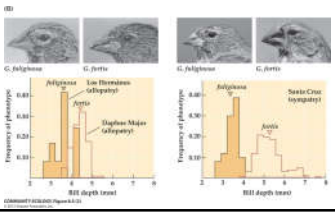


R* for PO_4 lower for *Asterionella*
Each species grows in monoculture
Asterionella outcompetes *Cyclotella* when combined

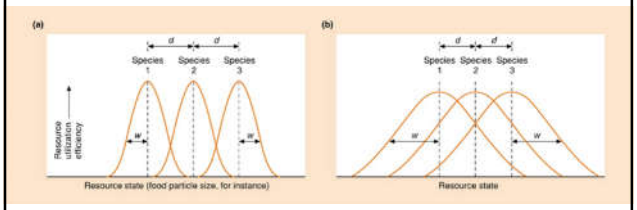
Evolutionary Response to Competitive Interaction

- Two coexisting and competing species, expect niche diversification/differentiation.





Niche Width and Niche Differentiation

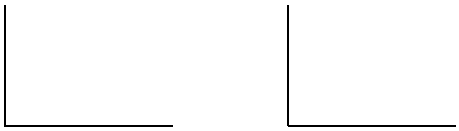


$$\alpha = e^{-d^2/4w^2}$$

- Competition coefficient (alpha) defined by the relative distance between niche modes (d) and the standard deviation in niche size (w).
- w determines if a species is a generalist or specialist

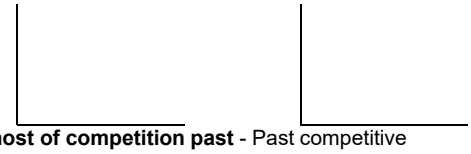
Niche Packing

- Stable and diverse systems (terrestrial tropical ecosystems) tend to display species packing.
- Niches are narrower (smaller w) and closer (smaller d)

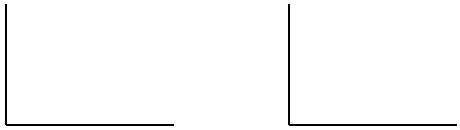


Competitive Release and Ghost of Competition Past

- **Competitive release** - In the absence of a competitor, a species niche expands. Realized niche expands, more similar to fundamental niche.



- **Ghost of competition past** - Past competitive interactions lead to change in a species such that the fundamental niche is different, competitive release does not occur.



Character Displacement

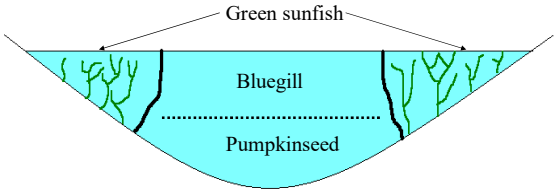
- Single species occupying variety of niches
- Morphological variability
- Density dependent competition
- Extreme morphotypes most succesful in slightly different niches
- Extreme morphotypes selected for (reduced competition increases fitness)
- Different habitat preference evolves after morphology

Werner and Hall 1976

Niche Shifts in Sunfishes: Experimental Evidence and Significance

Abstract. *Three species of sunfishes segregate ecologically when stocked together in small ponds. When each species is stocked separately in replicate ponds, it exhibits competitive release through increases in growth rate and average food size. Niche shifts are indicated by convergence of these species to the same food habits in the absence of competitors. These shifts are due to phenotypic (behavioral) plasticity. The significance of niche flexibility is related to seasonal patterns in resource availability.*

Distribution in Nature



Werner and Hall 1976

Table 2. Percent contribution of prey categories to the diets of the bluegill (*L. macrochirus*), pumpkinseed (*L. gibbosus*), and green sunfish (*L. cyanellus*) on the basis of dry weight and computed for the entire experimental period.

Prey	*L. macrochirus*	*L. gibbosus*	*L. cyanellus*	
Species alone				
Vegetation dwellers	61	41	43	Most abundant prey
Benthic in- and epifauna	10	12	23	
Open water zooplankton	8	1	1	
Other	21	47	33	
Species together				
Vegetation dwellers	15	5	40	← Reduced in all 3
Benthic in- and epifauna	15	34	12	
Open water zooplankton	33	6	4	
Other	37	55	44	← Increased in all 3

Werner and Hall 1976

Table 1. Mean size of individual *Lepomis* fish in October with mean values given in grams of dry weight ± standard error. The initial individual weight of each species was approximately 0.1 g ($N > 100$).

