Lecture 25. Speciation Mechanisms (cont.); Hybridization

EEB 2245, C. Simon

27 Apr 17

Last time …

- Speciation mechanisms (continued)
  - *Magicicada* case study (allochronic speciation and reproductive character displacement- disruptive selection)
  - Divergence with gene flow
  - Parapatric speciation
    - Ecotone- adaptive genes w hitchhiking male and female choice genes
    - Dobzhansky-Mueller interactions (certain allele combinations cause sterility).
  - Sympatric speciation (host races)

This time …

Speciation mechanisms (cont).

- The link btw character displacement and disruptive selection.
- Sympatric speciation (host races)
- Chromosomal speciation
- Parallel speciation
- Hybrid speciation w/o polyploidy (galapagos finches)
- Hybrid speciation w/ polyploidy (sunflowers)
- The importance of co-adapted allele complexes.

Remember from Lecture 19…

Three major categories of natural selection

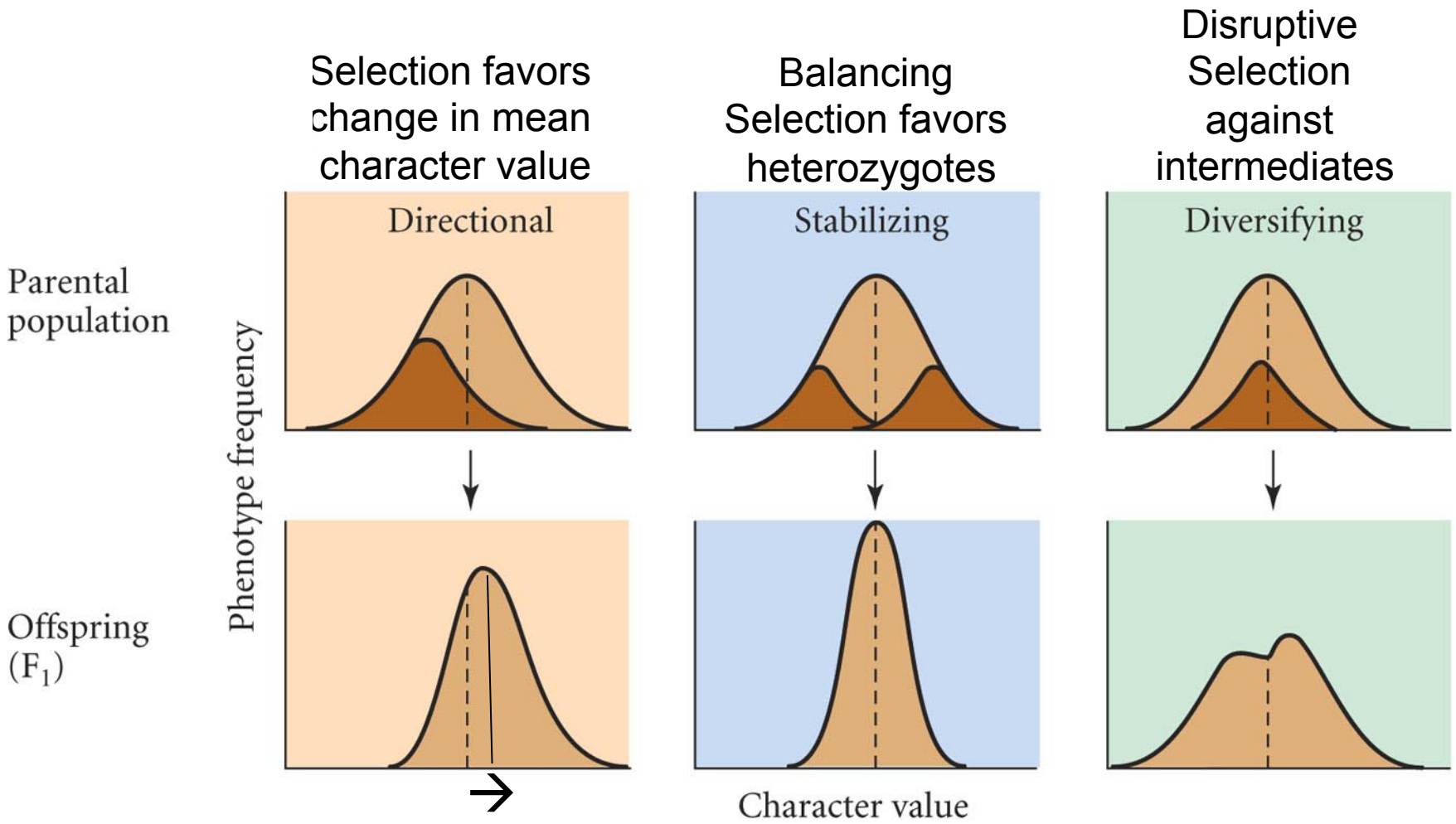


Fig. 12.1 Futuyma. Dark brown areas = lower fitness, selected against

Diversifying or Disruptive Selection against intermediates (heterozygotes, hybrids)

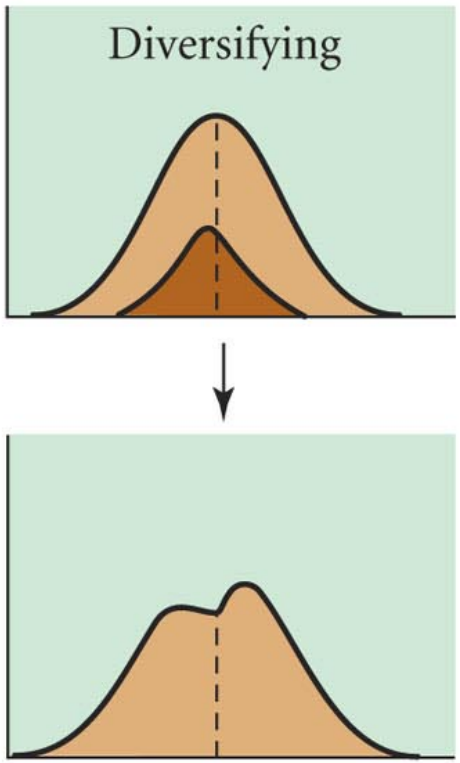


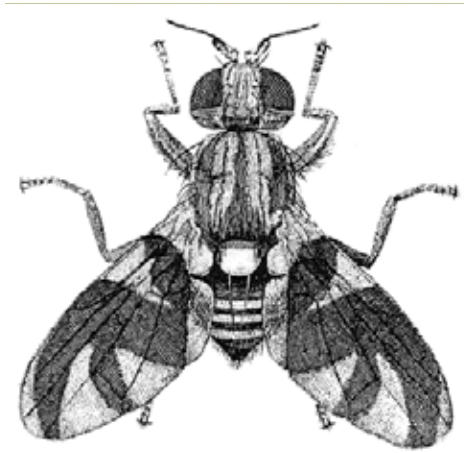
Fig. 12.1 Futuyma. 3e. Dark brown areas = lower fitness; selected against

