

Coevolution of competitors

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1) Coevolution

Strict definition of coevolution:

Reciprocal evolutionary change of interacting species.

In this course we will consider coevolution as well as other evolutionary consequences of these interspecific interactions:

- Competitive interactions
- Predator-prey interactions
- Host-parasite interactions
- Mutualistic interactions

2) Ecological character displacement

Definition of ecological character displacement:

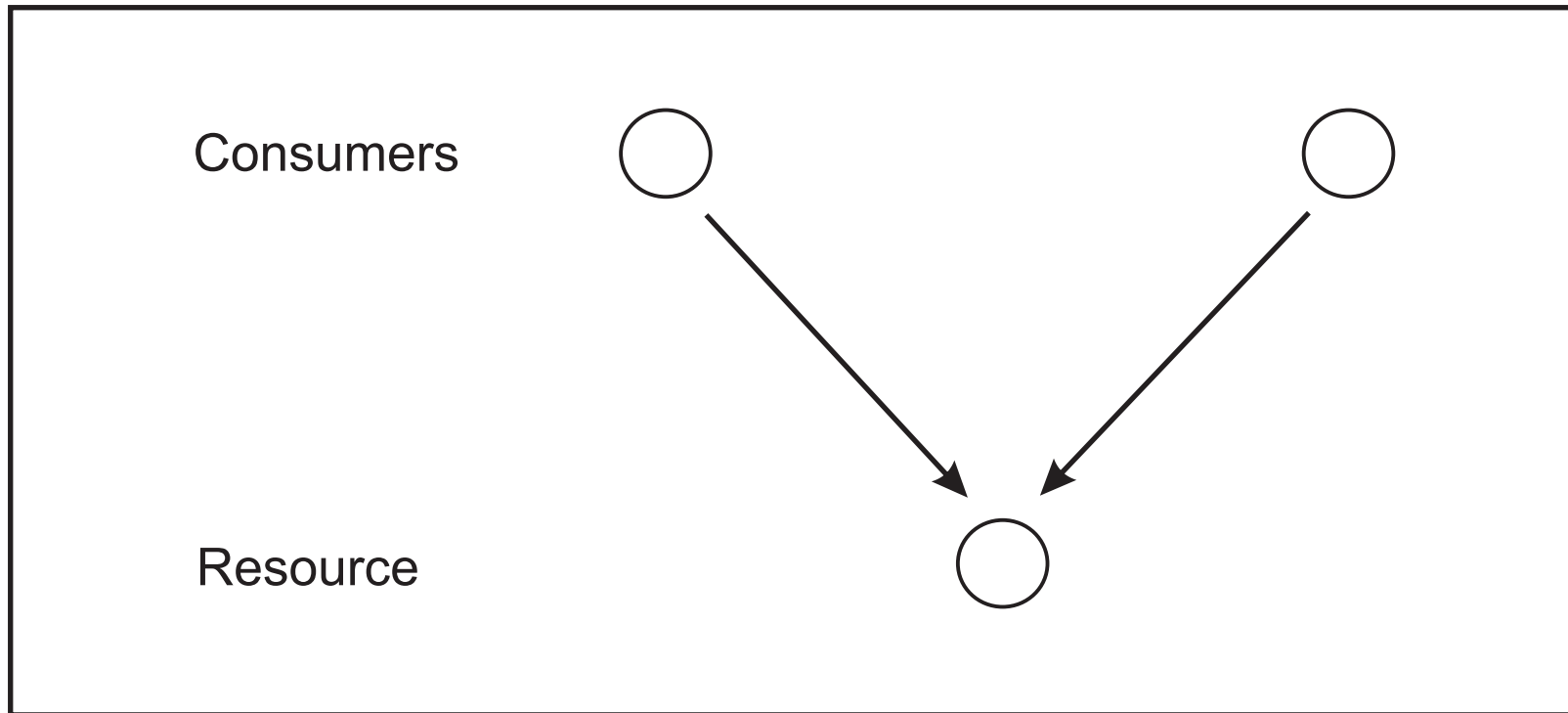
The process whereby one species influences the evolution of another species via interspecific competition.

Process is similar to coevolution of competitors, but it is broader. It also includes cases of non-reciprocal evolution (in which one species affects evolution in a second species, but not vice-versa).

2) Ecological character displacement

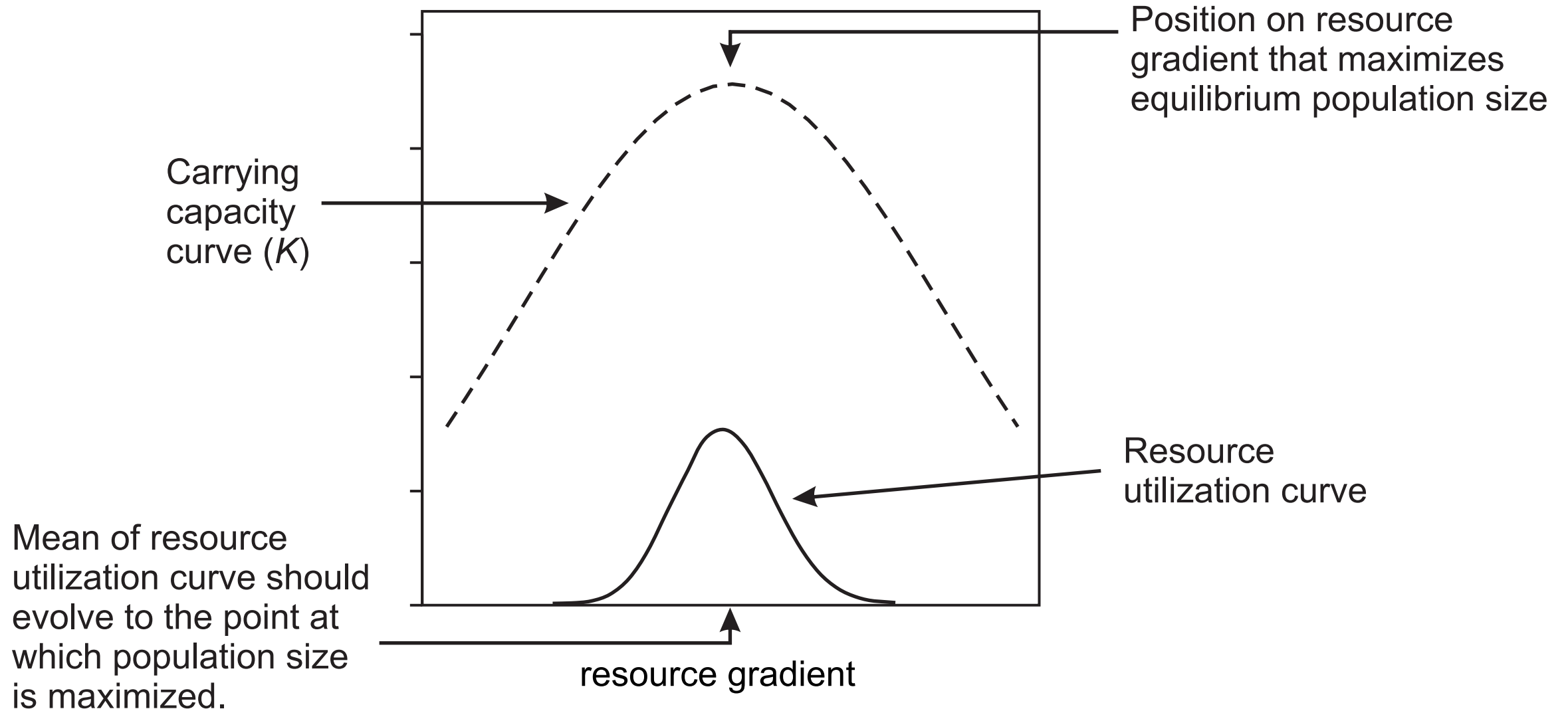
The term is usually applied to cases involving resource exploitation competition, not to interference competition