Fish	Species together	Species alone
L. macrochirus	1.29 ± 0.02	3.6 ± 0.15
L. gibbosus	1.21 ± 0.03	1.38 ± 0.04
L. cyanellus	1.34 ± 0.03	1.74 ± 0.04

Table 3. Mean size of food (milligrams of dry weight ± standard error) computed for the entire experimental period.

Fish	Species together	Species alone
L. macrochirus	0.0065 ± 0.001	0.0196 ± 0.002
L. gibbosus	0.0277 ± 0.004	0.0388 ± 0.007
L. cyanellus	0.0404 ± 0.008	0.0590 ± 0.009

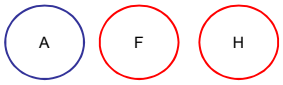
Ghost of Competition Past

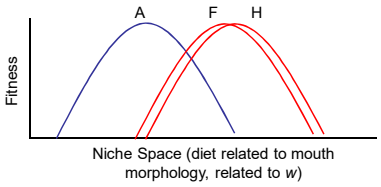
- Invoking **Ghost of Competition Past** - It's tempting to conclude two coexisting species do not compete because past competitive interactions lead to niche differentiation that reduced competitive pressure.
- Evolutionary and ecological explanation
- Phylogenetic explanation

Niche Conservatism

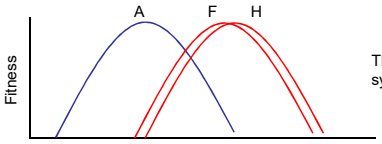
- Tendency for a species to retain the ecological niche of its ancestors
  - **Phylogenetic signal** – niches are similar, show a phylogenetic pattern, change gradually. Not under strong selection.
  - **Niche conservatism** – niches are more similar than expected. Stabilizing selection results in little change from ancestral niche.

Three competing species, color represents two distinct mouth morphologies. All are endemic to an island archipelago ~3 million years old.

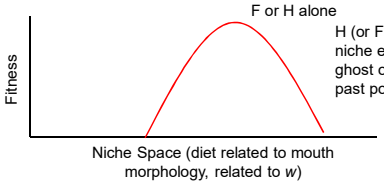




Is the difference in mouth morphology due to past competition?

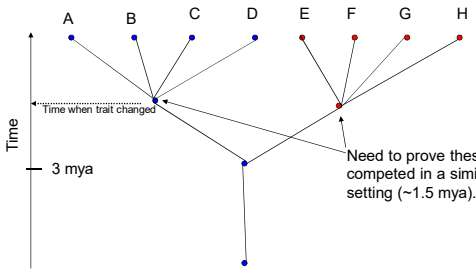


Three species in sympatry



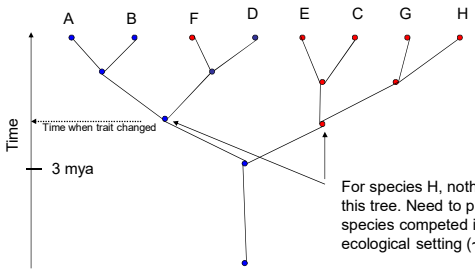
H (or F) alone, no niche expansion… ghost of competition past possible ?

Phylogenetic Tree 1



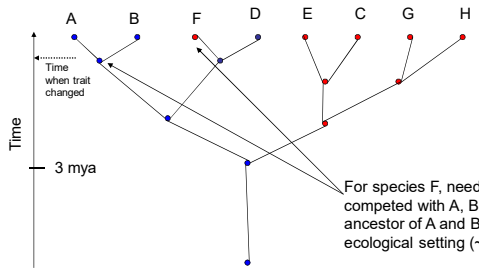
Need to prove these two species competed in a similar ecological setting (~1.5 mya).

Phylogenetic Tree 2



For species H, nothing changed in this tree. Need to prove these two species competed in a similar ecological setting (~1.5 mya).

Phylogenetic Tree 2



For species F, need to prove F competed with A, B or common ancestor of A and B in a similar ecological setting (~0.5 mya).

Easiest ghost of comp past to demonstrate is D and F – sister taxa recently diverged, endemic to a “new” habitat.