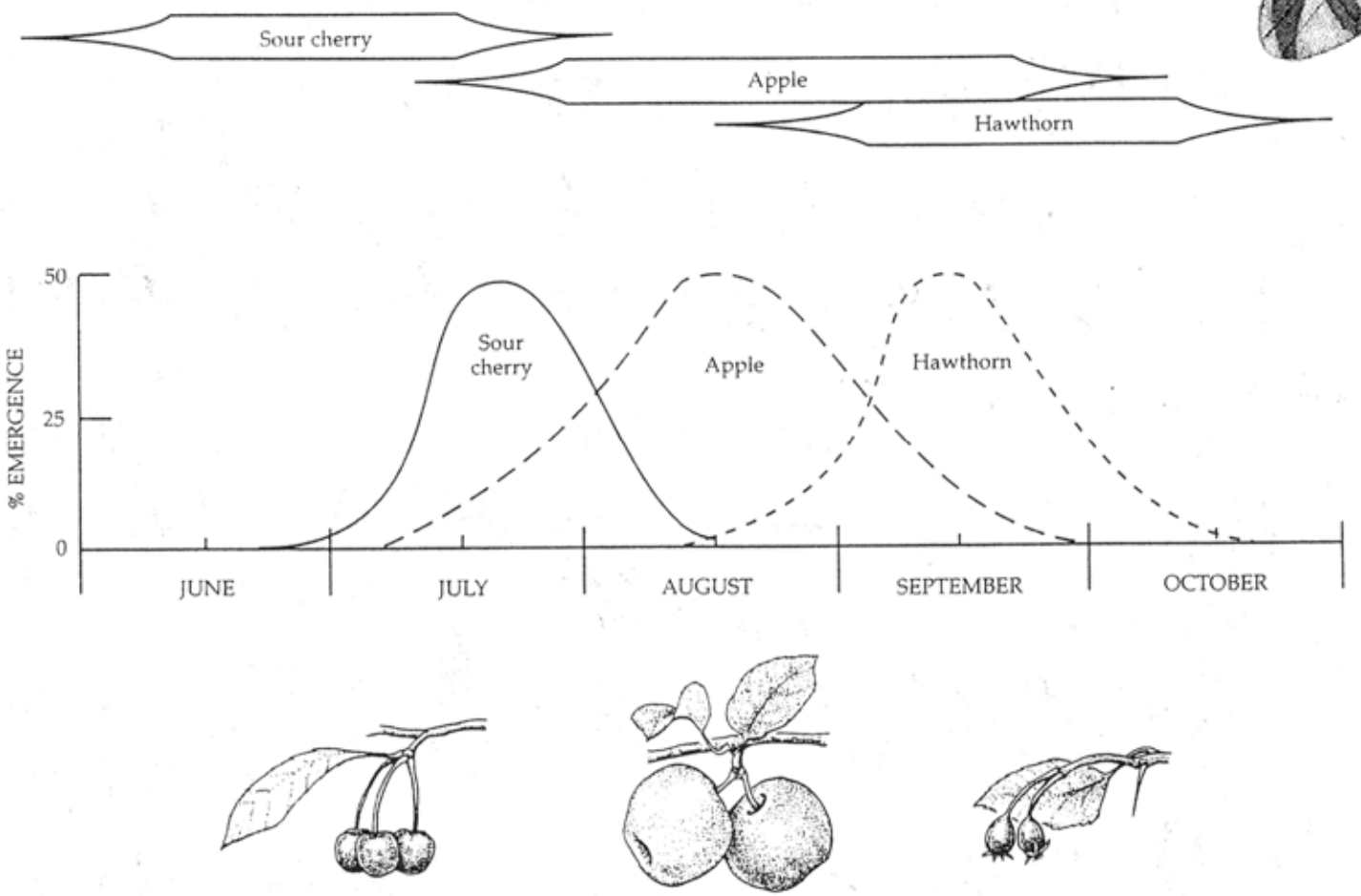
Leads to character displacement following secondary contact. Requires

1) Some variation in reproductive signal plus
2) lowered fitness of individuals that engage in courtship with other population.
   a) hybrid offspring fitness lower or
   b) selection against time wasting

Thus, selection favors individuals best able to distinguish their own population.

Host races of *Rhagoletis pomenela*





http://www.cals.ncsu.edu/course/ent425/text18/applemaggot.jpg

Enchenopa tree hoppers: Tom Wood, U. Delaware

http://farm3.static.flickr.com/2156/2535390394_4b8d20ede2.jpg?v=0

Criteria for defining host races

Drès and Mallet. 2002 Phil. Trans. R. Soc. Lond. B

1a. Use different host taxa in the wild.

1b. Individuals exhibit fidelity to particular hosts.

2. Coexist in sympatry w/ other races (at least in part)

3a. Are genetically differentiated at more than one locus.

3b. More genetically similar to distant populations on the same host than to sympatric populations on different hosts.

4a. Display a correlation between host choice and mate choice.

4b. Can survive in the face of gene flow.

5a. Have higher fitness on natal than alternative hosts; and

5b. Produce hybrids that are less fit than parental forms.

Spatial speciation is not instantaneous.
Chromosomal speciation can be.

Chromosomal Speciation

- Can be instantaneous
- Involving chromosomal rearrangements
- Involving polyploidy (*Hyla* tree frogs)

Chromosomal Speciation

- Involving Polyploidy (but no hybridization)

Example: eastern North American hylid tree frogs
Ptacek, Gerhardt, and Sage. 1994. Evolution 48(3):898-908; Holloway, Cannatella, Gerhardt, & Hillis. 2010. Amer. Natur. 167 (4): E 88- E 101

- *Hyla chrysoscelis* is diploid. Found in east & central west.
- *Hyla versicolor* is a tetraploid. Larger body, larger cell size, mating song slower pulse rate. Three disjunct popnls.
- Tetraploids cannot mate with diploids.
- Cyt. B. phylogeny shows multiple, independent origins of *H. versicolor*! Non-monophyletic.