A simplified interaction web



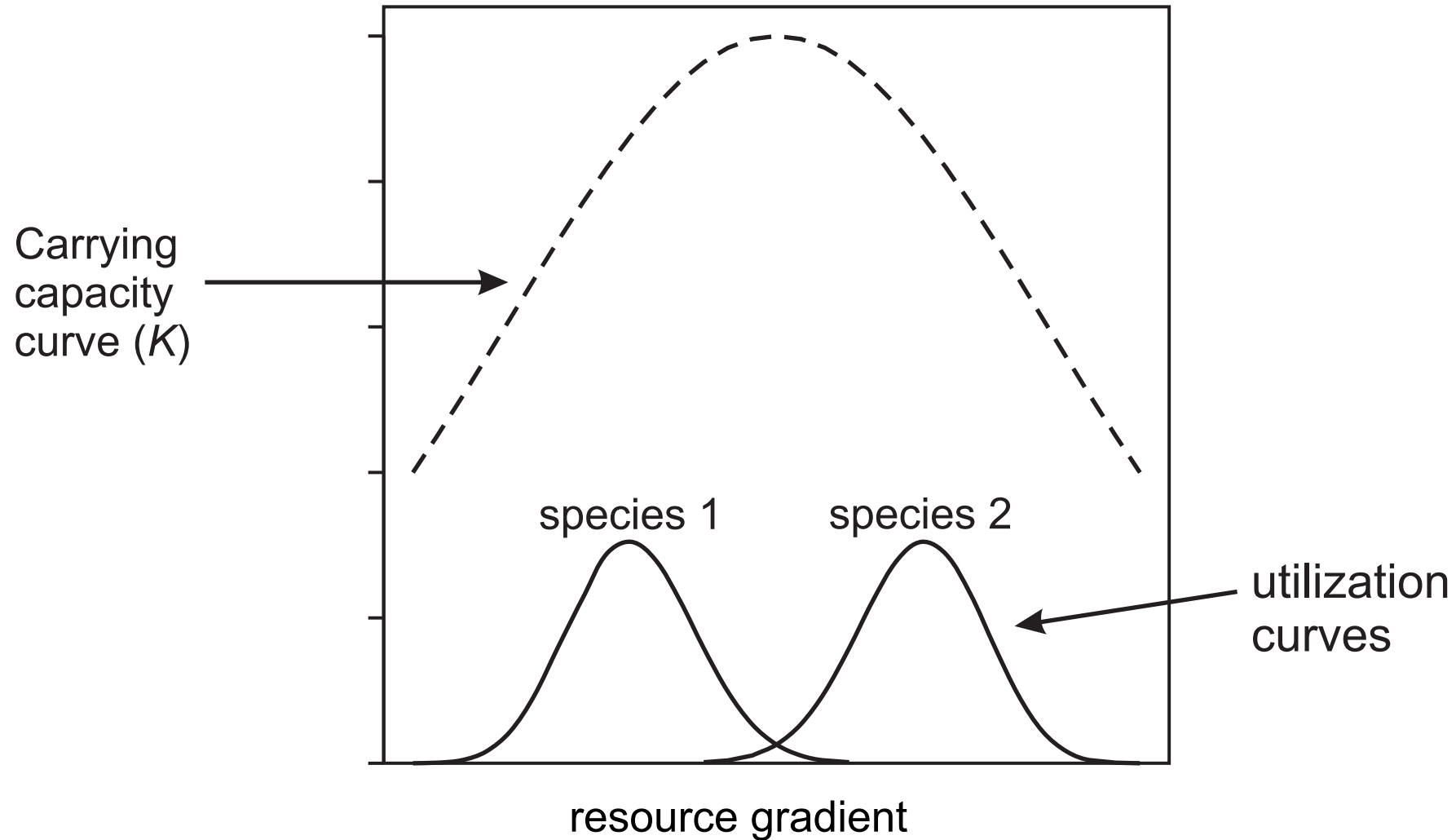
2) Ecological character displacement

Prediction of (simple) theory for evolution in a single species.
Only intra-specific competition is present



2) Ecological character displacement

Prediction of (simple) theory for evolution of two competing species
Both inter- and intra-specific competition are present



2) Ecological character displacement

Assumptions of simple theory:

- Competition is symmetric
- No other sources of selection on resource utilization are present
- Carrying capacity curve has a bell shape

Additional predictions:

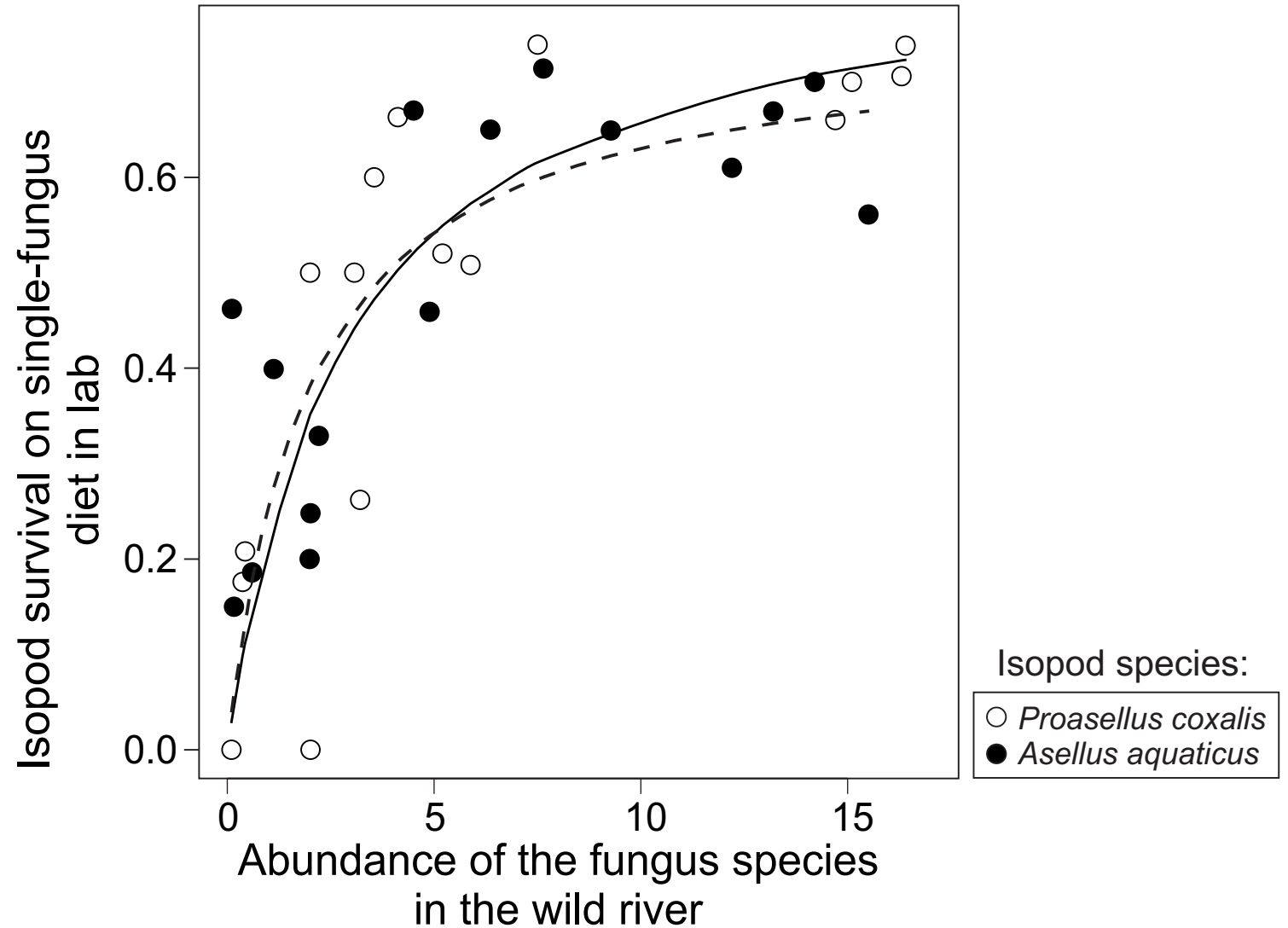
- Divergence does not occur if resource utilization curves are very broad relative to the breadth of the K-curve
- Divergence occurs most rapidly when there is an initial difference in utilization between the two species.

3) Examples

Isopods in separate rivers each are well adapted to the most abundant fungi there.
(This pattern breaks down in a river where both species occur together.)

