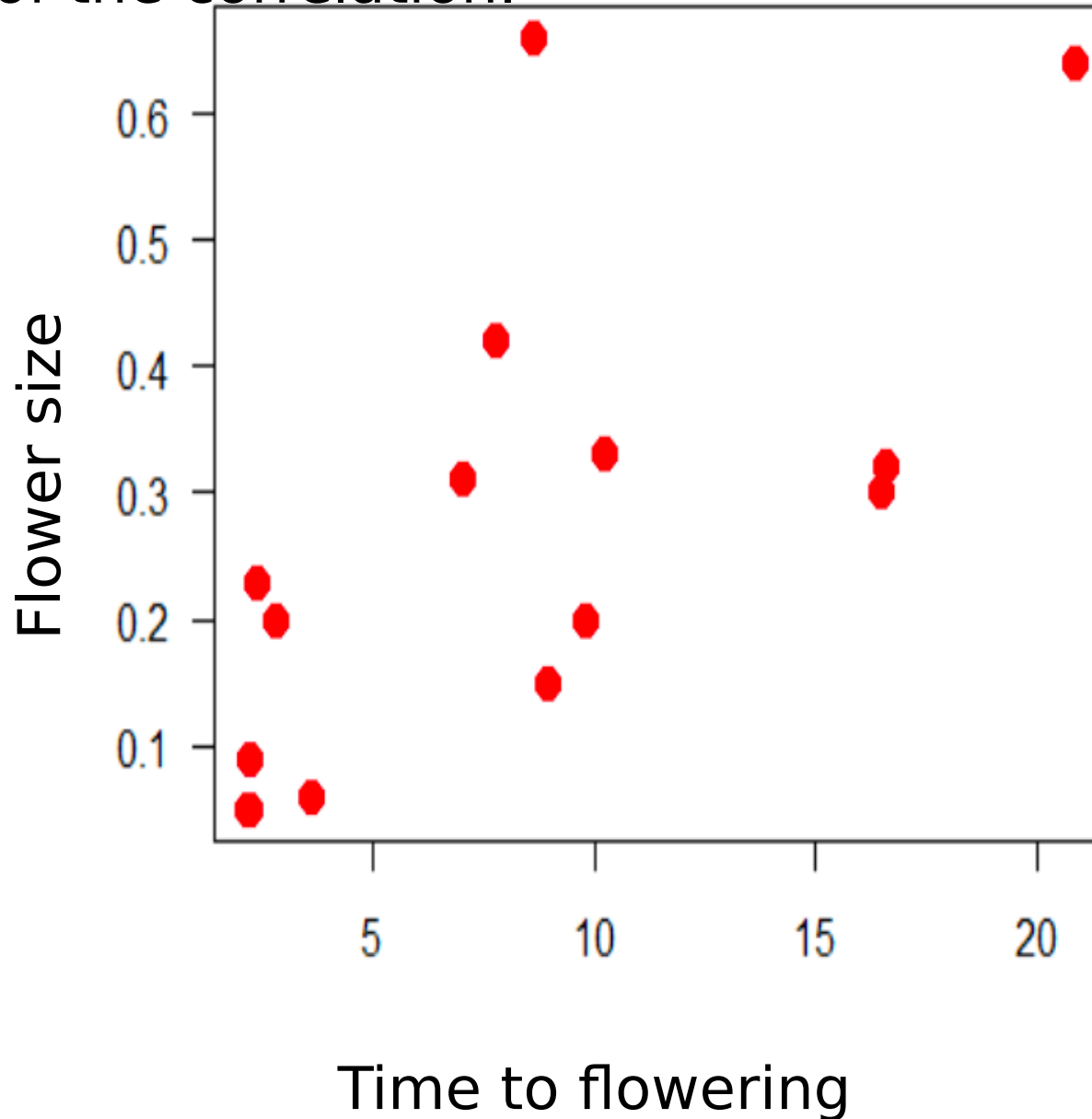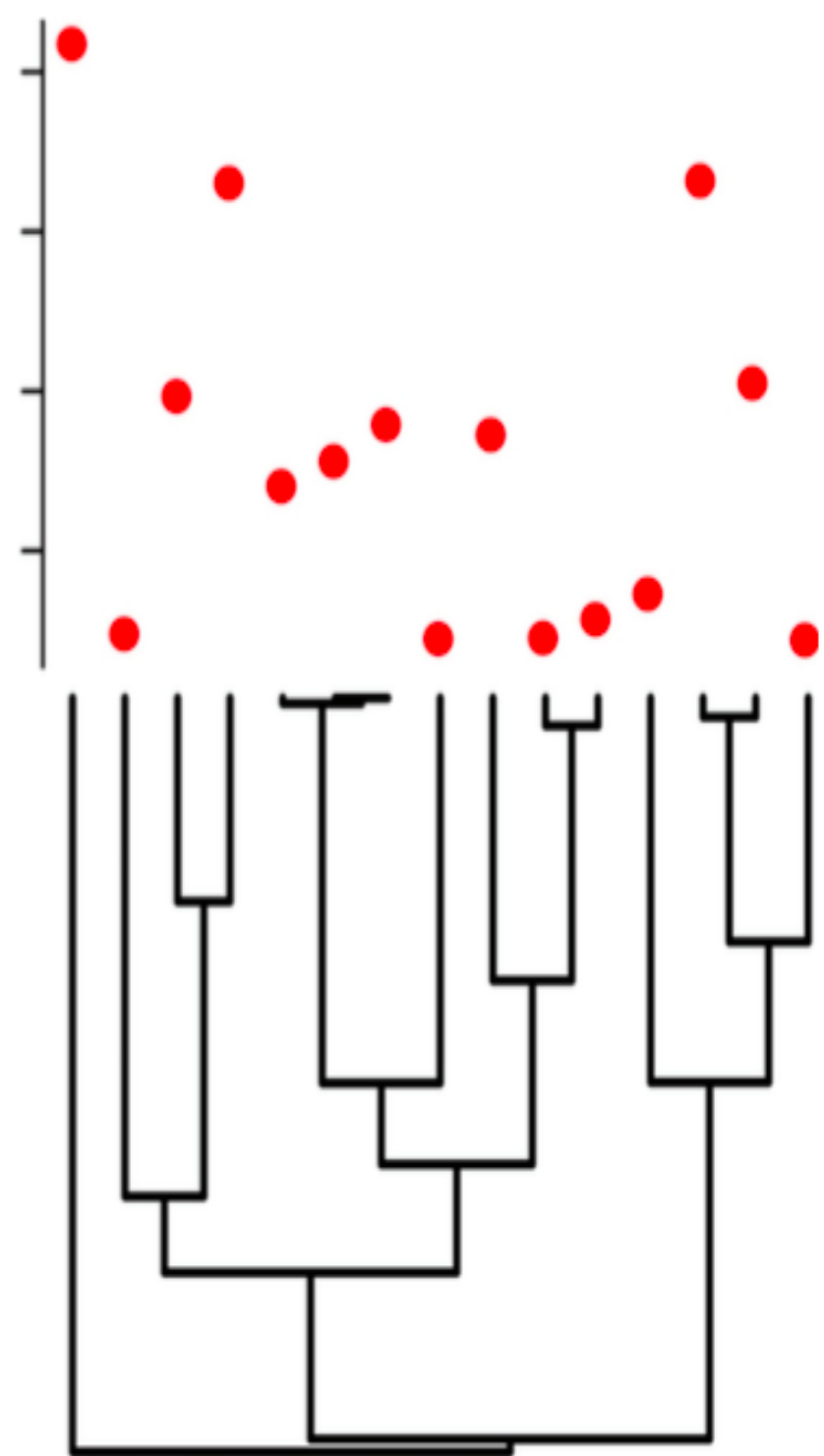# An example of species data

Data reveal a positive association between the two variables. We would like to estimate the strength of the correlation.