Chromosomal speciation with polyploidy

Hyla chrysoscelis 2N

Hyla versicolor 4N

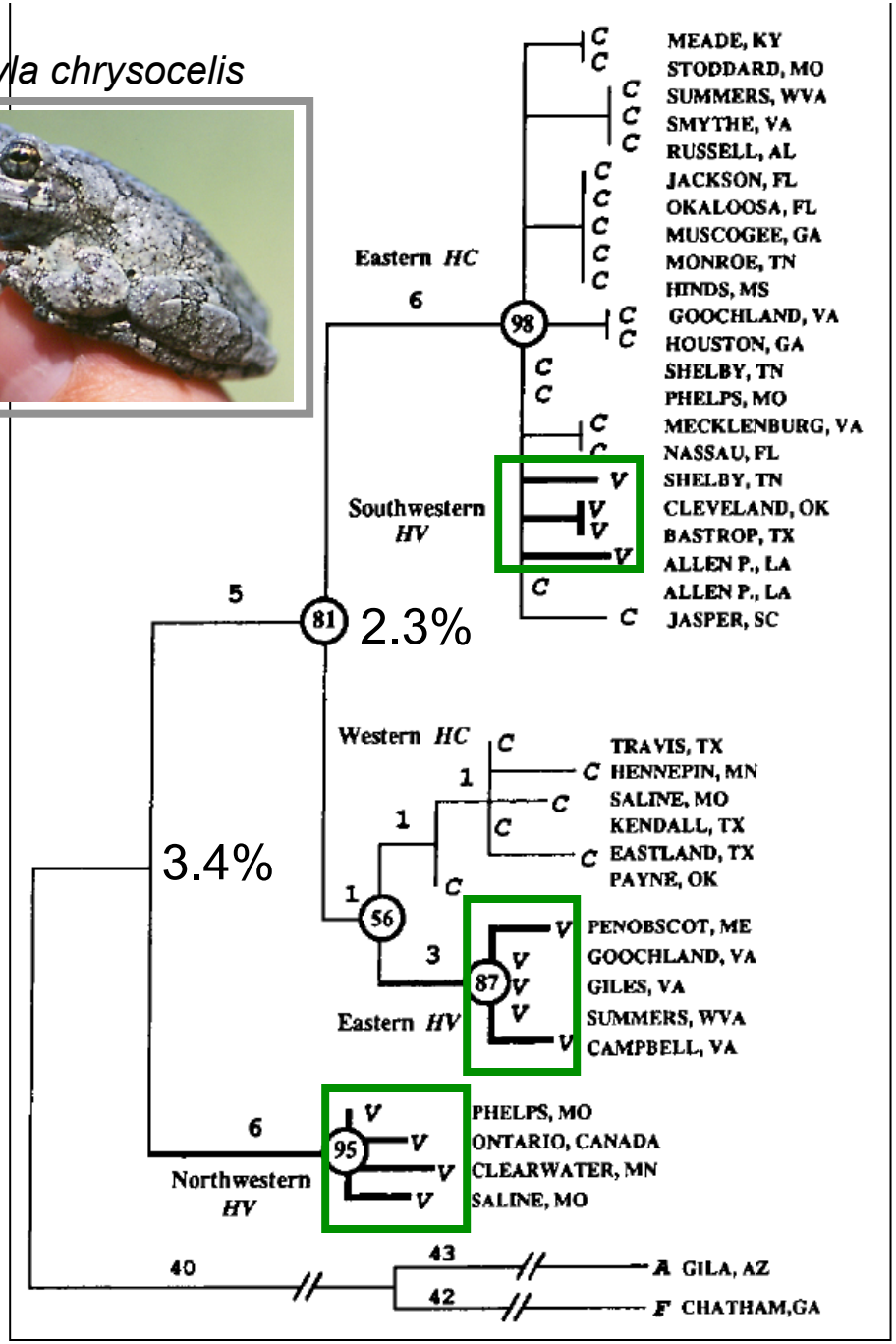
polyploid

Polyphyletic species?

Parallel Speciation!

Hyla versicolor

Hyla chrysocelis



http://www.marietta.edu/~biol/biomes/images/deciduous/hylavers.jpg; http://www.biology.duke.edu/dnhs/pics/Hylachry2.jpg

Species are often viewed as “real” biological entities while higher taxa are correctly recognized as artificial human constructs.

Definition of higher taxa--genera, families, orders, etc.—inconsistent across the tree of life.

No specific taxon age, nor number of included descendant taxa.

Only defined by morphological gaps

Why are species different?

Parallel Speciation

How would you view H. versicolor under the biological species concept vs. phylogenetic species concept?

H. chrysoscelis?

Other examples of parallel speciation

http://evolution.unibas.ch/salzburger/team/dberner/?view=printable

Stickleback fish:
benthic & limnetic forms arose multiple times independently; competitive character displacement.

(Schluter 2001. TREE)

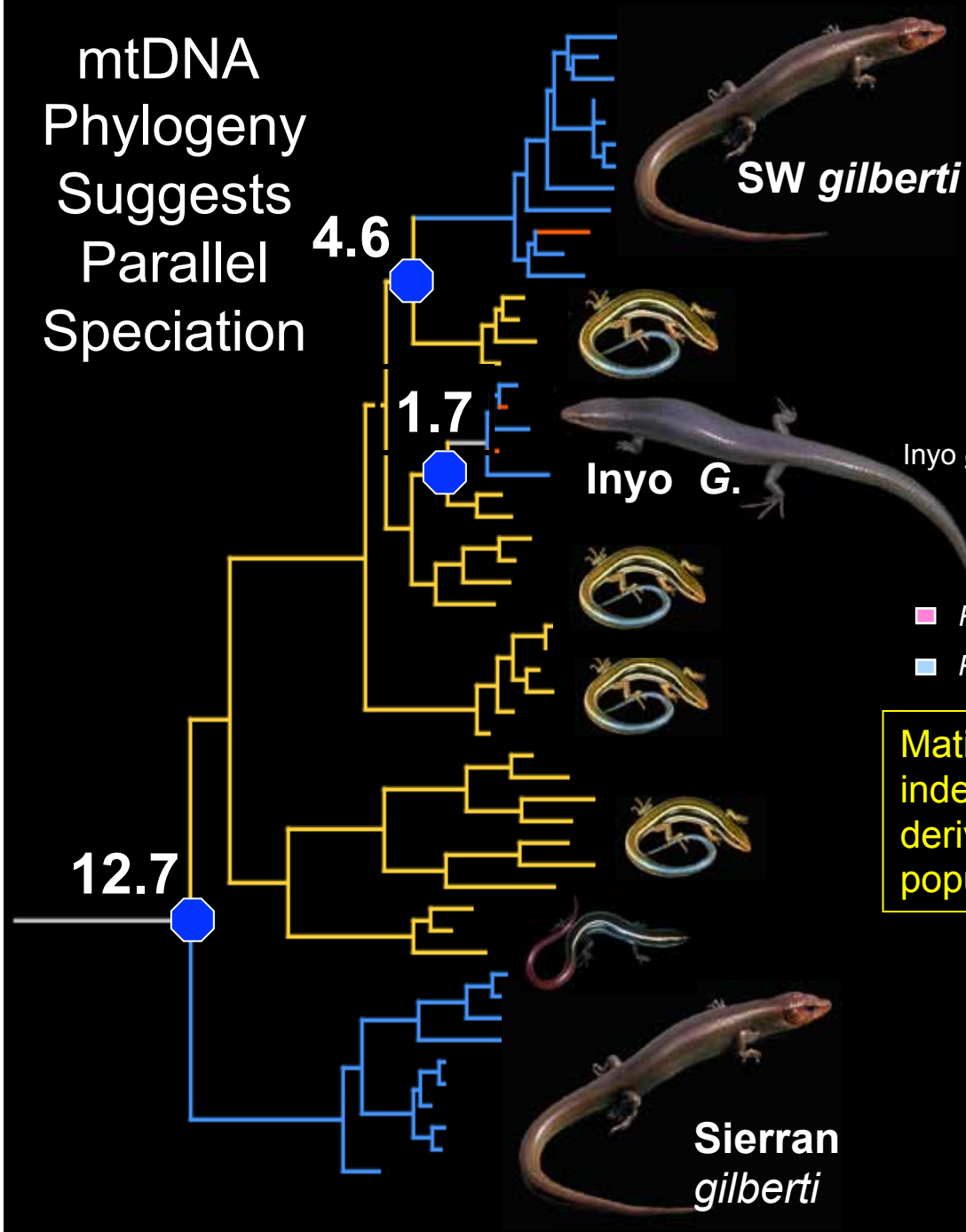
http://www.alaskafishingak.com/salmon_types/sockeye/sockeye.htm

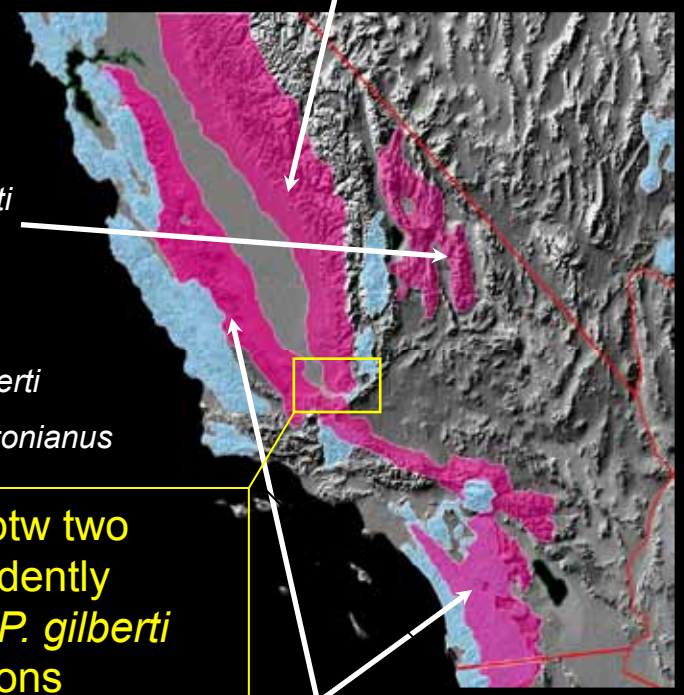
Marine sockeye salmon vs. freshwater Kokanee:
Freshwater morph formed many times independently; different reproductive timing.