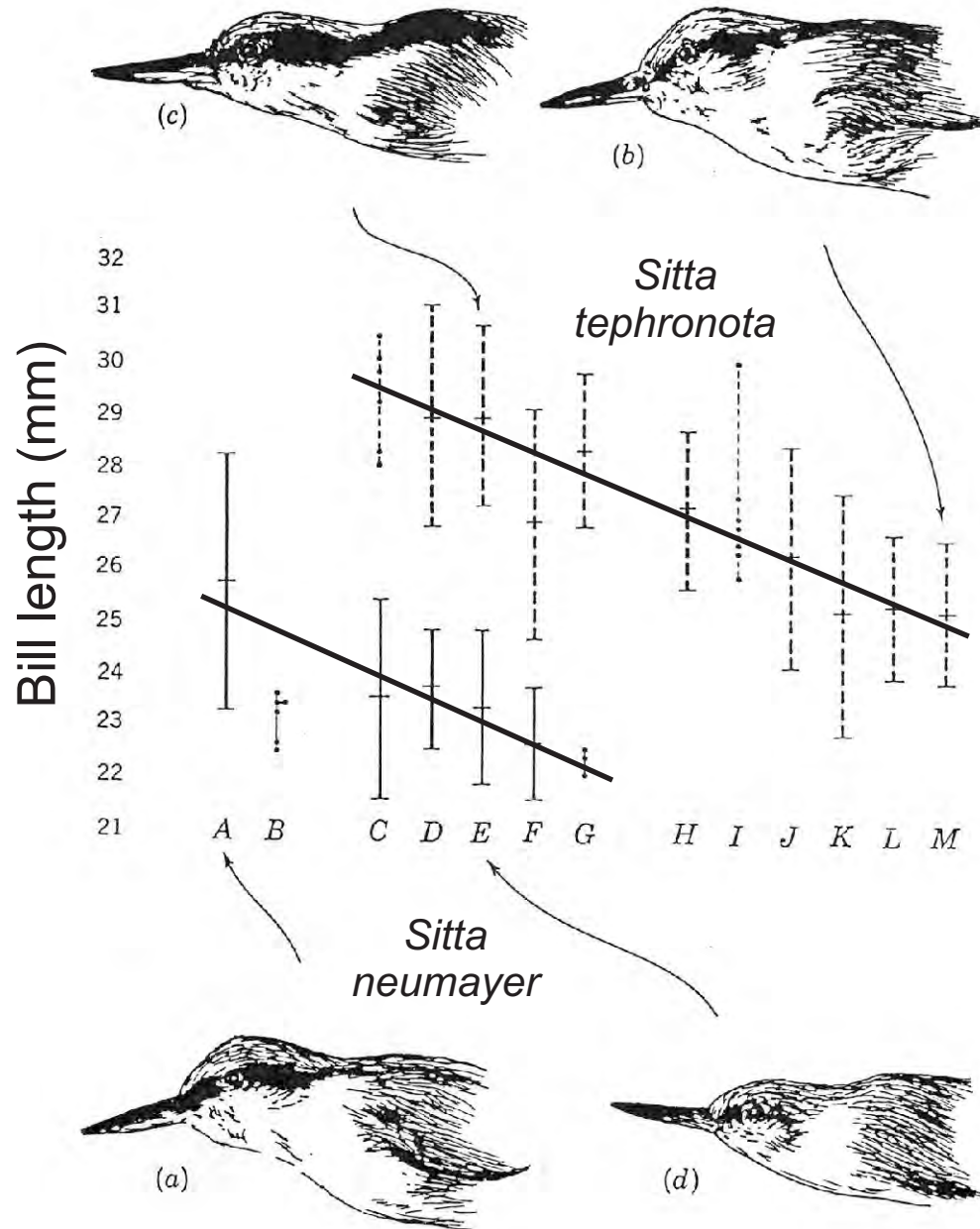


<http://nathistoc.bio.uci.edu/crustacea/Isopoda/Water%20slater.htm>



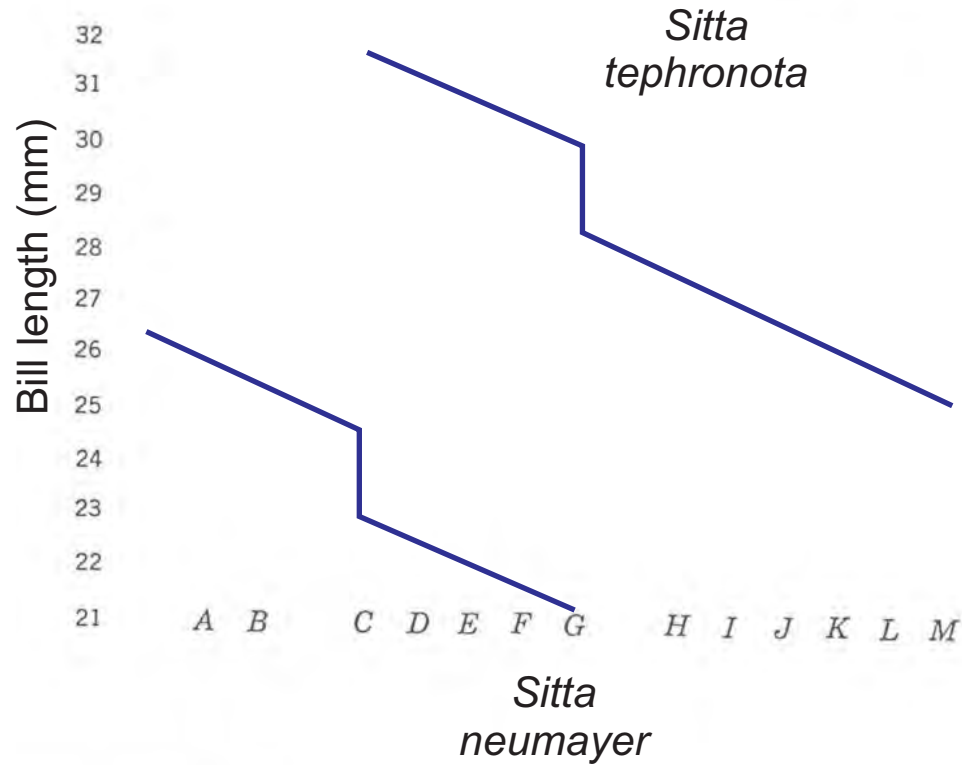
3) Examples

Character displacement in Eurasian nuthatches?



<http://www.larslundmark.se/klippnotvacka.asp>

3) Examples



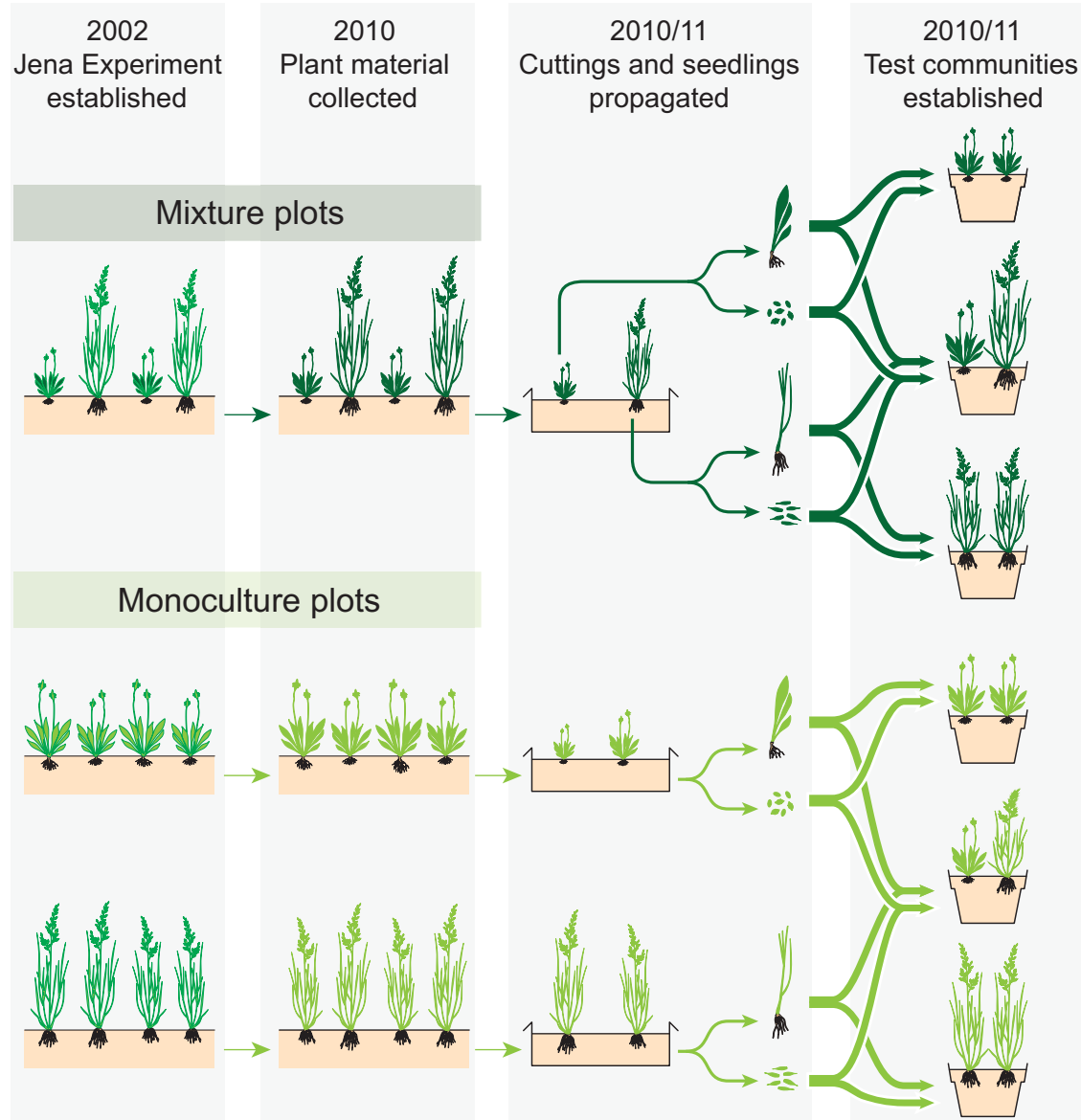
Critique:

Character displacement would be a more convincing interpretation if the pattern had this form instead.



3) Examples

Niche differentiation in plant communities



Field monocultures and mixed plots were established in 2002 in Jena, Germany. After 8 years, plants were collected and assembled in test monocultures and mixtures in the greenhouse.

