Lect. 20. Natural Selection II; Begin Geographic Variation

11 April 2017

Last time…

- Mutations are not directed
- Different mutations can solve the same problem
- Teleology revisited
- Directional Selection
- Strength of Selection
- Competitive character displacement

This time …

- Competitive character displacement
- Sexual Selection
- Conflicting selection pressures (sexual selection and predation)
- Frequency dependent selection
- Multiple niche polymorphisms (disruptive selection re-set each generation)
- Balancing selection

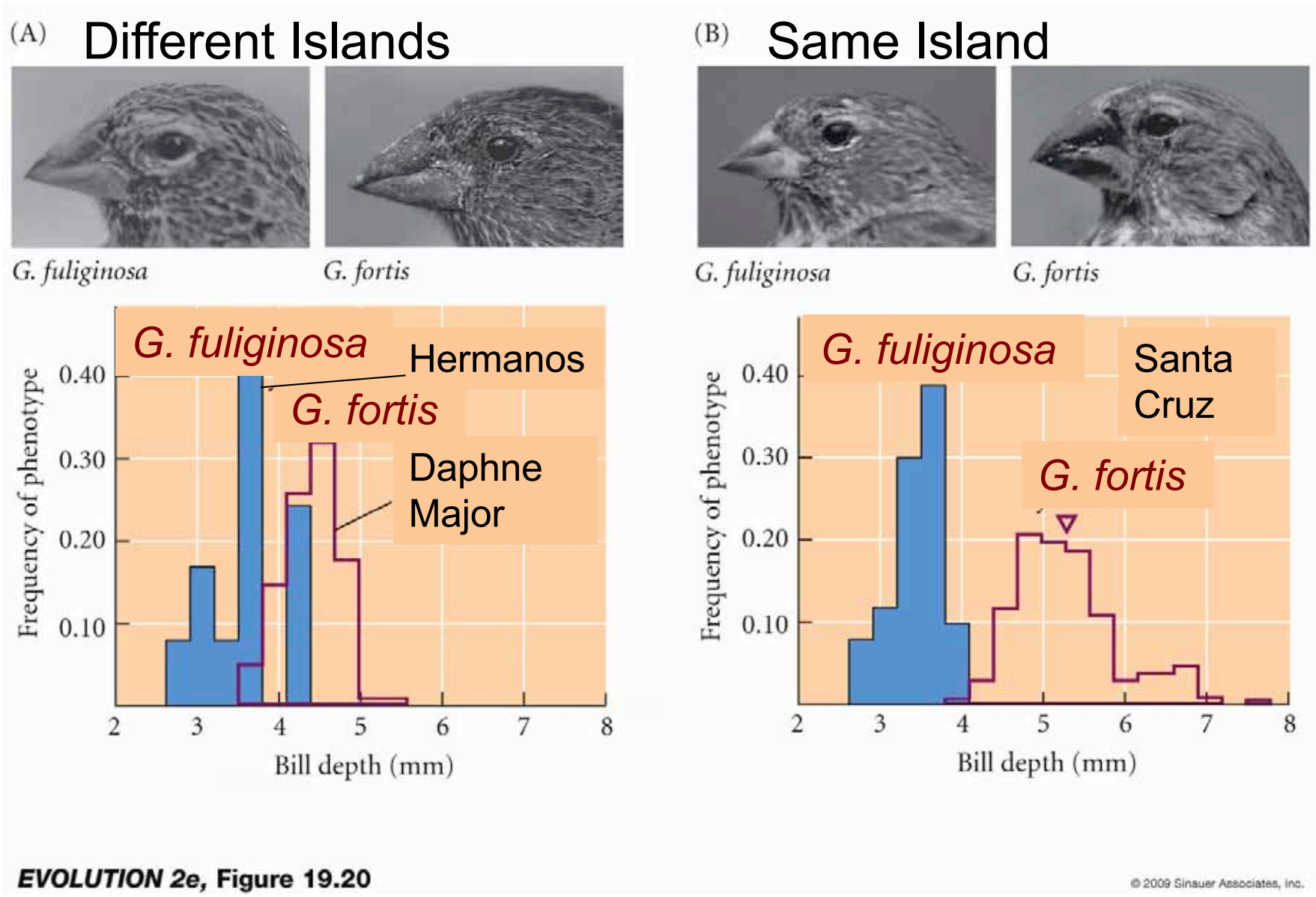
- Begin Geographic Variation

Last time …

Galapagos Is.

Competitive Character Displacement among small, medium and large ground finches

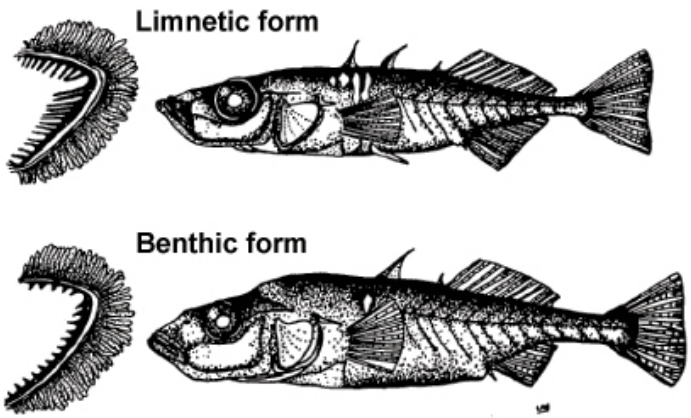
Grant, P. 1986.



***EVOLUTION 2e*, Figure 19.20**

Another example… this time an experiment.

Competitive Character Displacement in Stickleback Fish, 12,000 year old glacial lakes in Canada, Dolph Schluter



two species lakes

surface

Vs

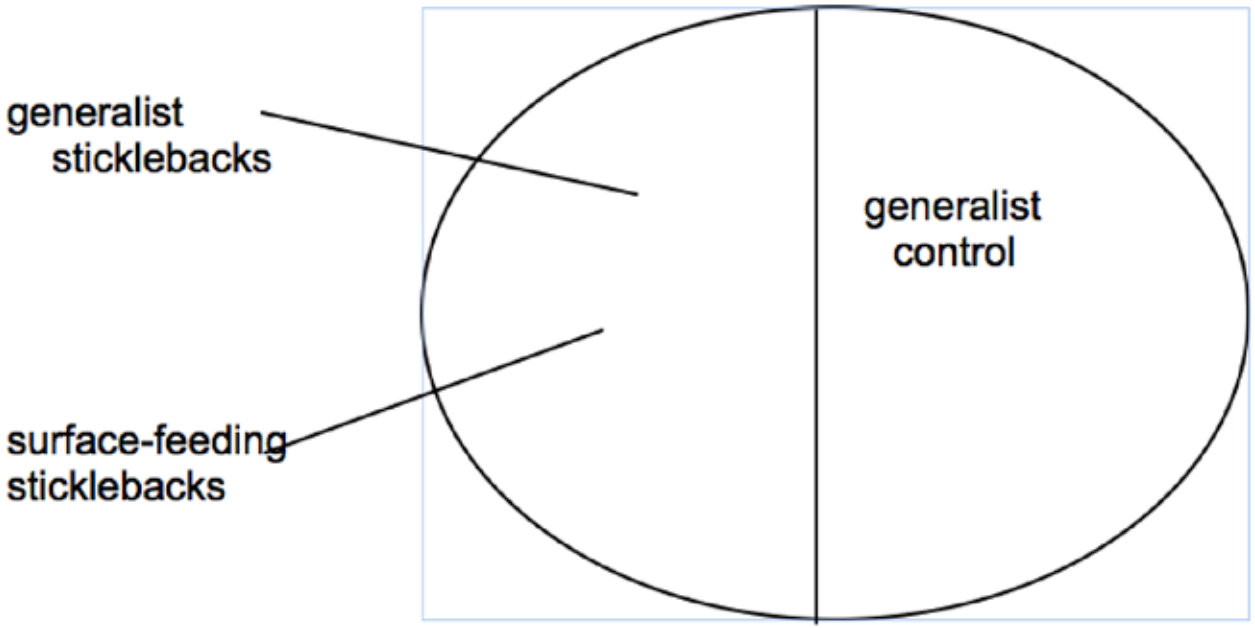
benthic

one species lakes

generalist

Competitive Character Displacement in Stickleback Fish, 12,000 year old glacial lakes in Canada, Dolph Schluter

Experiment: Artificial ponds on UBC campus. Schluter experimentally introduced (and replicated w/ fish at different densities…