(Waples et al. 2004. Evolution)

Plestiodon skinks

mtDNA Phylogeny Suggests Parallel Speciation



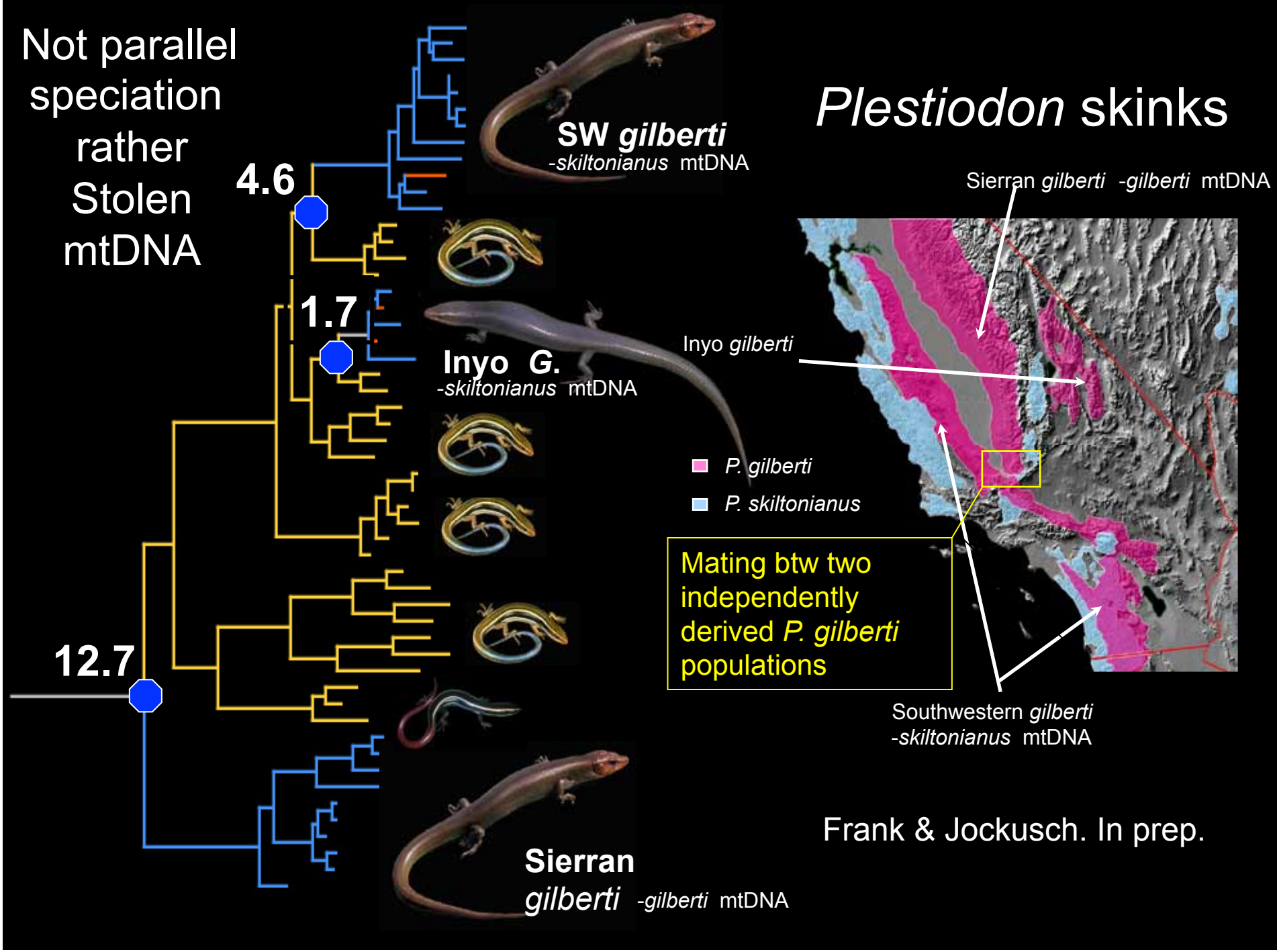


Mating btw two independently derived *P. gilberti* populations

Richmond & Jockusch. 2007. Proc. Roy. Soc. B.

Plestiodon skinks

Not parallel speciation rather Stolen mtDNA



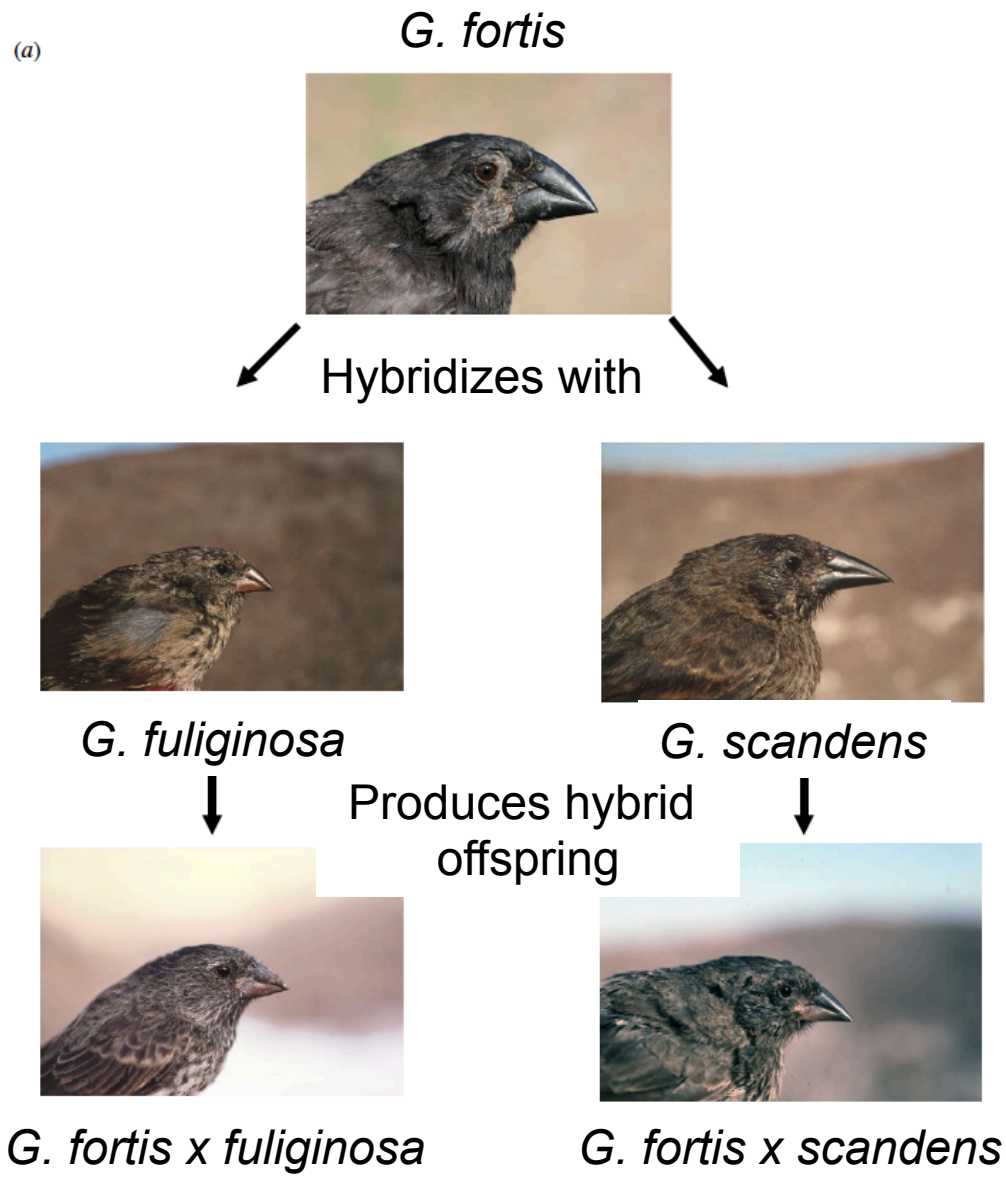
Frank & Jockusch. In prep.