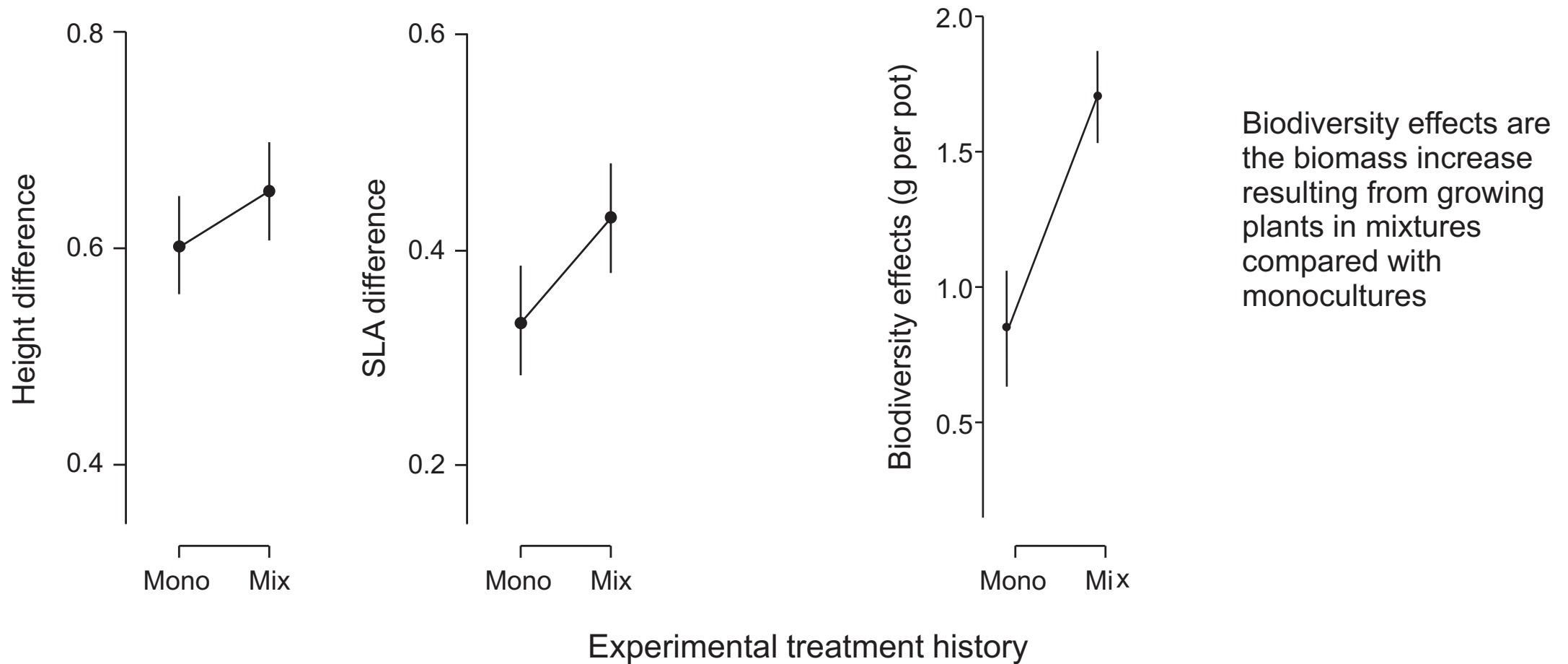


<http://www.the-jena-experiment.de/The+Experiment.html>

3) Examples

Plants grown for 8 years in mixtures had larger species differences in plant height and plant specific leaf area (SLA), and had larger biodiversity effects, than species grown for 8 years in monocultures.

Whether it has a genetic basis, and therefore represents evolution, is not known.



3) Examples

Character displacement in stickleback

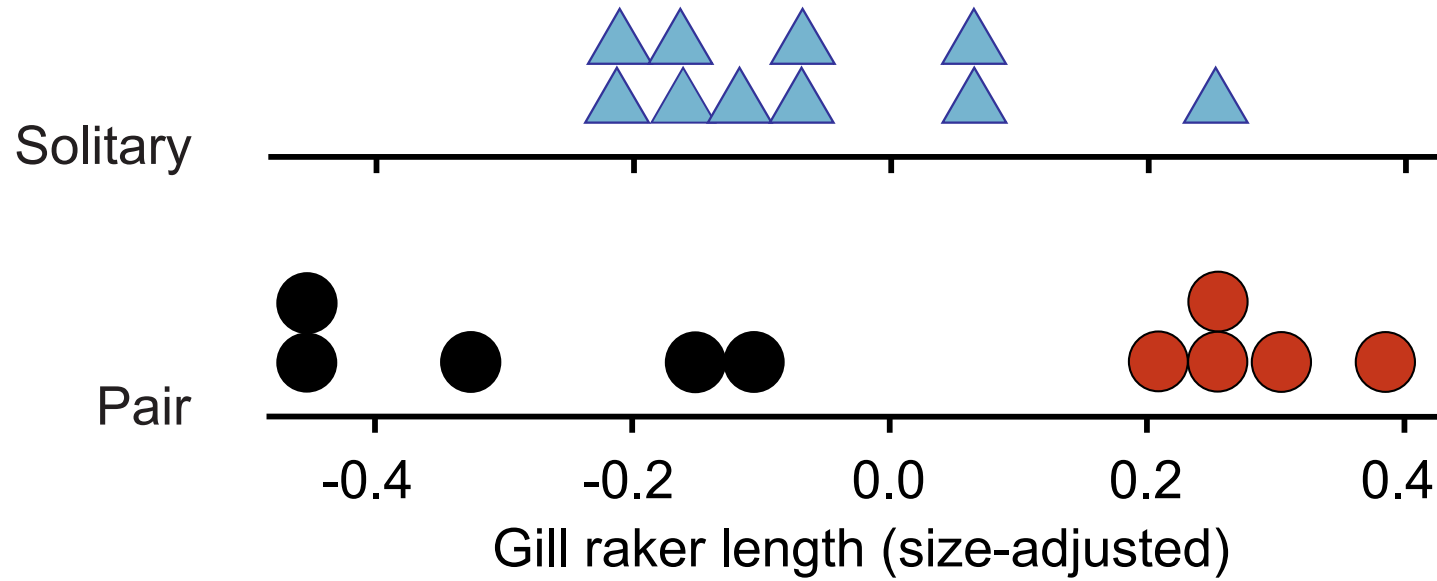
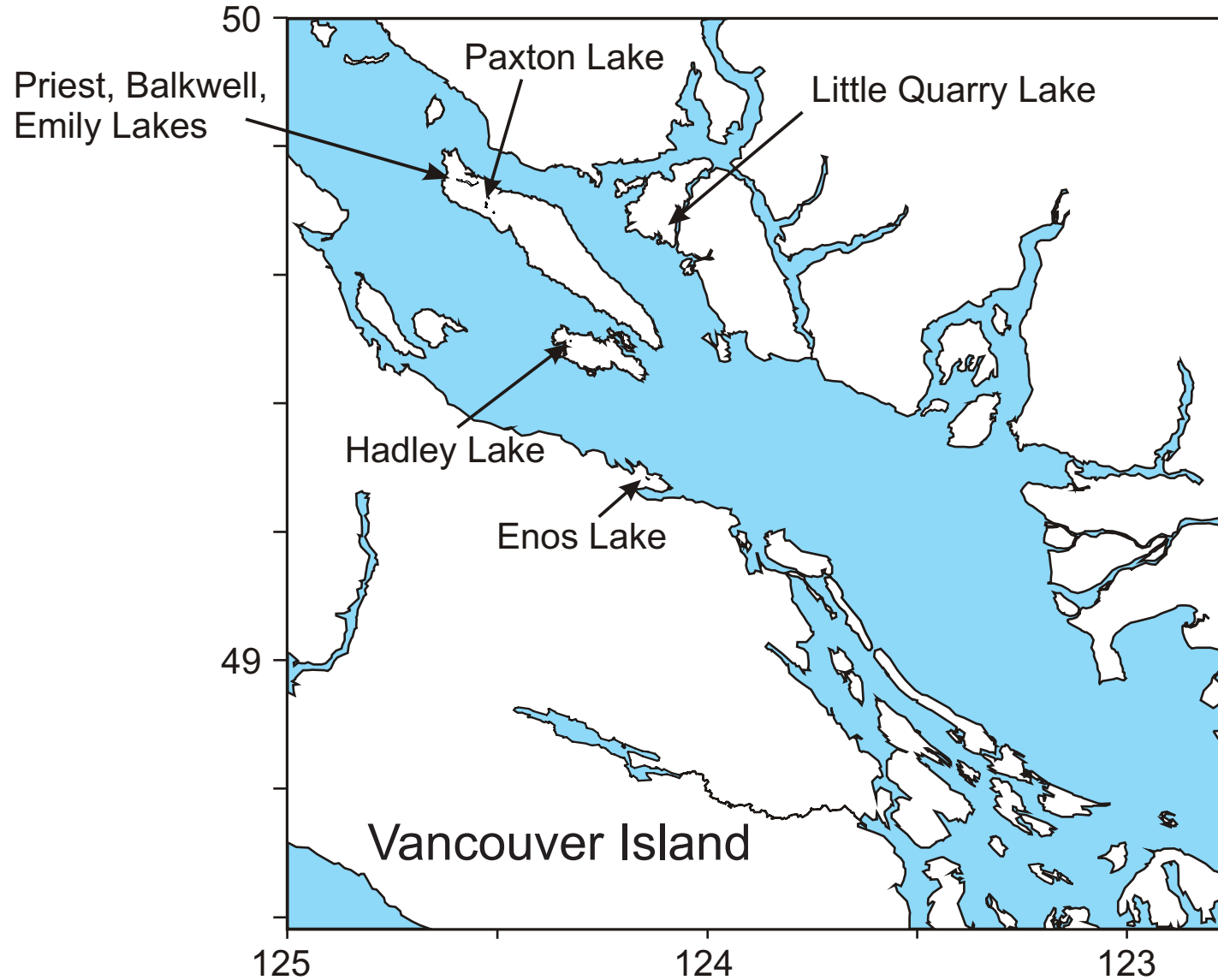