Sexual Selection: A special case of directional selection

- Traits are favored that enhance mating success
- Sexual selection exists because

  *females produce few, large gametes (eggs)

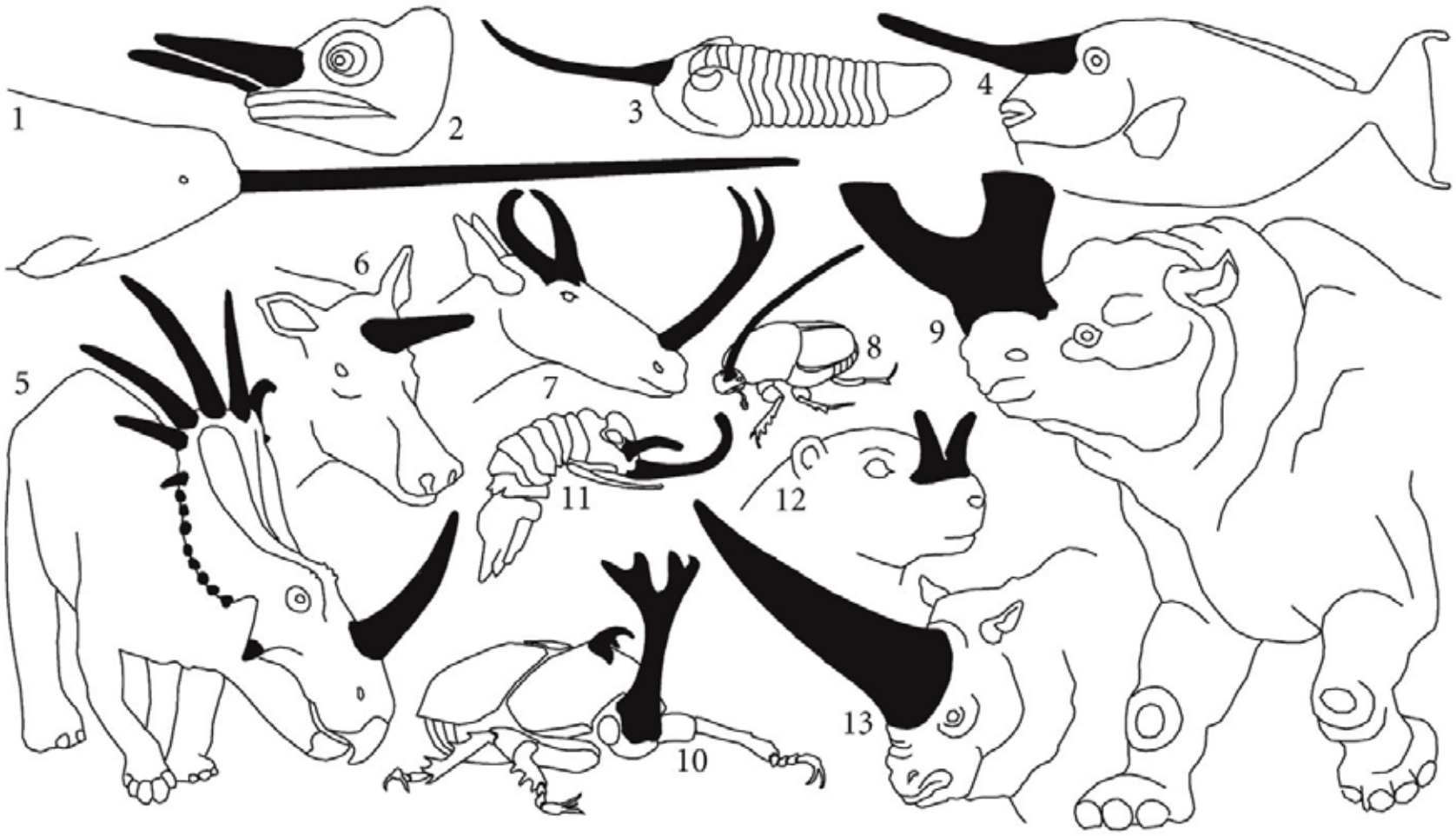
  *Thus, females are choosy

  *males many small gametes

  *males suffer much less reduction in fitness if they make a wrong choice.

Run-Away Sexual Selection

- Predicted by R.A. Fisher, 1930
- Attractiveness in males selected by females
- Females w/ best discrimination ability will leave more offspring
- Runaway process until counteracted by an opposing force (e.g., predation).
- Preference alleles do not directly influence fitness but
- Males w exaggerated male trait father more offspring
- The exaggerated male trait and the female preference become genetically correlated (linked, hitchhiking)



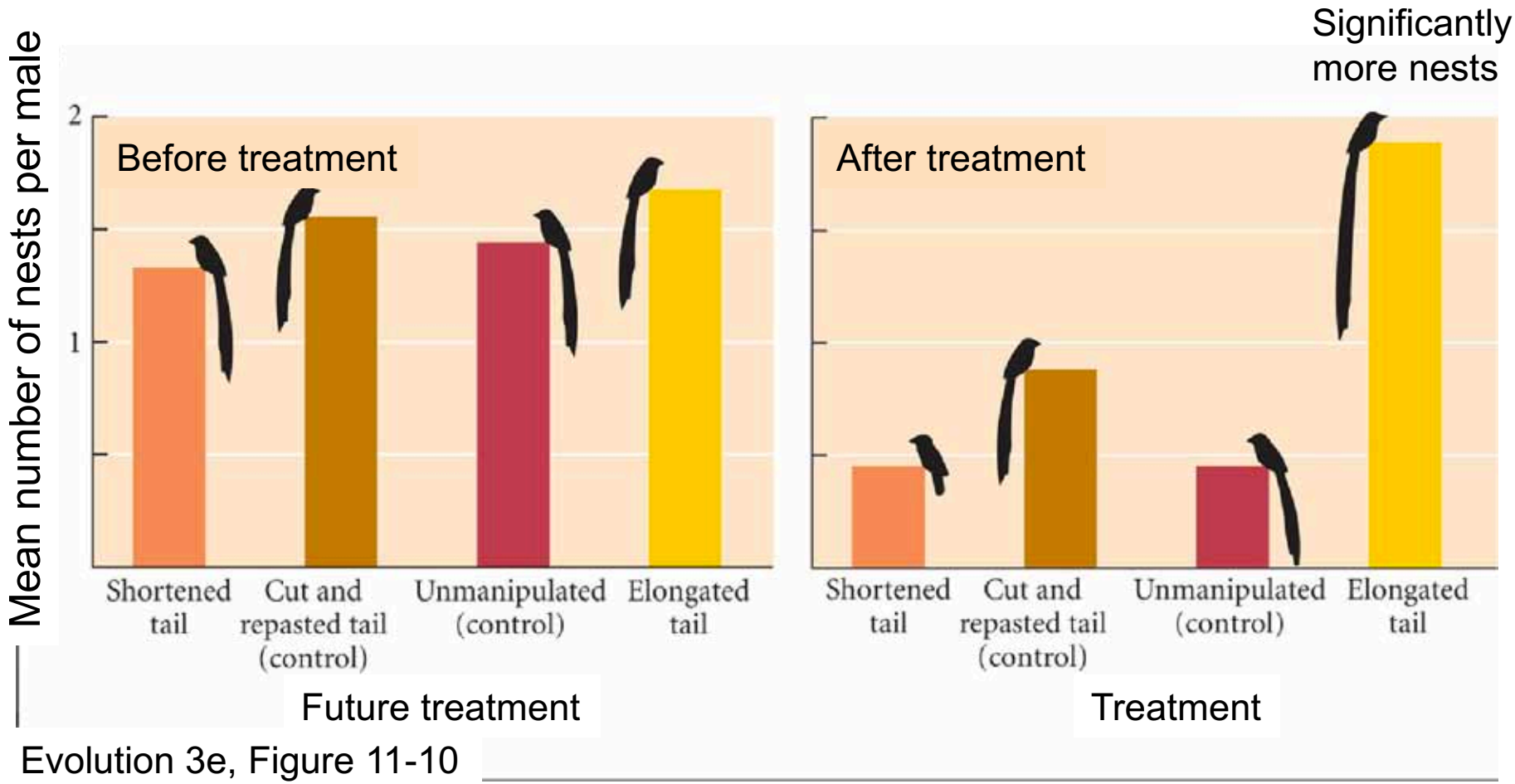
Horn-like structures have evolved in males of many species for intraspecific compete for females. Futuyma Evolution 3e, Fig. 15-18.