Hybrid speciation w/o polyploidy

G. scandens hybridizes with *G. fortis* on Daphne Major

Over 20 years of observations hybrid became much more fit!

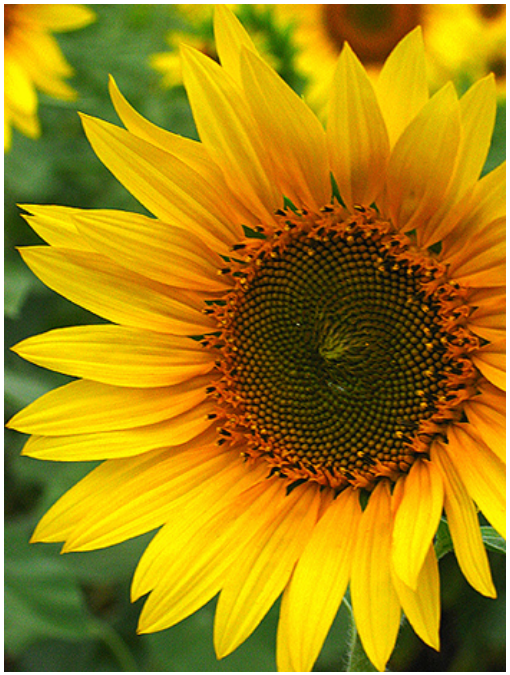
Peter & Rosemary Grant



Next…

A case of hybrid speciation involving polypoid sunflowers that illustrates the conservation of co-adapted allele complexes.

Hybrid speciation with polyploidy



Example: Sunflowers

Many sunflower species are polyploid and hybridize with other polyploid sunflower species.

An estimated 30 to 70% of all flowering plant spp. arise from polyploidy. Autopolyploidy- w/in spp.; Allopolyploidy- btw

Polyploidy allows spp. with different chromosome numbers to reproduce successfully b/c chromosomes can pair with their polyploid duplicate in the zygote rather than with the chromosomes from the other hybrid parent species (that may differ in number) .

Hybrid sunflower species

Rieseberg et al. 1996

Helianthus annuus,
clay soil,
Self incompatible

H. petiolaris,
Sandy soil,
Self incompatible

X

H. anomalus- self compatible but reproductively isolated from *H. petiolaris*

Hybrid sunflowers in nature

Loren Rieseberg, UBC

Helianthus annuus x *H. petiolaris*

gene arrangements differ between parents
on 10 of the chromosomes (7 transloc., 3 inver.)

Hybrids [*H. anomalus*] mostly sterile but some
reproduced by self fertilization

F1 pollen viability 10%, seed set < 1%
F5 pollen viability >90%

Hybrid sunflowers recreated experimentally

H. annuus x H. petiolaris --> *H. annomalus*

Made 3 lines w/ different patterns of sib matings

Independently ended up w/ same allele arrangements

Conferred high fitness on the hybrids

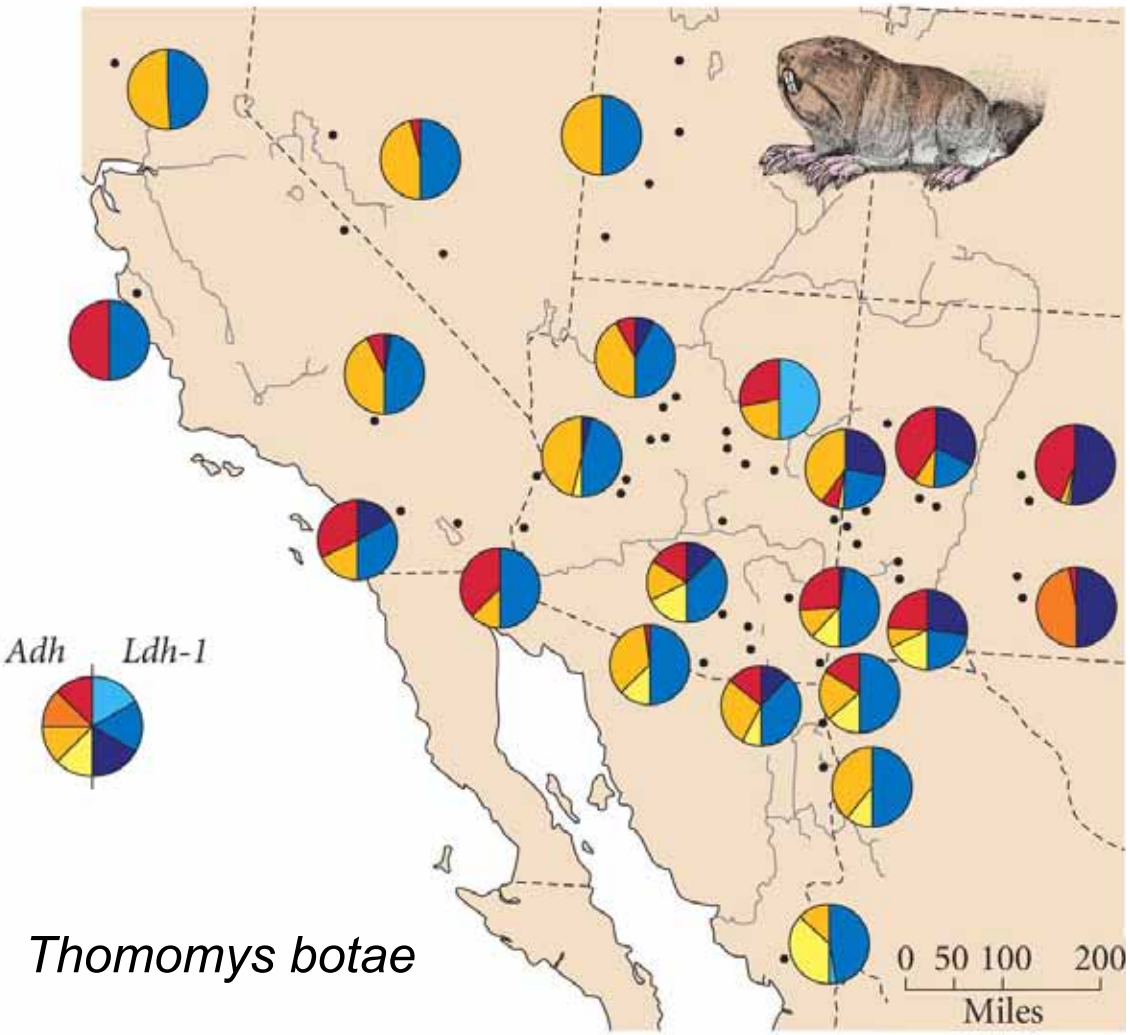
Experimental allele arrangements identical to field collected hybrids that arose > 100,000 yrs ago

Co-adapted allele combinations

The end

Remember….