photo: T Hatfield

3) Examples

Pairs occurred in 5 small-lake systems

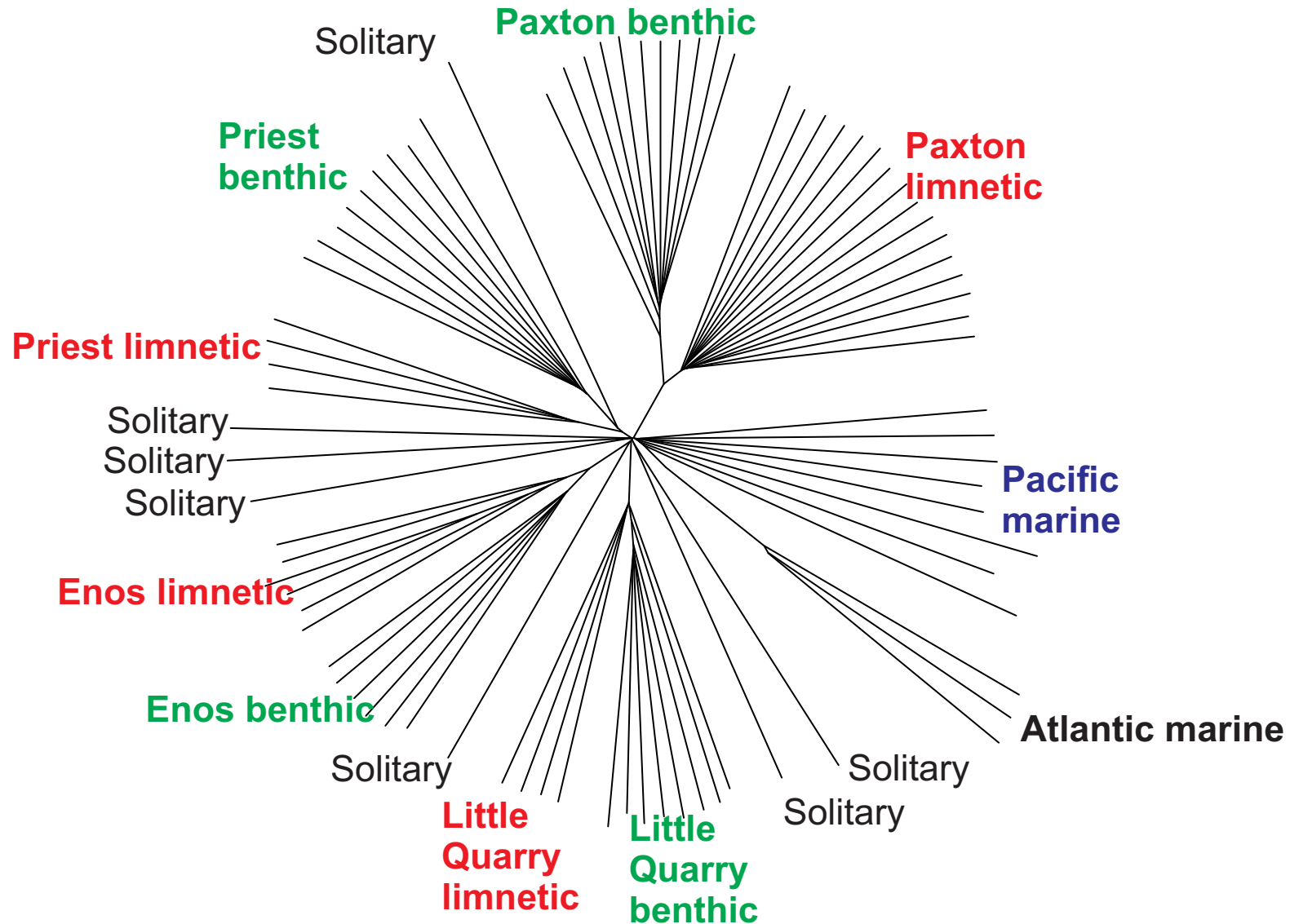


4) Criteria for demonstrating character displacement

1. Chance should be ruled out as an explanation (i.e., replication needed)
2. Phenotypic differences between populations should have a genetic basis
3. Enhanced differences in sympatry should be the outcome of evolutionary shifts, not simply biased extinction of similar forms
4. Morphological differences should reflect differences in resource use
5. Sites of sympatry and allopatry should not differ in food, climate, etc.
6. Independent evidence should be gained that similar phenotypes compete for resources.

4) Criteria for demonstrating character displacement

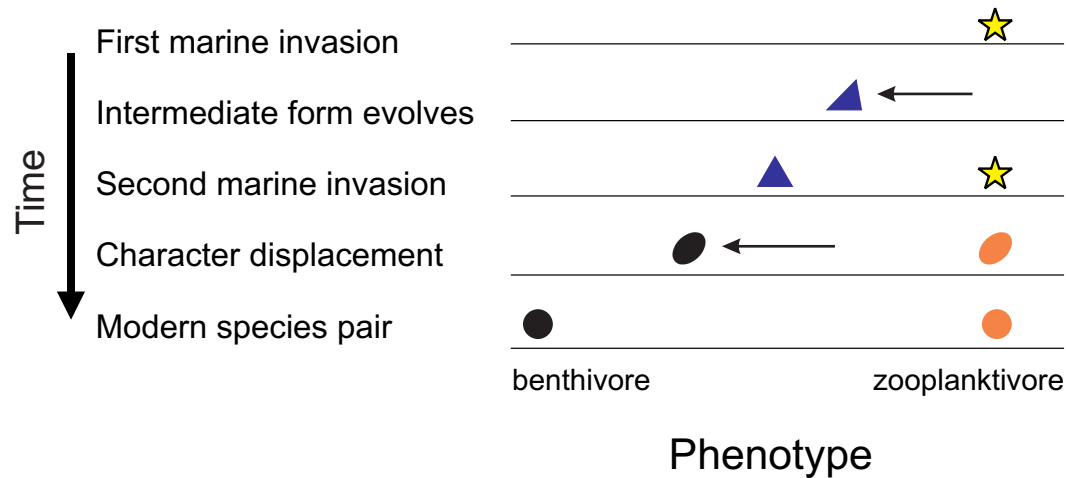
Evidence for multiple origins of stickleback forms from complete genome sequences



4) Criteria for demonstrating character displacement

Experimental test of declining competition during stickleback divergence

Character displacement sequence



Experimental treatments

Early in series
(pre-displacement)



Late in series
(post-displacement)