Sexual selection – Birds of paradise bowerbirds, pheasants, widowbirds

Birds of Paradise.
https://www.youtube.com/watch?v=W7QZnwKqopo

Bower Birds:
https://www.youtube.com/watch?v=PS_YT9U5MKU

Sexual selection results in increased reproductive success in Widowbird (Anderson 1982)



Evolution 3e, Figure 11-10

Trinidad Guppies- conflicting selection pressures, John Endler

*In streams w/ predators, males have smaller spots less colorful.

*Females prefer more showy males.

*Endler moved 200 guppies to a predator free stream…

*2 years (15 generations) later, larger spots, more colorful.

*Experiment repeated in greenhouse w/ same results.

Male guppies, *Poecilia reticulata*

predator 1: *Crenicichla*

Sexual Selection requires heritable traits

- “Quantitative geneticists” studies the heritability of traits over generations
- Degree of heritability can vary from partial to full heritability.
- Carson and Witsotsky studied picture-winged Hawaiian *Drosophila* and found a large variation in successs of males.
- Successful males = studs; less successful = duds
- Hypothesized run-away sexual selection but mating experiments by postdoc Chris Boake showed that the traits were not heritable.

Timing of selection….

Deleterious Dominant Alleles are Rare

- Selected out of a population unless…?

Wood Guthrie

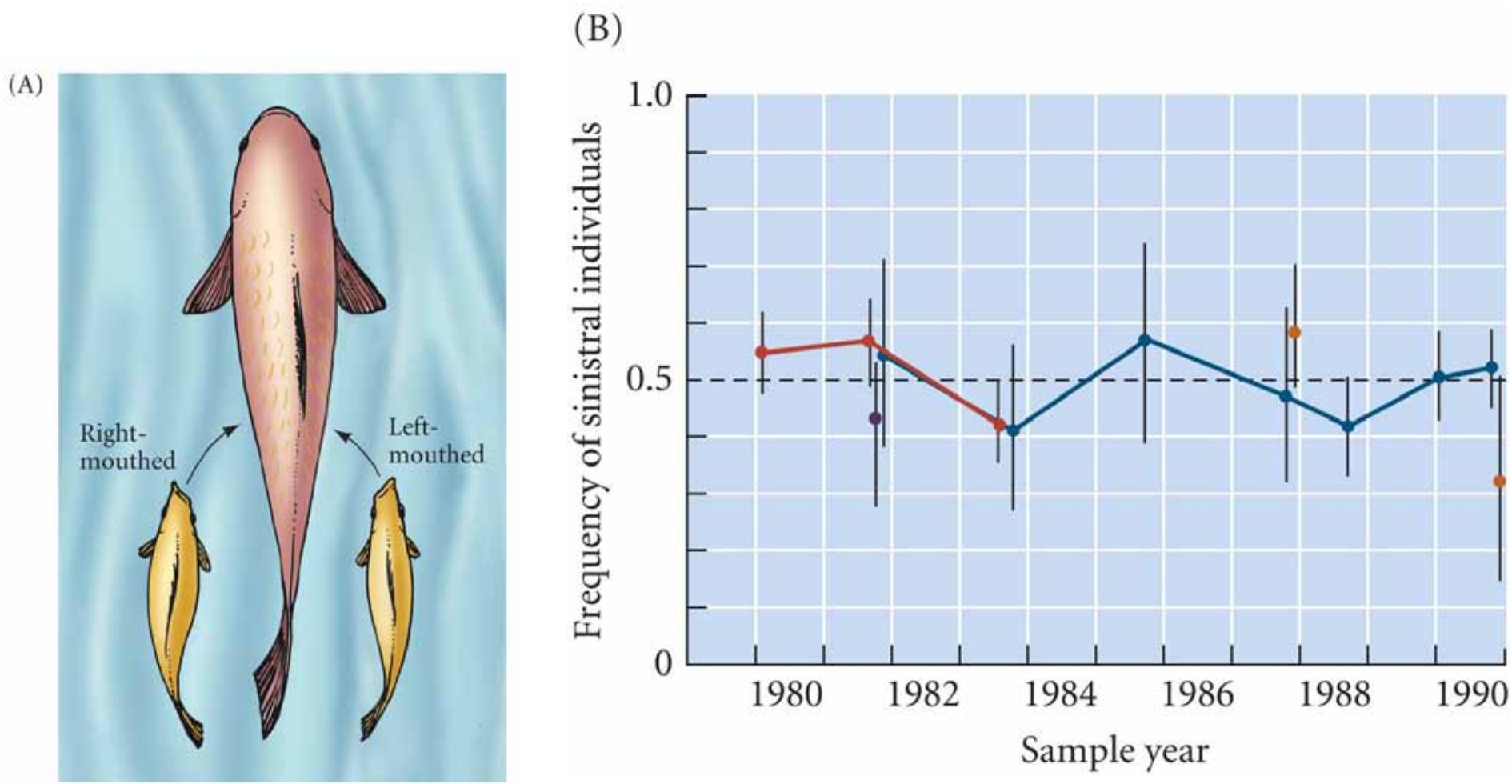
Arlo Guthrie

Frequency Dependent Selection: three examples (directional but switches)

- Classic Study: Colored rice grains on Oxford lawn, birds develop search image
- Scale-eating cichlid fish, Lake Tanganyika

See review by Bond, J. 2007. Crypticity, searching images, and apostatic selection. Ann. Rev. Ecol. Evol. Syst. 38: 489-514.

Frequency dependent selection



Lake Tanganyika Cichlid Fish

Futuyma, 2005. Fig. 12.16

Environmental change alters directional selection

- Peppered moths- environment changed due to industrial pollution and then clean-up.
- Endler's guppies- environment was changed experimentally
- Galapagos finches- abiotic environment changed from wet to dry and back again. Biotic environment (seed size) also changed.
- Sometimes the environment changes between adult and offspring stages resulting in "multiple niche polymorphisms."

Multiple Niche Polymorphisms: swallowtail butterfly, *Papilio demodocus*

Camouflaged on citrus

Camouflaged on parsley

Females lay eggs at random on both plants.

Stabilizing Selection = **Balancing Selection** = **Heterozygote Advantage** = Overdominance