Chromosomal rearrangements. Pocket Gopher. Two electrophoretic loci show high among popln. differentiation.



Thomomys botae

Nearby localities differ strongly in allele frequency.

Gene flow low.

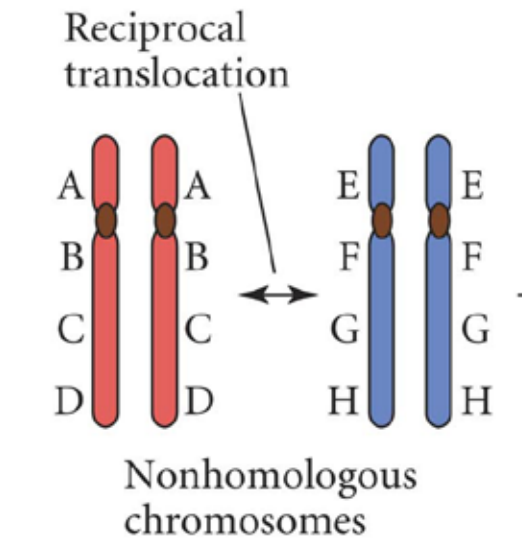
Populations small.

Chromosome number/ configuration differ among populations more than other mammals.

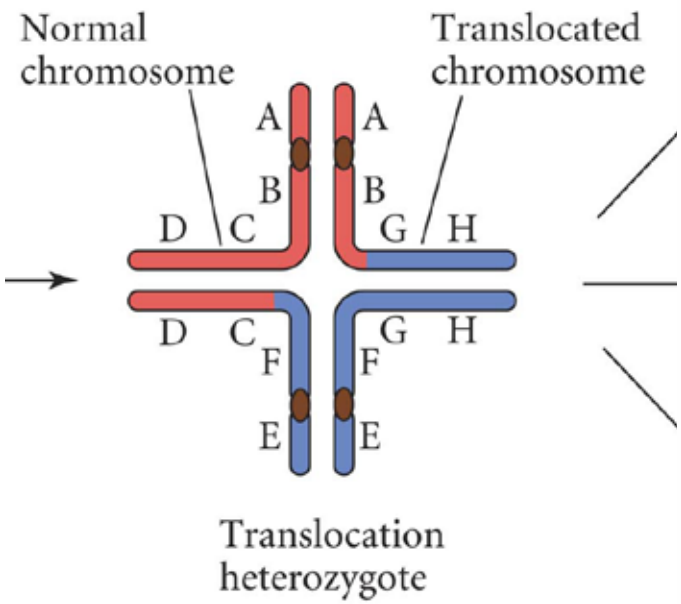
> 150 named subspecies.

Futuyma text

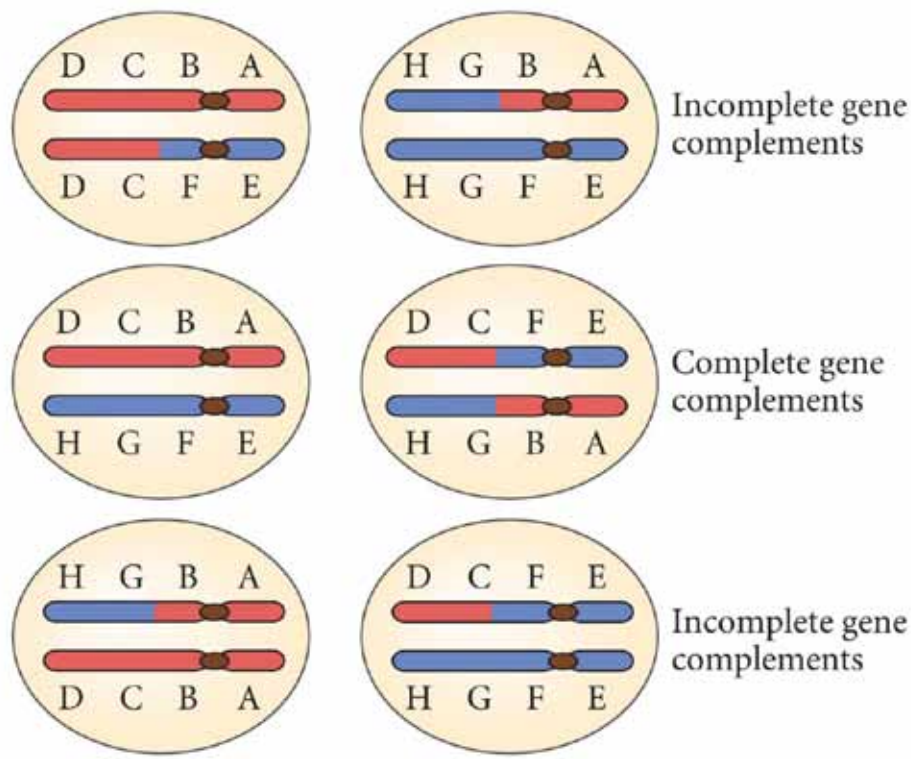
From Futuyma Text



Translocations reduce fitness of heterozygotes. So fixation must occur by drift in small populations!

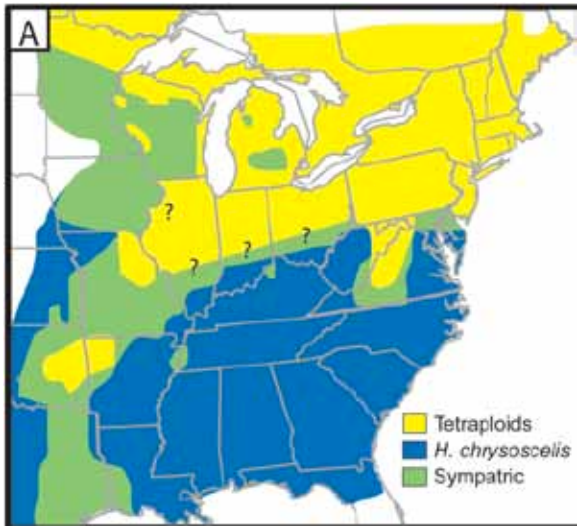


Possible Gametes



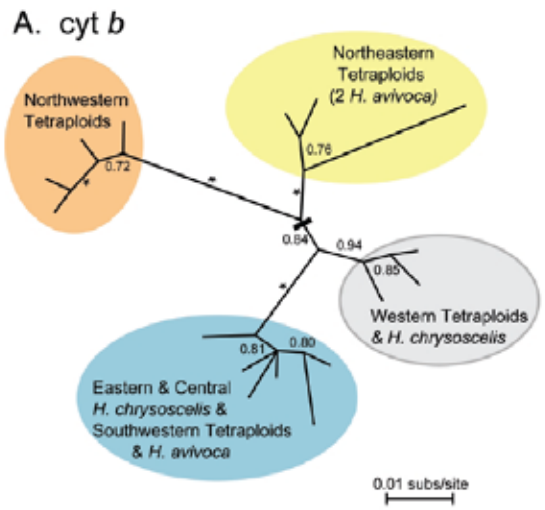
EVOLUTION, Figure 5.22 (Part 2) © 2005 Sinauer Associates, Inc.