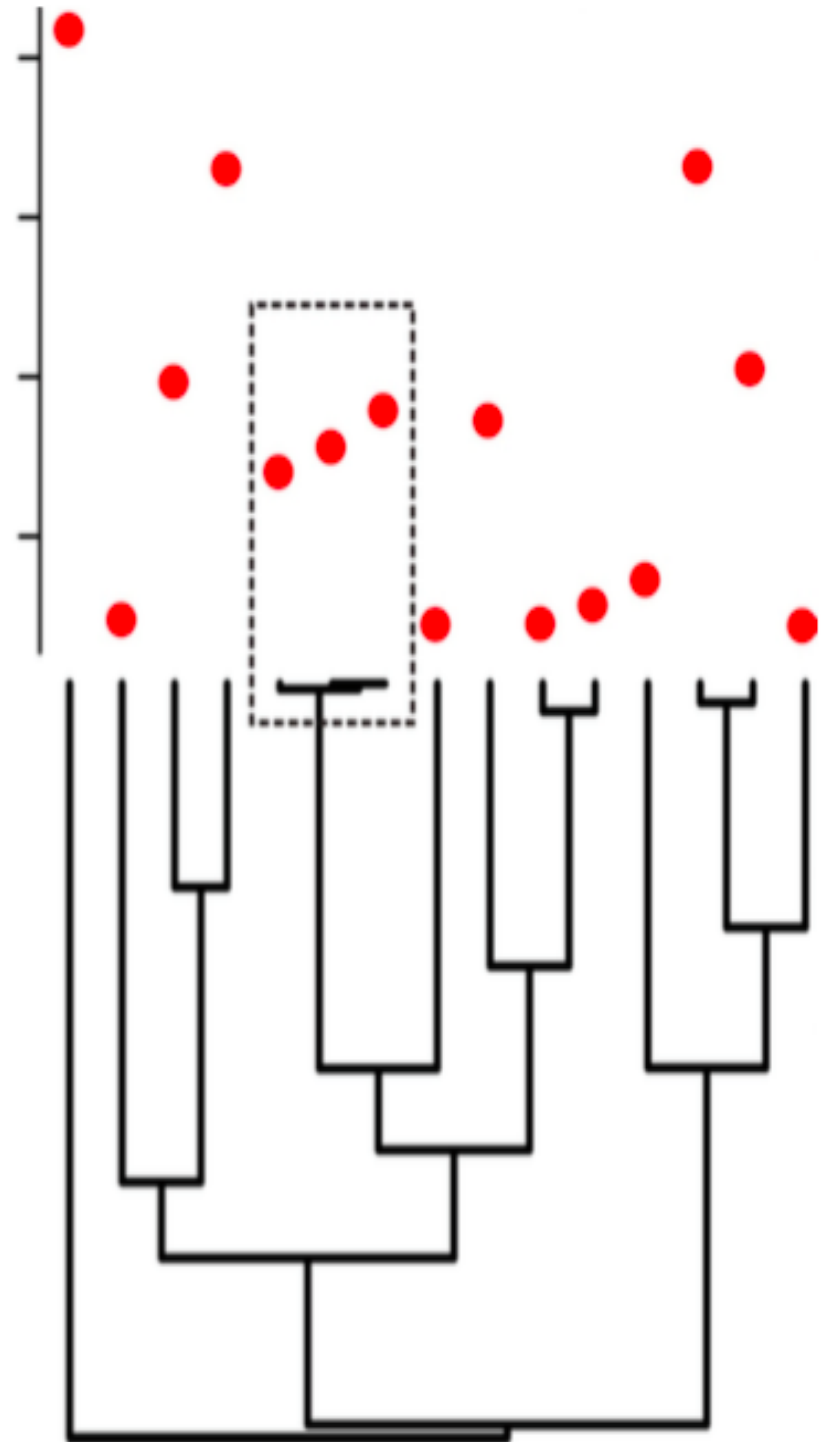

Time to flowering

The problem with species data