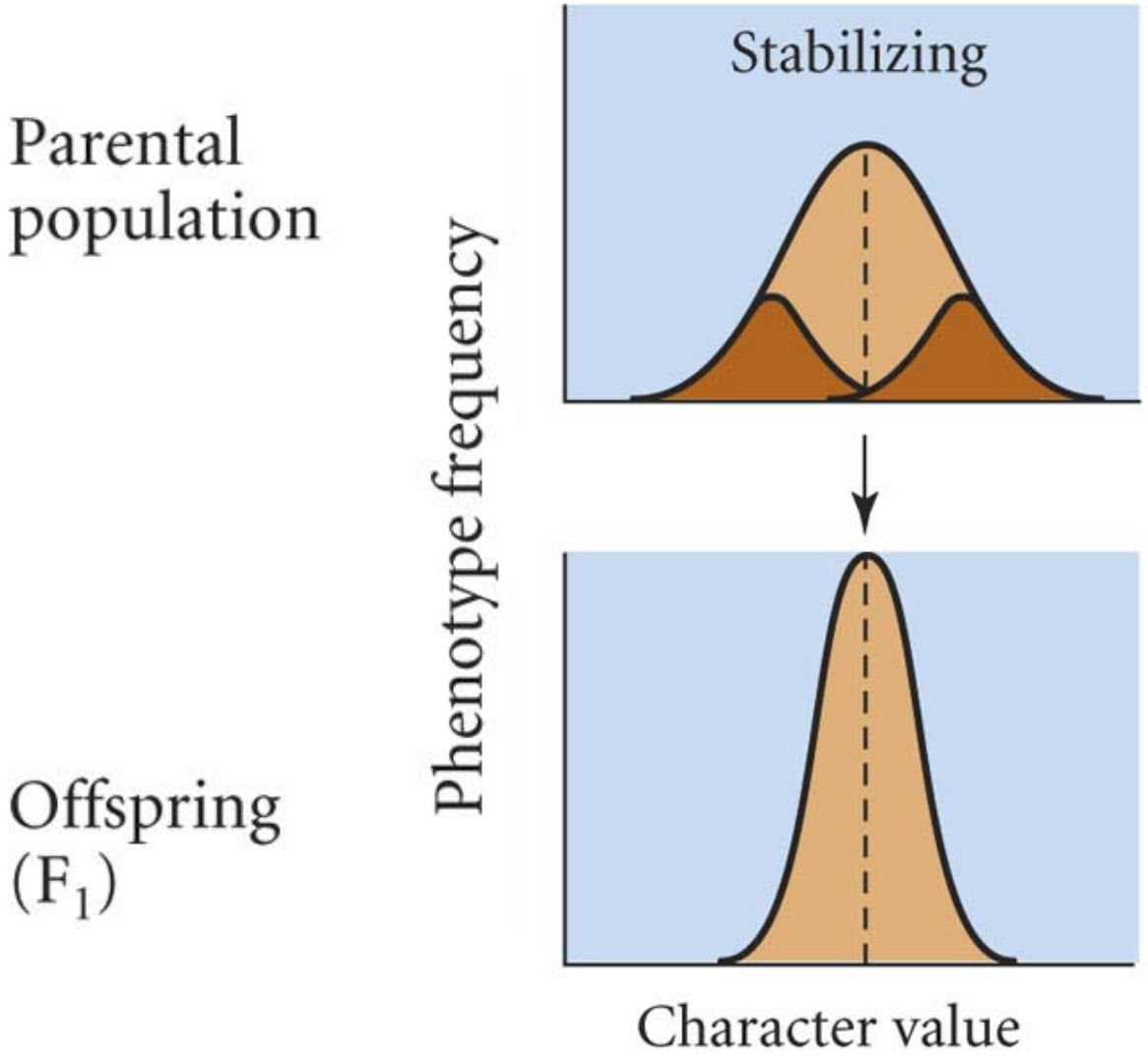


Fig. 12.1 Futuyma. Dark brown areas = lower fitness

Balancing Selection: Cystic Fibrosis

- CF a fatal condition affecting 1/2500 live births in Northern Europe
- Caused by mutations in a gene encoding a sodium channel protein
- Up to 500 different recorded mutations in this gene are thought to cause the disease. e.g.,

  --3-bp deletion knocks out an entire amino acid

  --an arginine converts to a stop codon

  --alteration of splicing omits an exon from mRNA

Balancing Selection: Cystic Fibrosis

- CF mutation knocks out CF transmembrane conductance regulator of lining of lungs and gut.
- CF is more* prevalent in areas of former typhoid fever epidemics. Salm*onella typhi* crosses gut epitheleum using CFTR protein
- Mouse lines Homozygous CFTR mutant – resistant to typhoid but have CF. Heterozygotes- resistant to typhoid, Homozyous wild type- vulnerable to typhoid.

* Note that there was a typo here during lecture.

Geographic Variation

Geographic Variation: Some Definitions

Population: an interbreeding unit

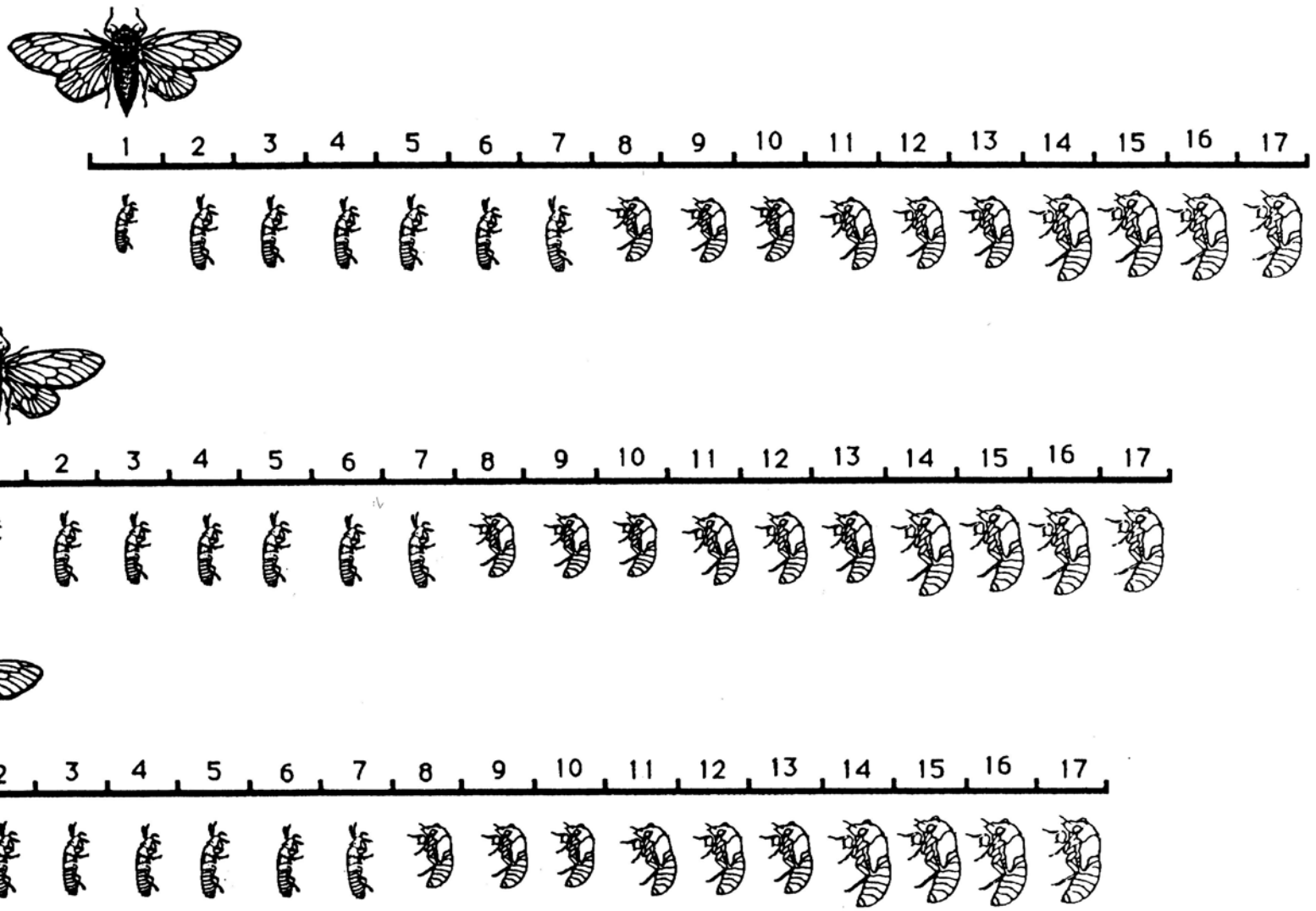
Sympatric: overlapping

Parapatric: adjacent

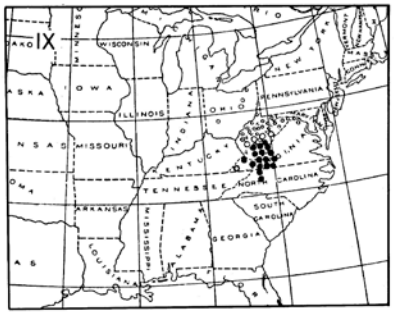
Allopatric: not overlapping or adjacent

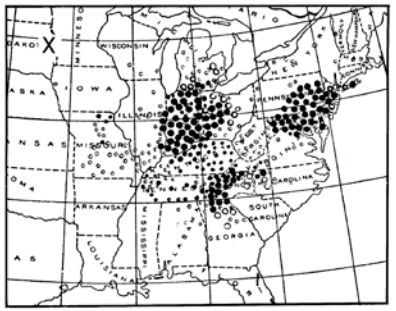
Allochronic: separated in time

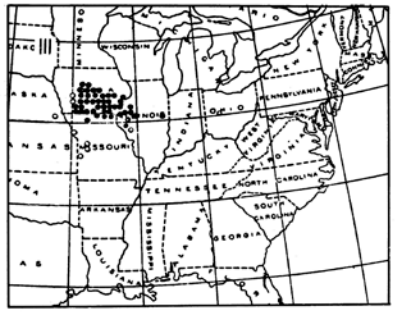
Allochronic year classes of periodical cicadas called “broods”

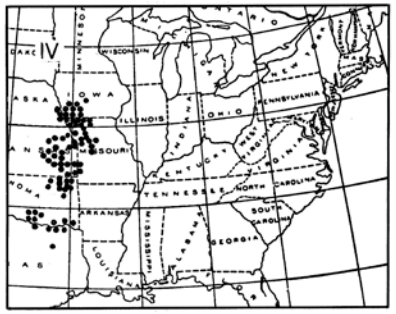


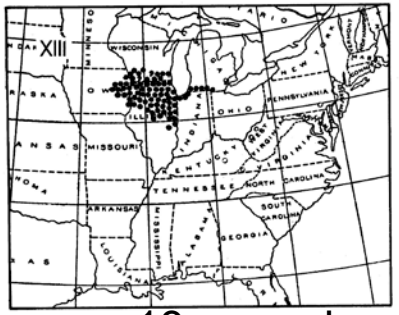
17-year cicada broods = year classes = cohorts; numbered sequentially by emergence year