Phenotype

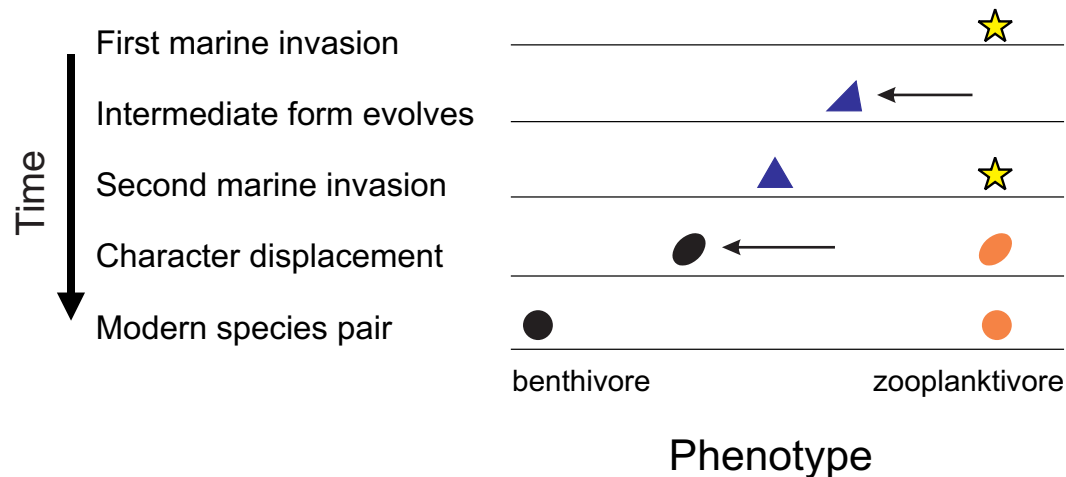
Experimental ponds



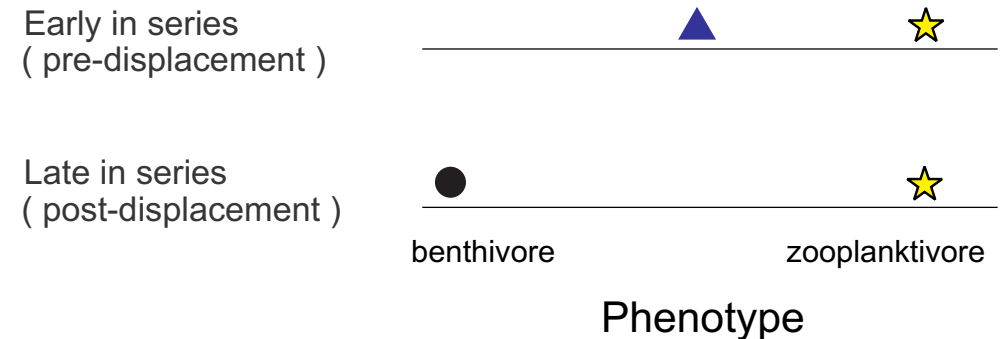
4) Criteria for demonstrating character displacement

Experimental test of declining competition during stickleback divergence

Character displacement sequence



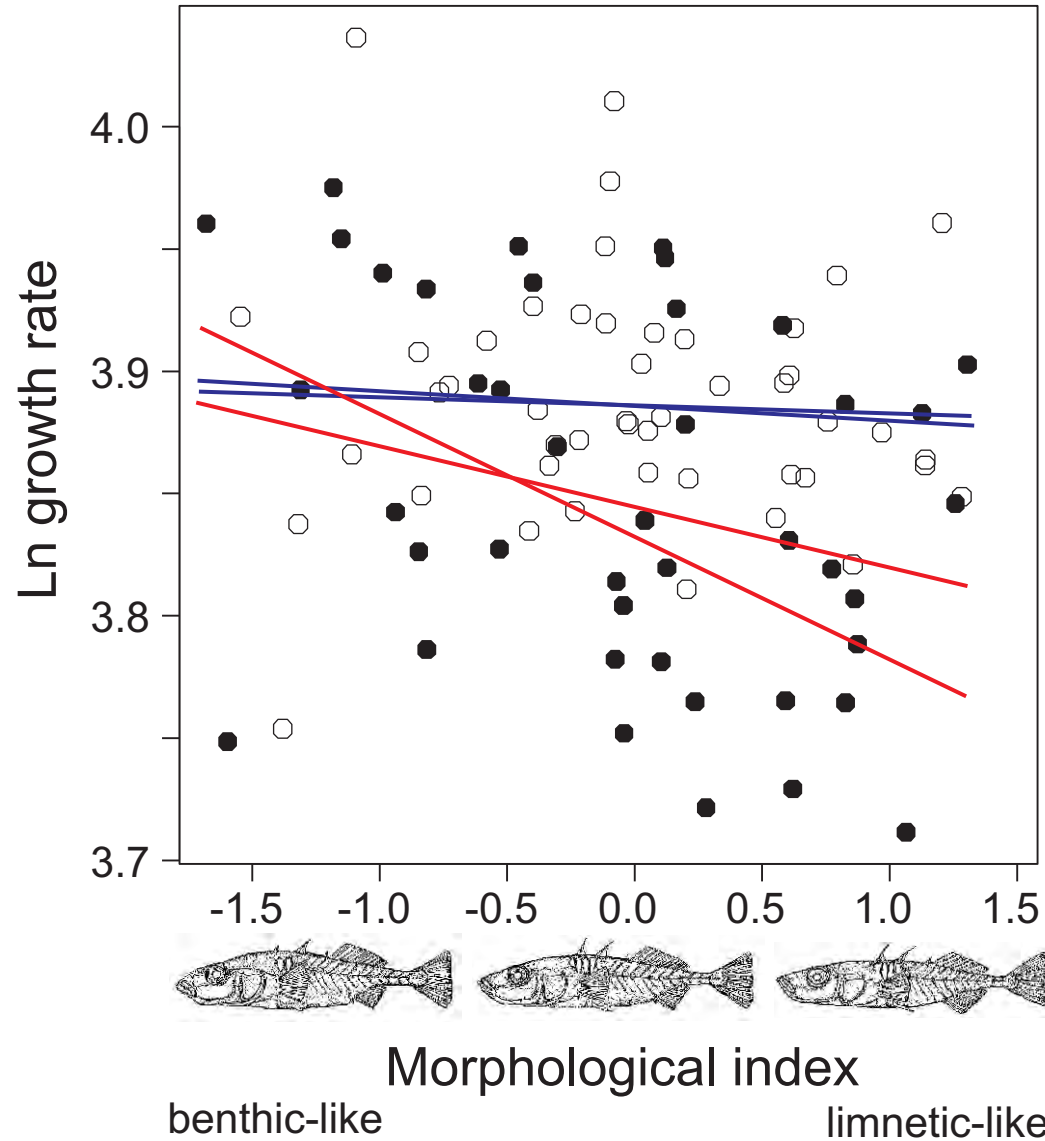
Experimental treatments



Results:
Competition between the forms was indeed weaker in the “late” treatment than in the “early” treatment.

5) Experiments on selection and evolution

Selection on an experimental intermediate stickleback population

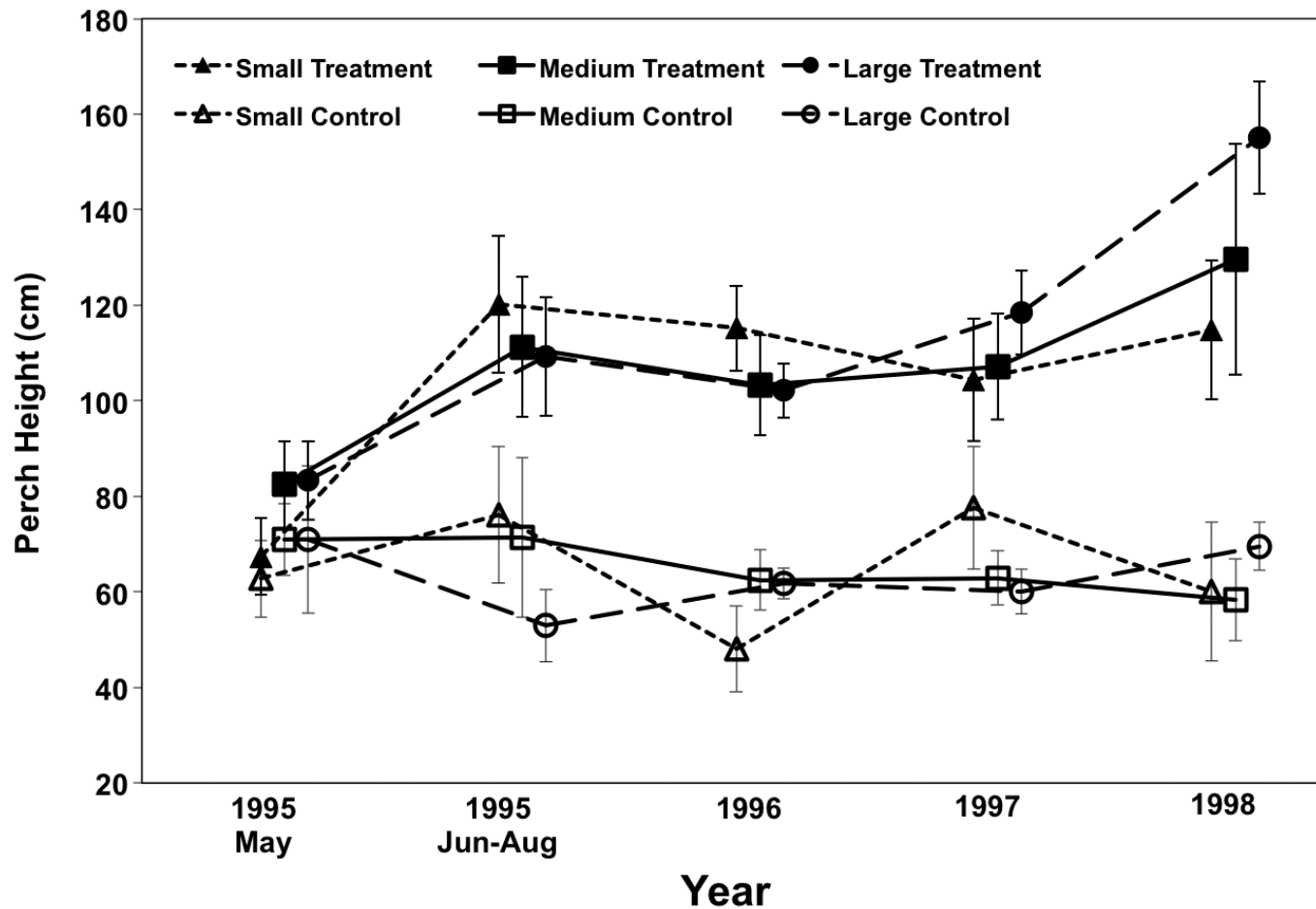


Growth of intermediate phenotypes in ponds in the presence and absence of a limnetic competitor

5) Experiments on selection and evolution

Experimental sympatry between *Anolis* lizard species on three islands

Shift in perch height by *A. carolinensis* (a native species) after experimental introduction of *A. sagrei* (an invasive species) in 1995 to small, medium, and large islands in Florida.