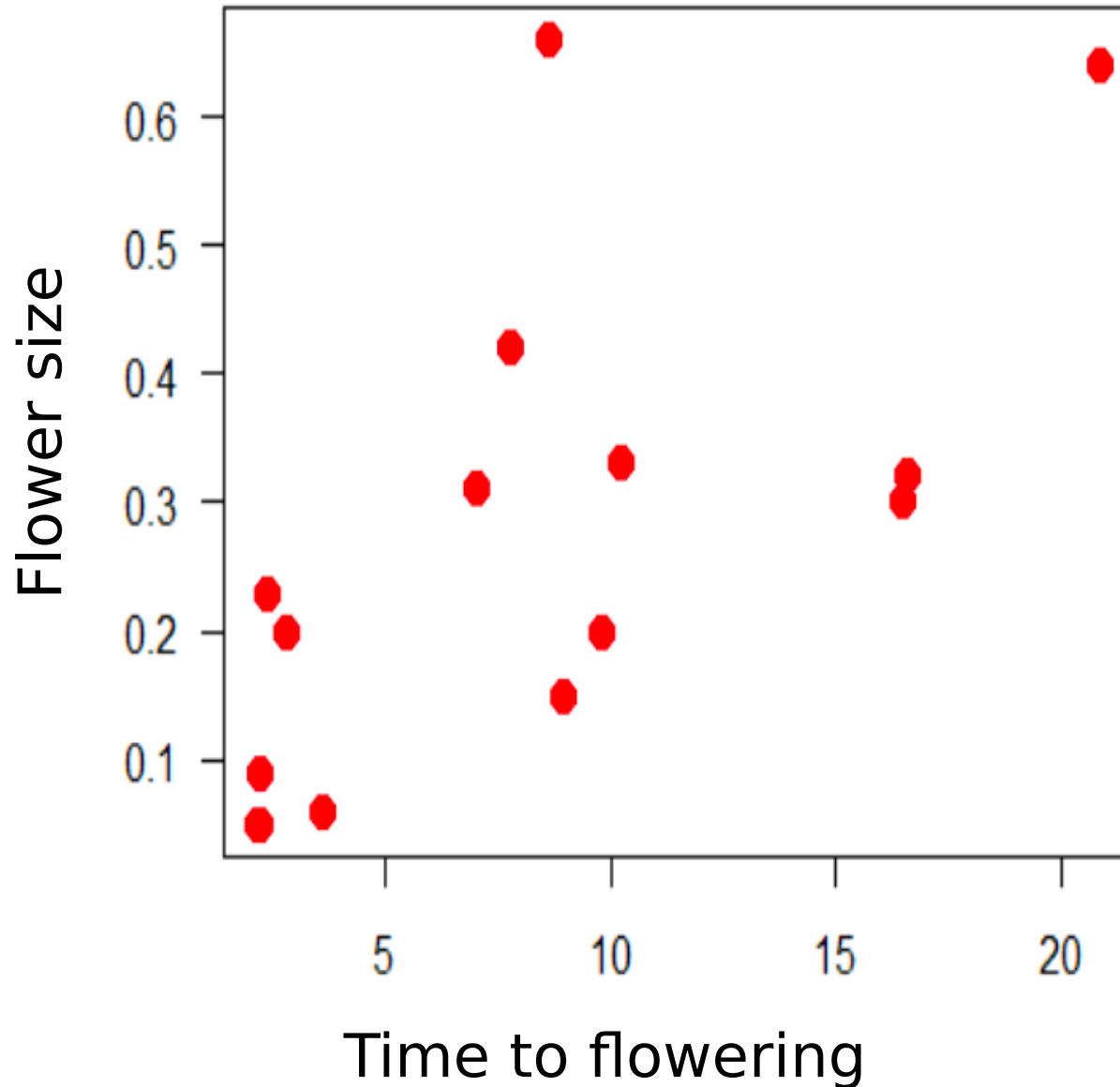The data points (species) are not independent.