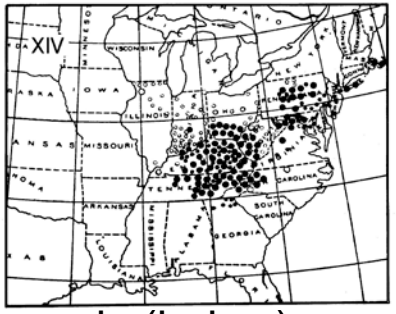




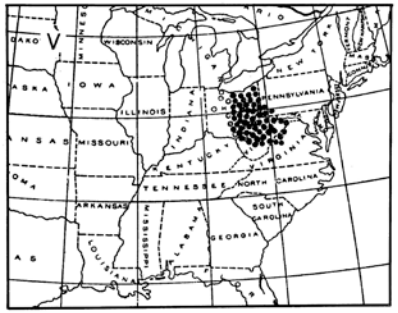


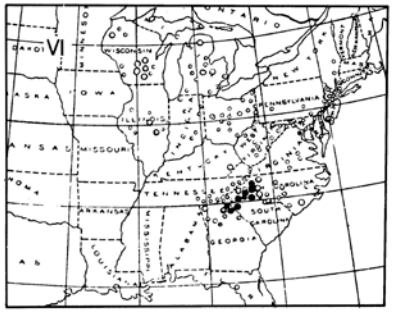


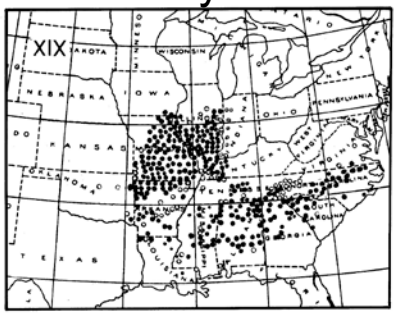


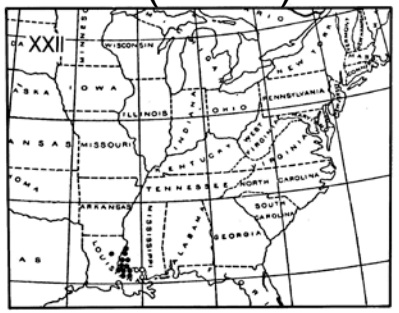


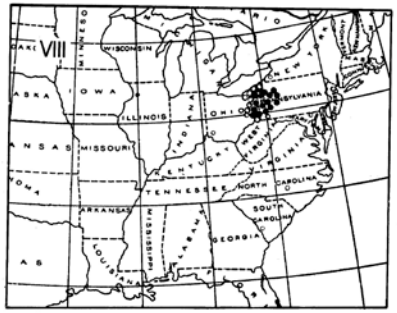
13-year cicada broods (below)

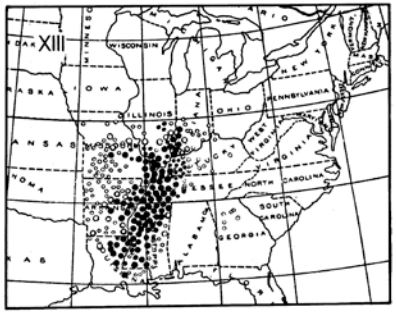






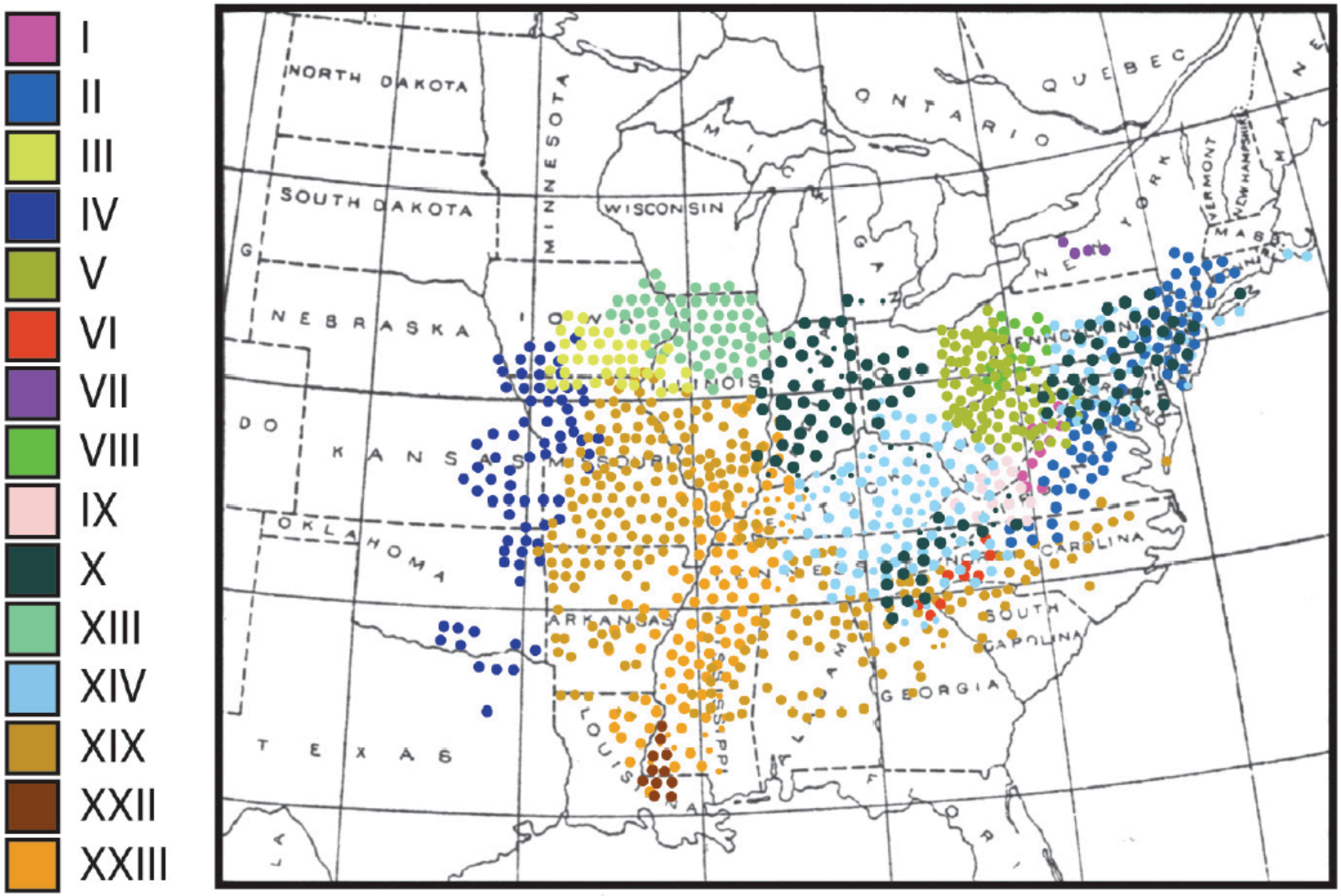






Some allopatric„
Some parapatric,
Some sympatric,
All allochronic

All year classes of periodical cicadas superimposed



Cooley, J.R., G. Kritsky, J.D. Zyla, M.J. Edwards, D.C. Marshall, K.B.R. Hill, R. Krauss, and C. Simon. 2009. The distribution of Periodical Cicada Brood X. American Entomologist 55(2): 106-112.