The Hyla example is also more complicated than originally thought!
Parallel speciation not caused by natural selection:

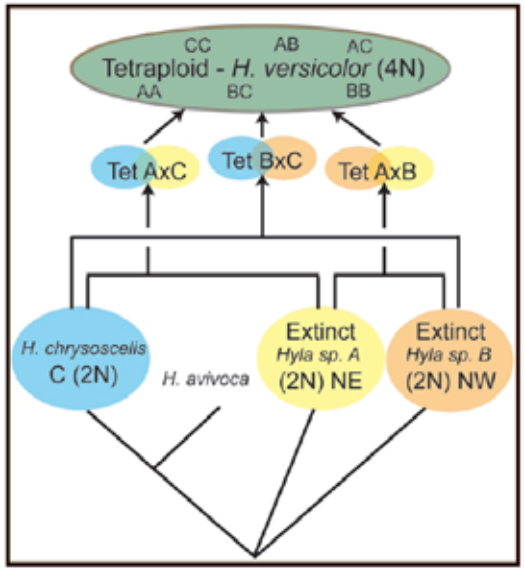


Hyla versicolor

Hyla chrysoscelis



+ 3 nucl. genes

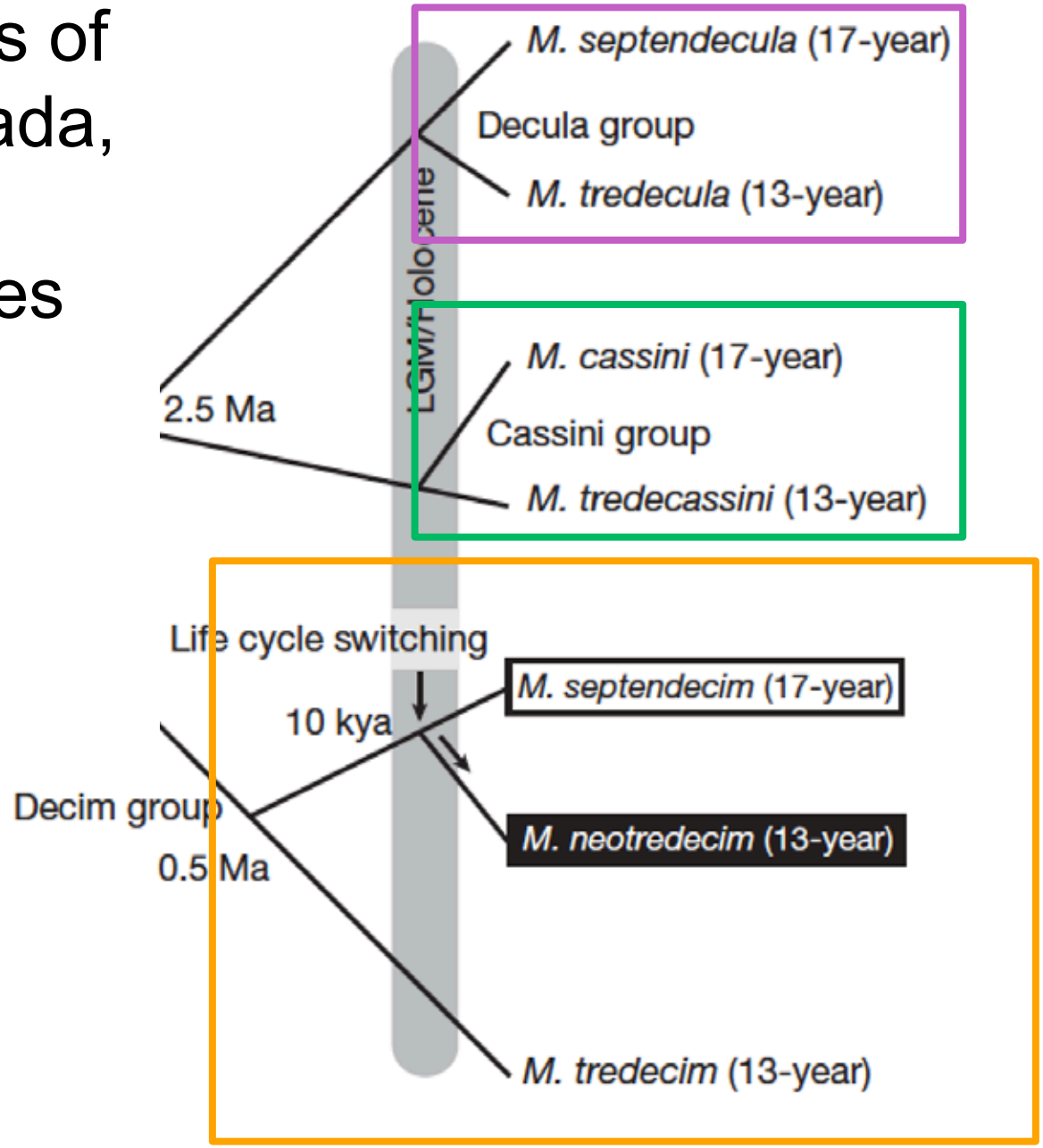


Holloway, Cannatella, Gerhardt, & Hillis. 2010. Amer. Natur. 167 (4): E 88- E 101

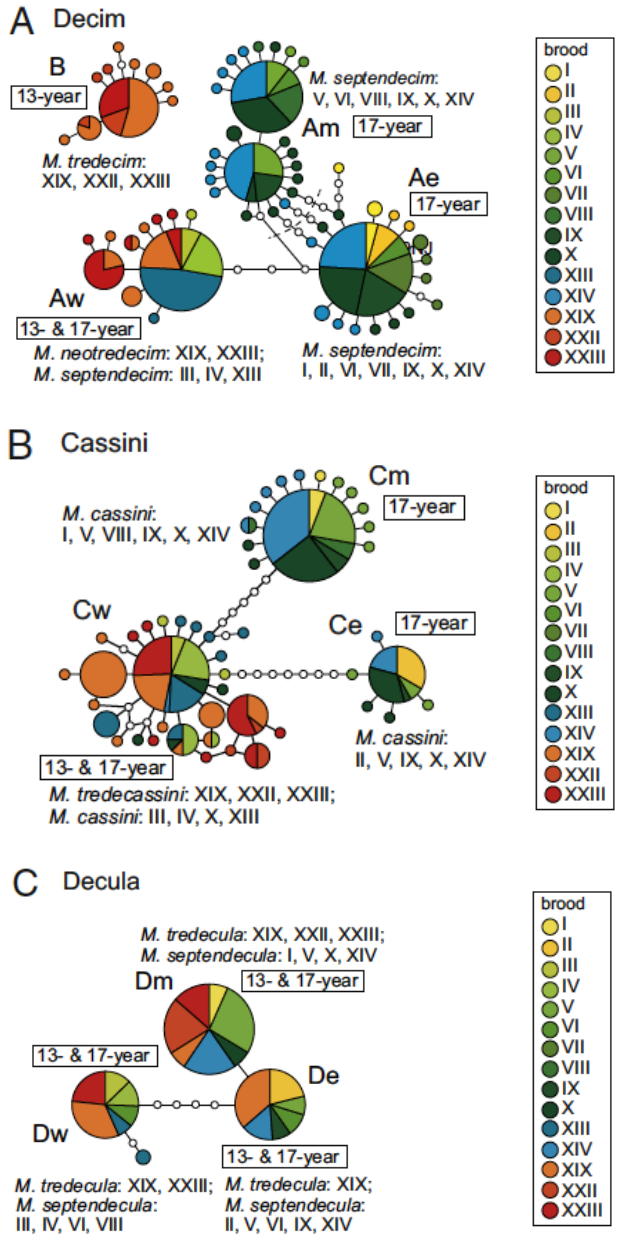
http://www.marietta.edu/~biol/biomes/images/deciduous/hylavers.jpg; http://www.biology.duke.edu/dnhs/pics/Hylachry2.jpg