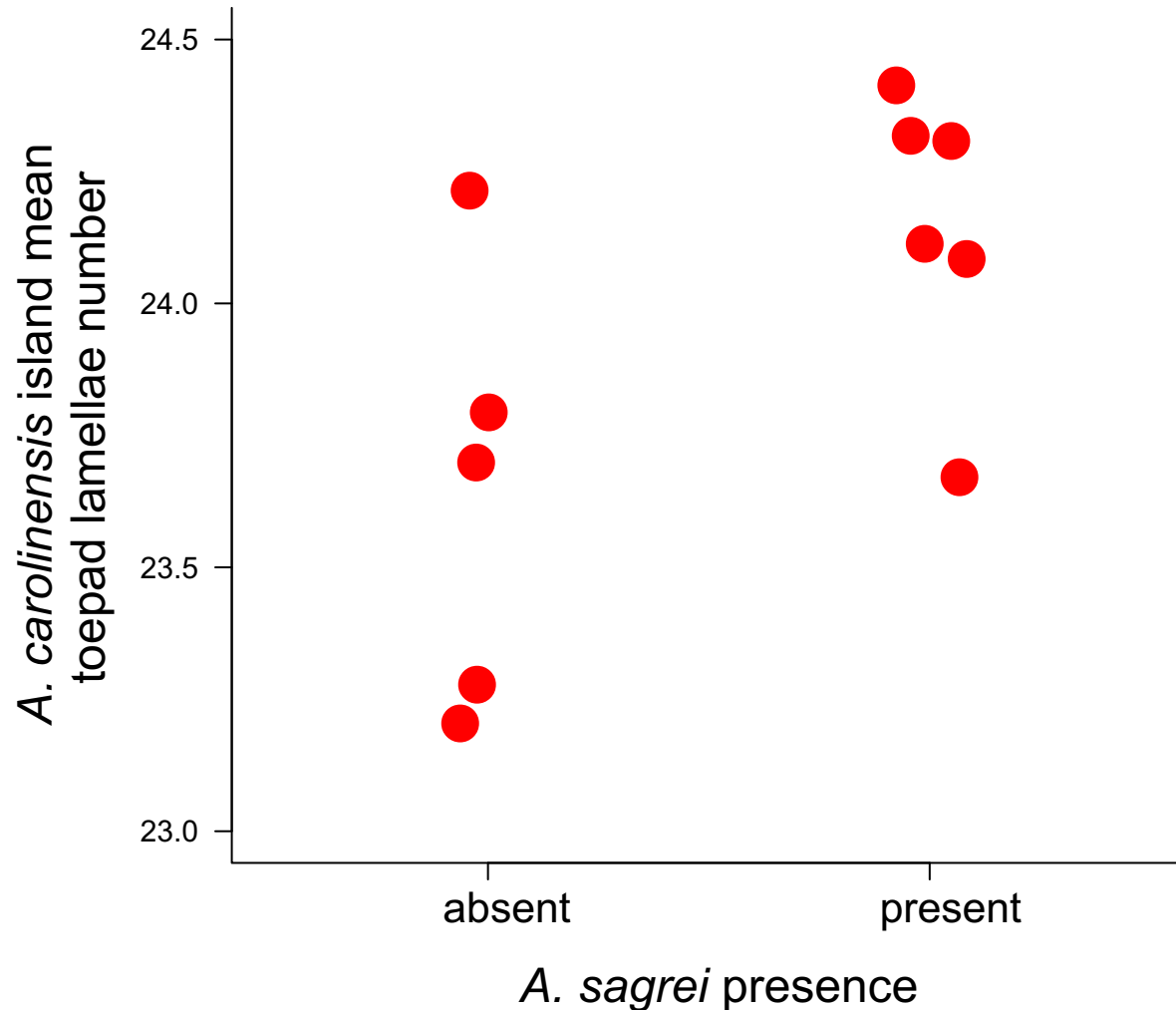
A. carolinensis by J. Losos



A. sagrei by T. Sanger

5) Experiments on selection and evolution

Mean number of toepad lamellae in 2010 on these same islands plus a few other islands colonized about the same time

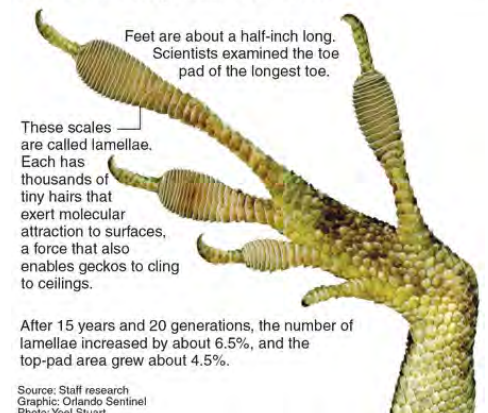


A. carolinensis
J. Losos

Toe pad lamellae are adhesive, setae-laden scales. Larger and better developed toepads improve clinging ability, allowing lizards to better grasp narrow perches.

Evolution gives native lizards a leg up

Scientists have found that rapid evolution gave bigger, stickier feet to Florida's green anole lizards, which fled from the ground into bushes and branches to escape Cuban brown anoles.



6) Convergent character displacement

When species converge as a consequence of interspecific competition.

Not to be confused with a failure to diverge despite interspecific competition.

Theory by Abrams (1987) predicts circumstances that might favor convergence, such as non-substitutable resources.

Interspecific competition for the same, limiting non-substitutable resource (e.g., light) might cause species to evolve similar traits to harvest it (e.g., both of two plant species redirect growth toward shoots).

There are no known examples.

7) Community-wide character displacement

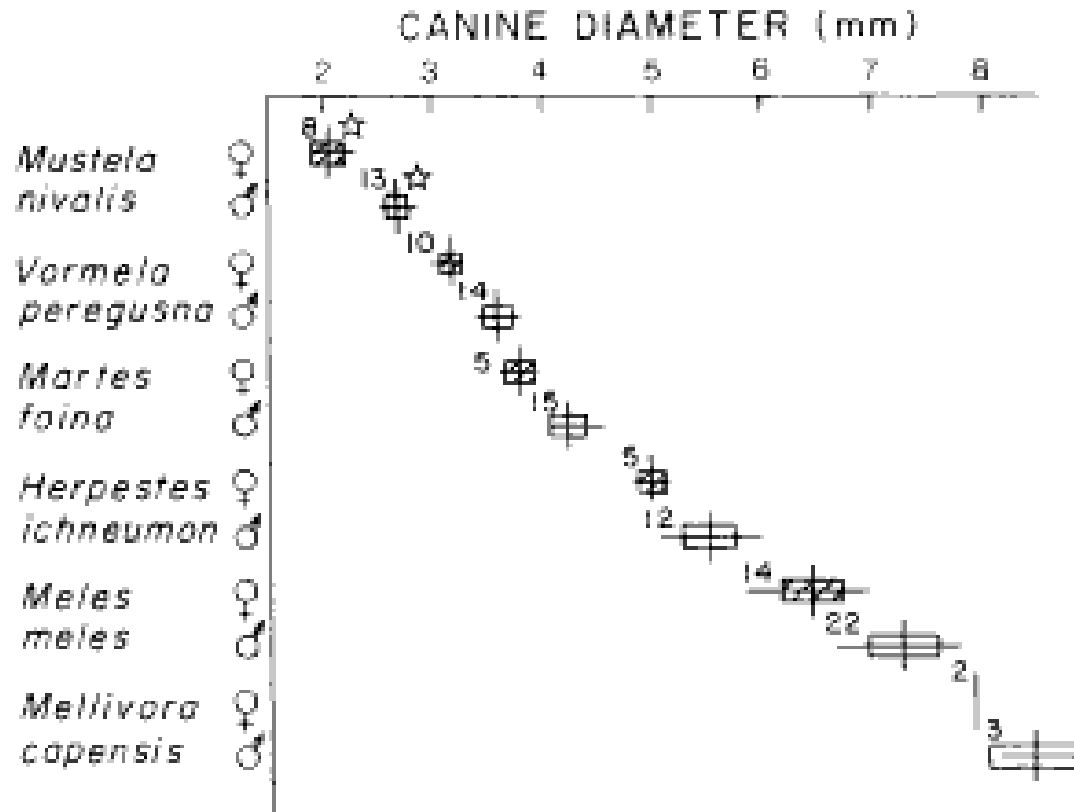


FIG. 4. Anterior-posterior diameters of upper canines ($C^{sup}L$) of members of the Israeli mustelid-viverrid guild, plus an extinct weasel (☆). Conventions as in Fig. 1.