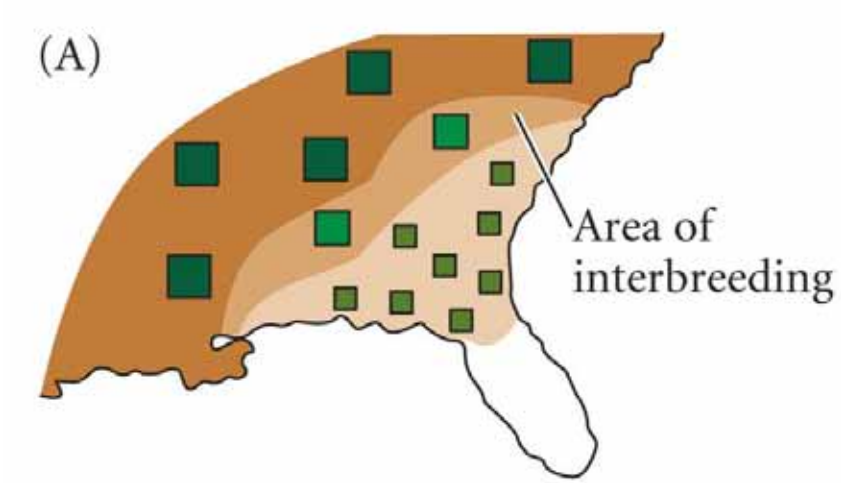
Geographic Variation: Some Definitions

Clines: step cline (abrupt) vs gradual cline

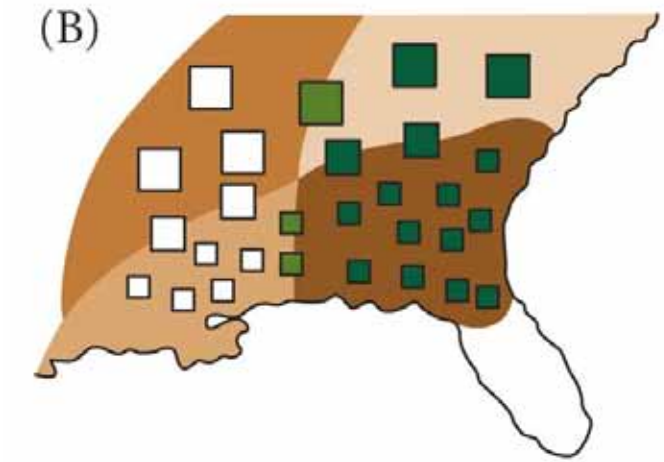
Geographic race or subspecies

Species

Fig. 9.22. Futuyma 2e. Patterns of geographic variation e.g., size and color clines