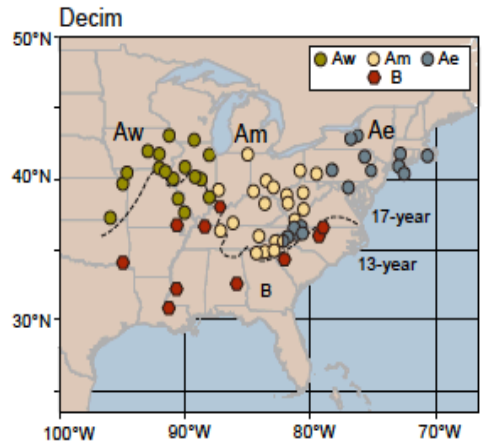
Seven species of periodical cicada, *Magicicada* in three species groups

Decula
Cassini
Decim

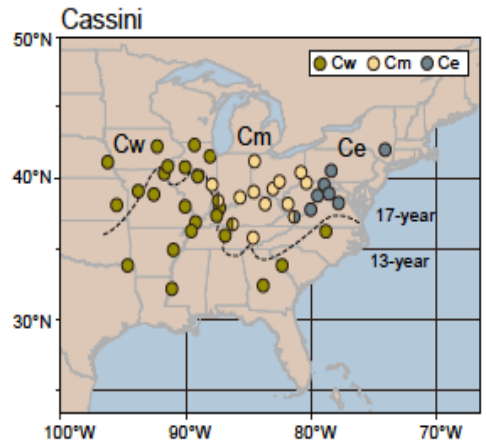


TCS Haplotype networks

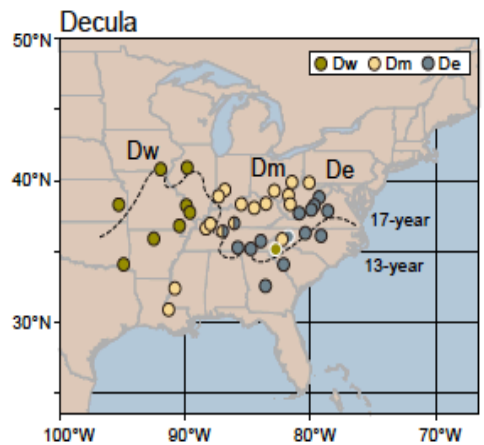




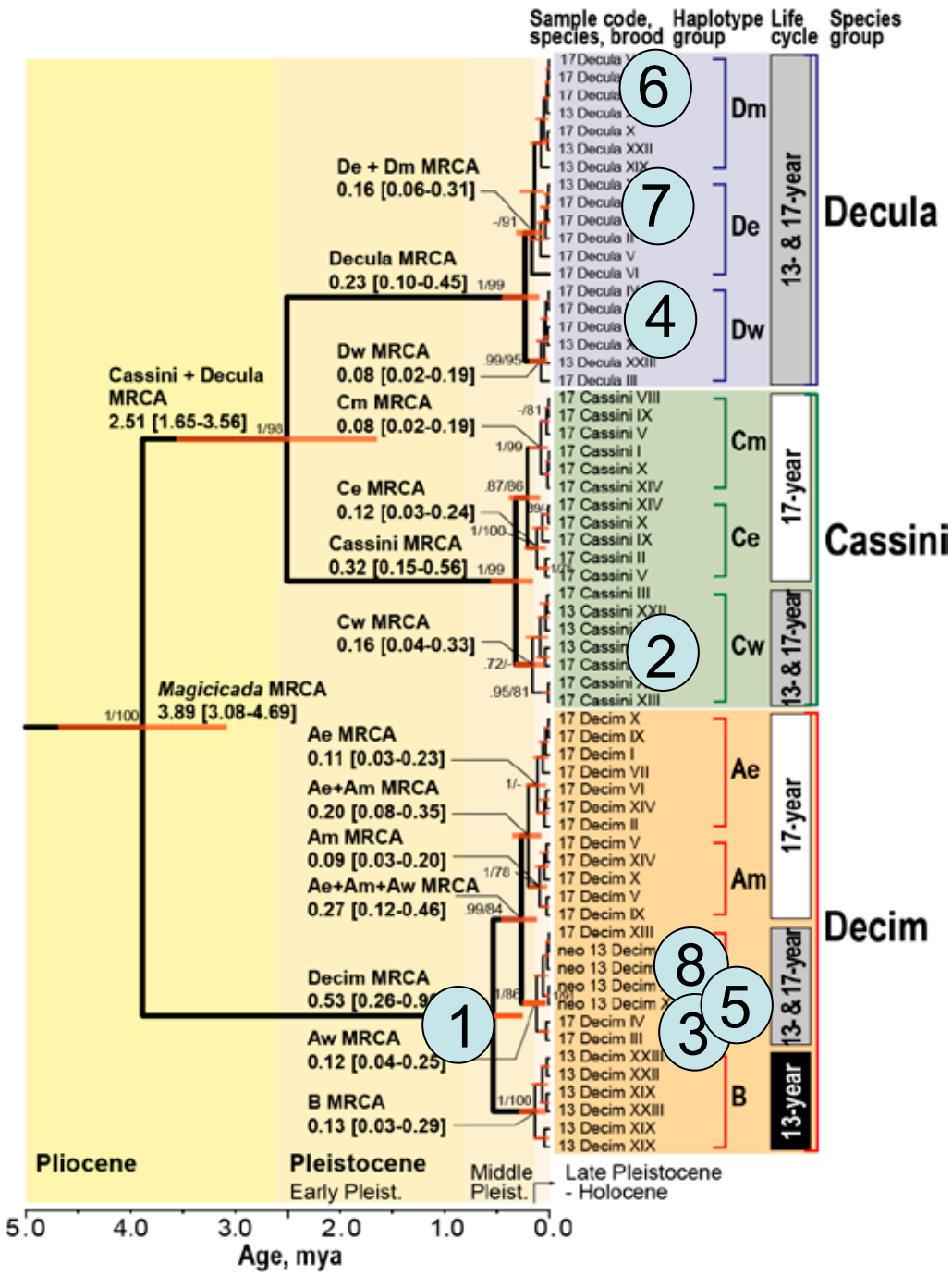
Decim

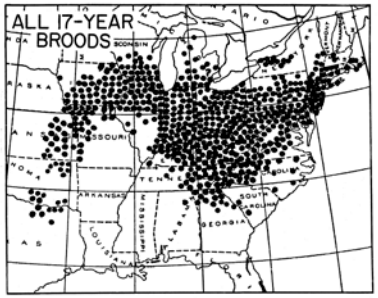


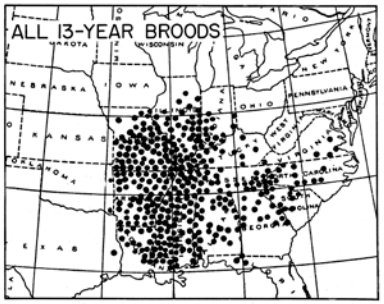
Cassini



Decula







Eight instances of 13-17-year splits (species formation)

Three independent origins of 13 in the Decula species group.

>Two independent origins of 13 in the Decim species group.

One origin nested inside the Cassini species group (paraphyletic).