vertical lines represent means
 horizontal bars represent \pm standard deviation
 horizontal lines represent ranges

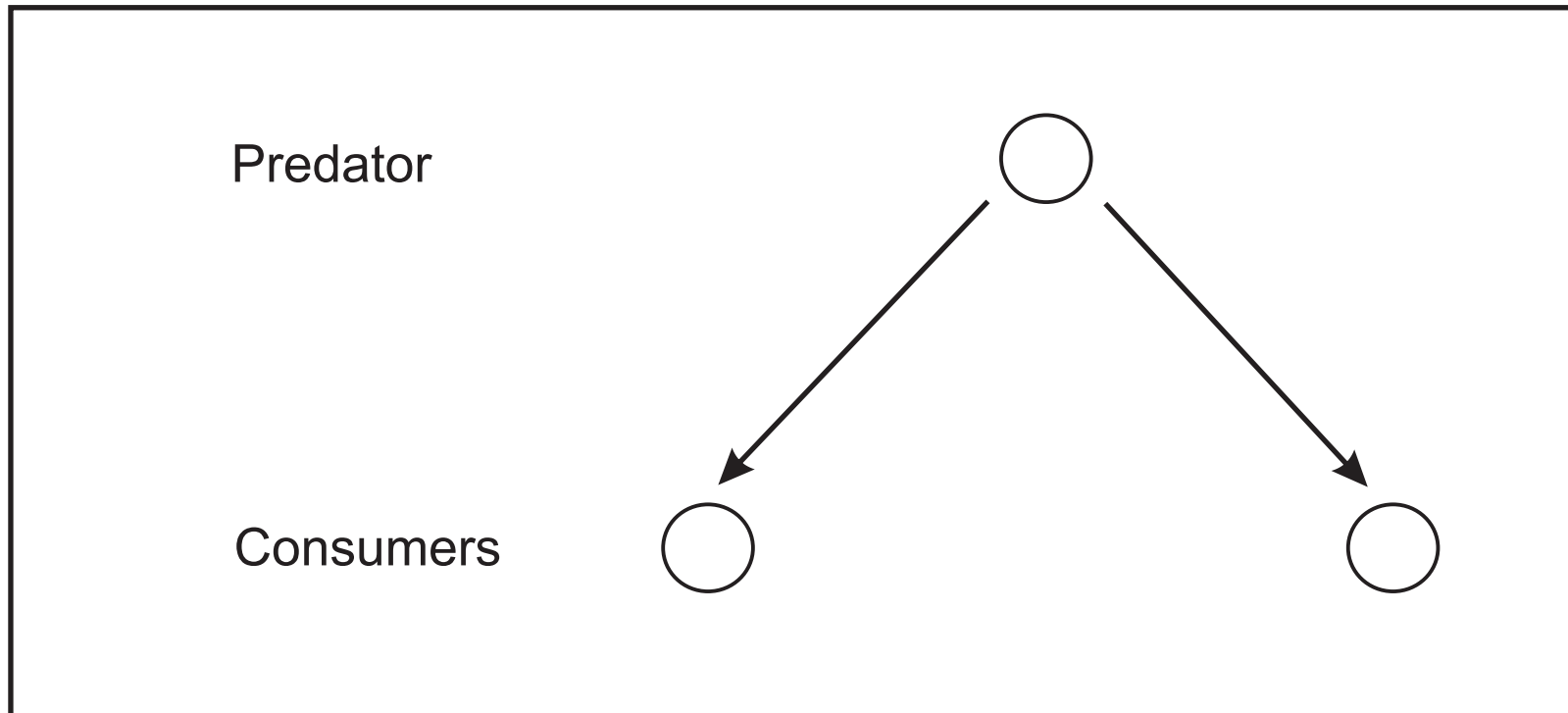


<http://www.myoops.org/twocw/tufts/courses/5/content/215908.htm>

8) Divergence via 'apparent competition'

An indirect antagonistic interaction between prey species that might result when they share a predator

'Apparent competition'



8) Divergence via 'apparent competition'

Character displacement in *Passiflora* leaf shape via apparent competition?

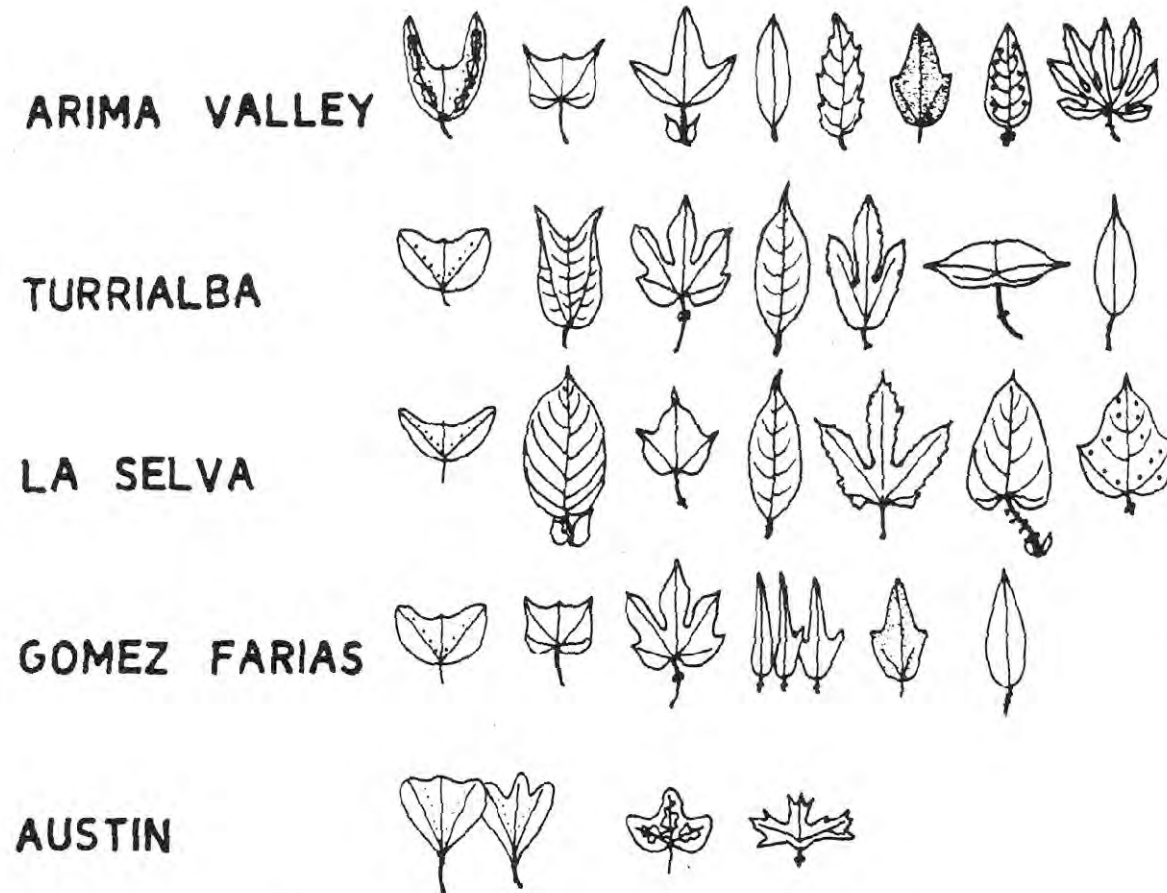


Figure 4. Leaf shape variation among sympatric species of *Passiflora*. The localities are from the top: Trinidad, Costa Rica, Costa Rica, Mexico and Texas.

Heliconius cydno (host generalist)



http://www.kiisla.fi/Uudet_galleriat/Costa_Rica/Elaimet_Tortuguero/

9) Example exam questions

Under what circumstances might we expect competition between two species to result in

- - divergent character displacement
- - convergent character displacement
- - lack of divergence

A researcher recently observed that two species of weasels are more different in size where they occur together (site A) than where they occur separately (sites B and C). The researcher suggested that the pattern was evidence of ecological character displacement between the weasels. Is the evidence compelling? Provide three alternative explanations that might also account for the pattern instead.

Describe the evidence that you think ought to be obtained before we can conclude that a pair of sympatric species has evolved greater differences in mean phenotype because of “apparent competition” (the negative interaction between species arising via their shared predators rather than via shared resources)?