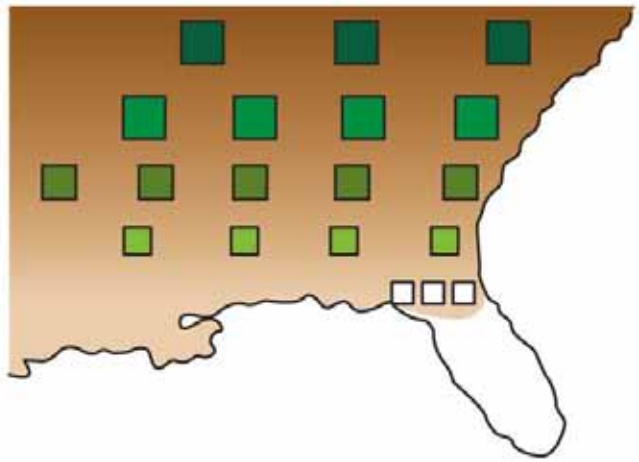


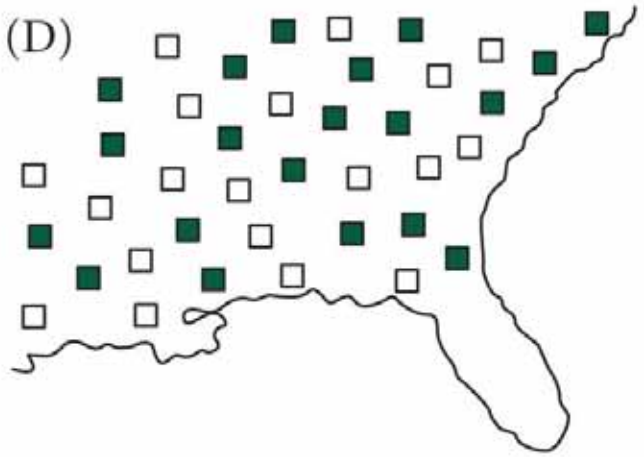
Concordant: gradual size, abrupt color,



Perpendicular: gradual size, abrupt color,

(C) Concordant: gradual size & color



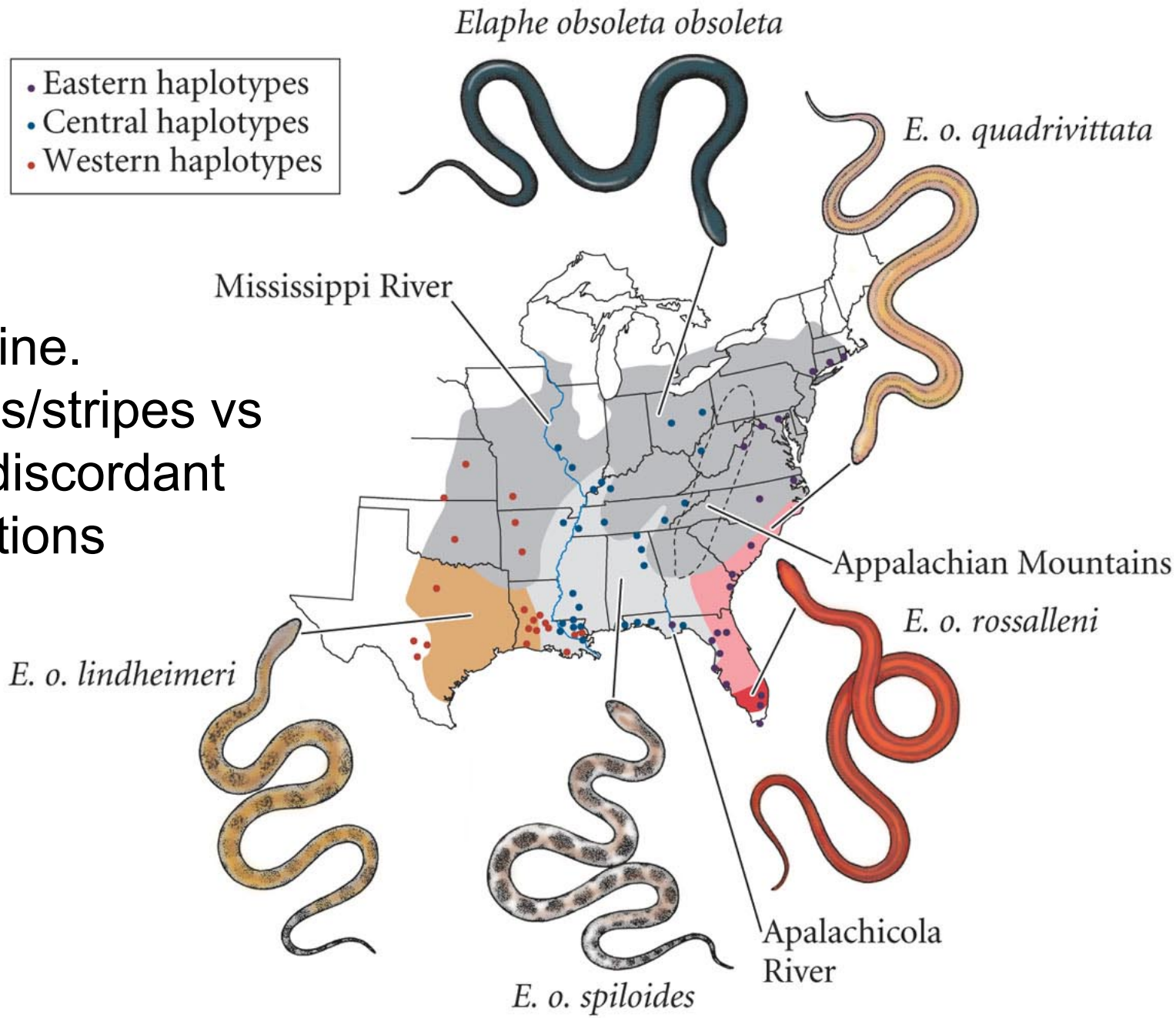


Mosaic color, uniform size

Geographic Races

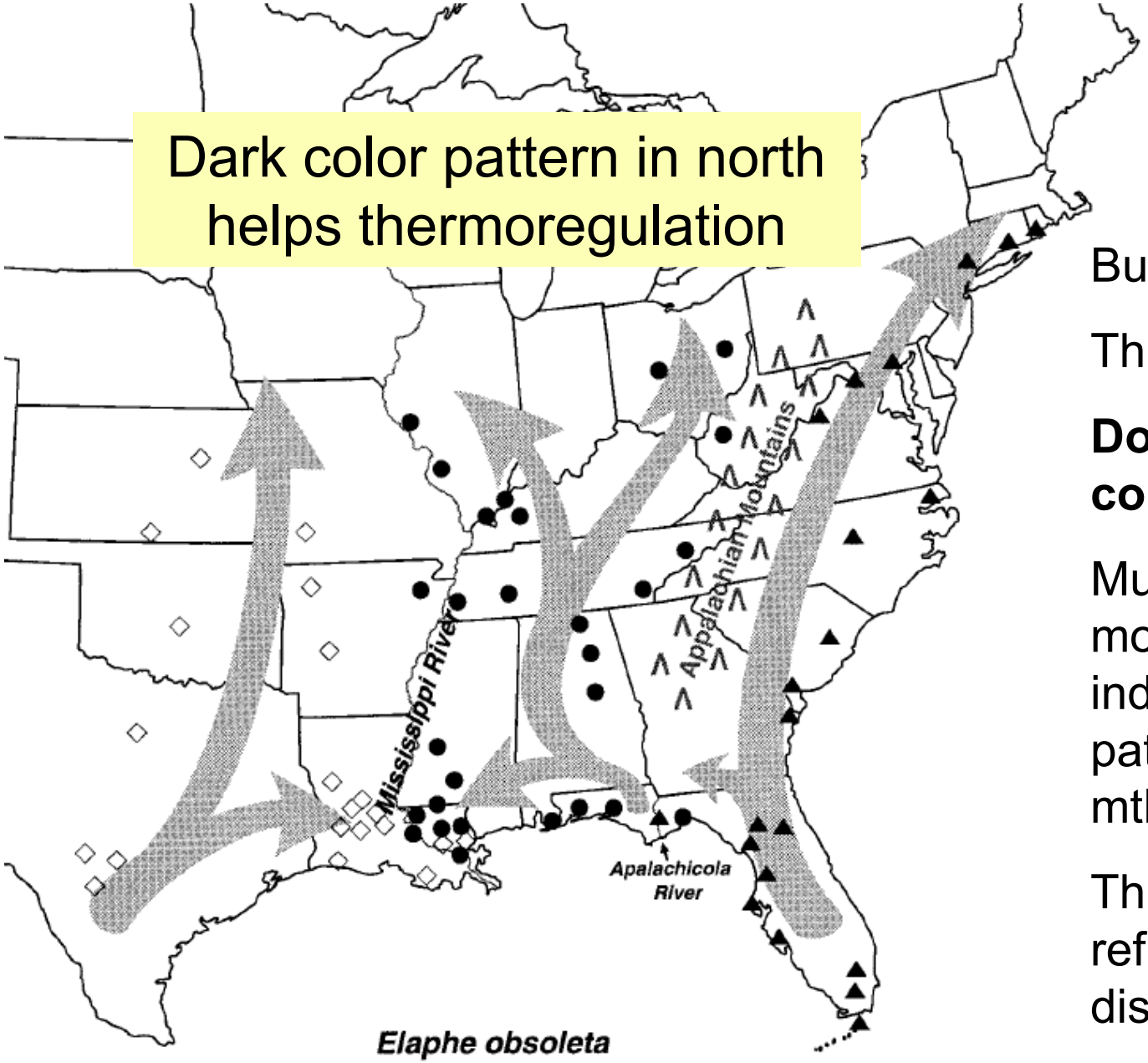
- Geographic races, subspecies, varieties- often defined based on combination of one or two characters (that may or may not correspond to other visible features).
- Examples: Rat snakes (*Elaphe obsoleta*).

Fig. 9.24. Subspecies (geographic races) of rat snake



Step Cline.
Blotches/stripes vs color: discordant distributions

Rat Snakes Genetics



Burbrink et al. 2000.

Three mtDNA lineages

Do not correspond to color pattern

Multivariate analysis of morphology independent of color pattern does match mtDNA pattern

Three Pleistocene refugia & subsequent dispersal

Are there geographic races or subspecies of rat snakes?

Yes, but they do not correspond to previously named subspecies based on color pattern.

Races in Humans?

- Classic studies: Lewontin (1972) and Nei & Roychoudhury (1972) studied human races using published allozyme data.

85% of variation was within races

15% of variation was among races

- J.Z. Li et al. (2008)

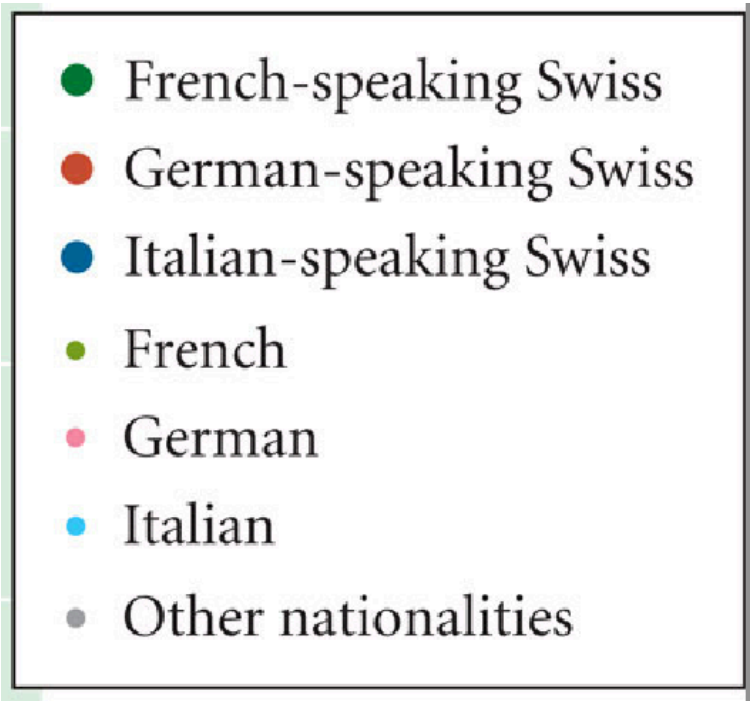
  938 individuals, 51 populations, >640,000 single nucleotide polymorphisms in DNA sequences (Snp's) surveyed

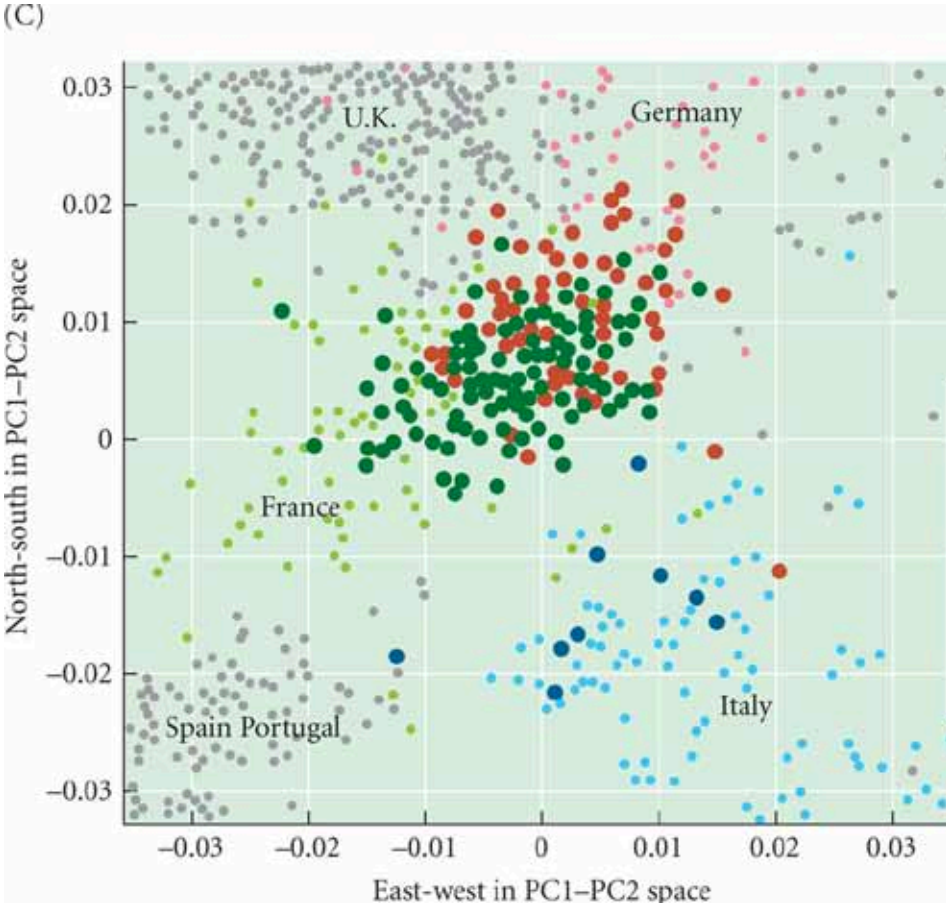
  88.9% of variation among individuals within populations

  2.1% among populations within geographic regions

  9% among major geographic regions

- The 9% of variation among geographic regions explains
  - Regional variation in phenotypic characteristics
  - Different regional blood-group frequencies
  - Different regional frequencies of some genetic diseases (e.g., Cystic Fibrosis in Northern Europe but not Finland)
  - How companies like “ancestry.com” and “23andMe” can trace your ancestry

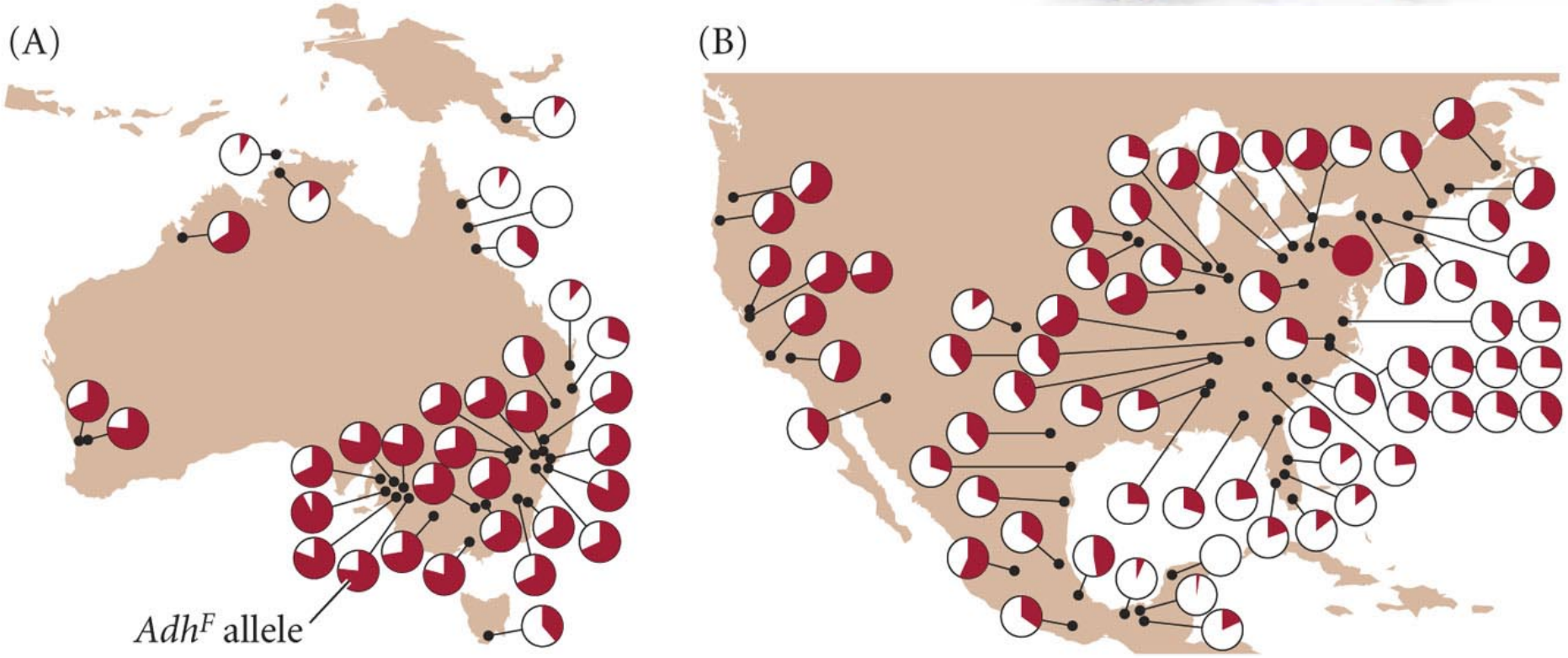




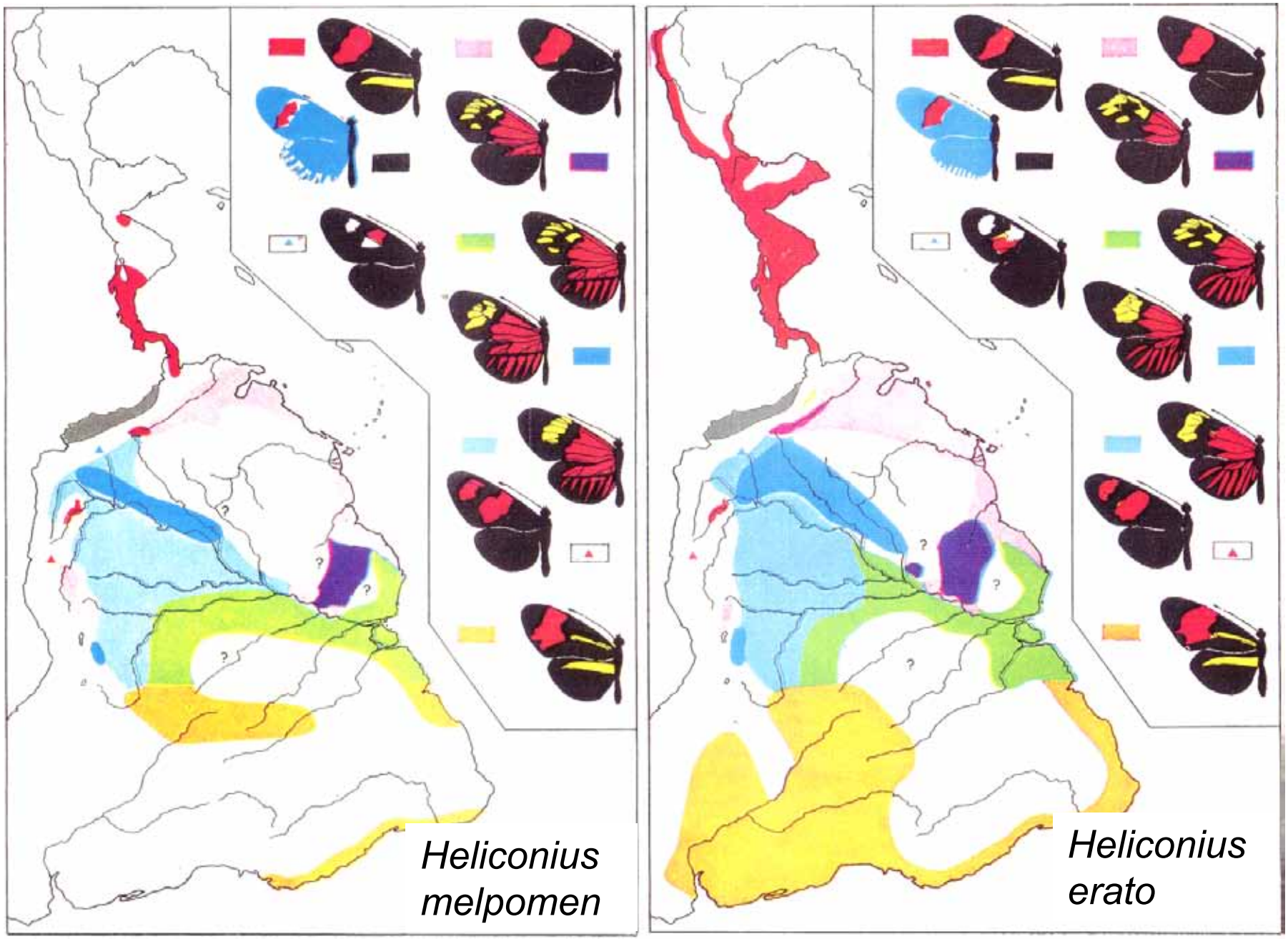
Novembre et al. 2008
Fig. 9.34 C, Futuyma 3e

More examples of clines

Gradual Cline. Fig. 9.25. High Adh^F allele frequency in *Drosophila melanogaster* associated with colder latitudes; parallel clines on two continents; repeated patte strengthens the argument for selection.



Stepped Cline: abrupt changes between phenotypes; parallel cline btw two species!



"Aposematic" (warning) Coloration

End of April 11th