The problem with species data

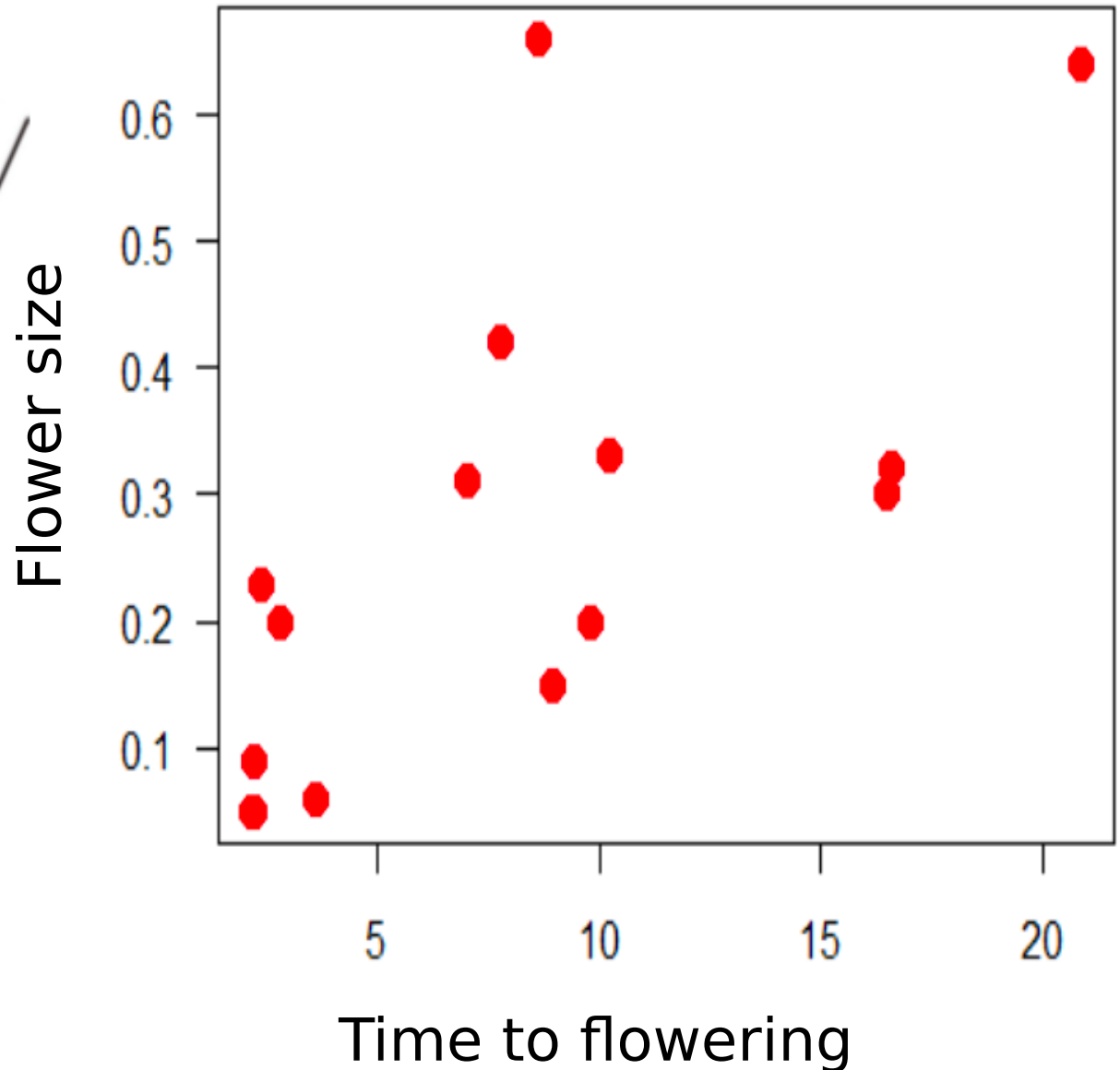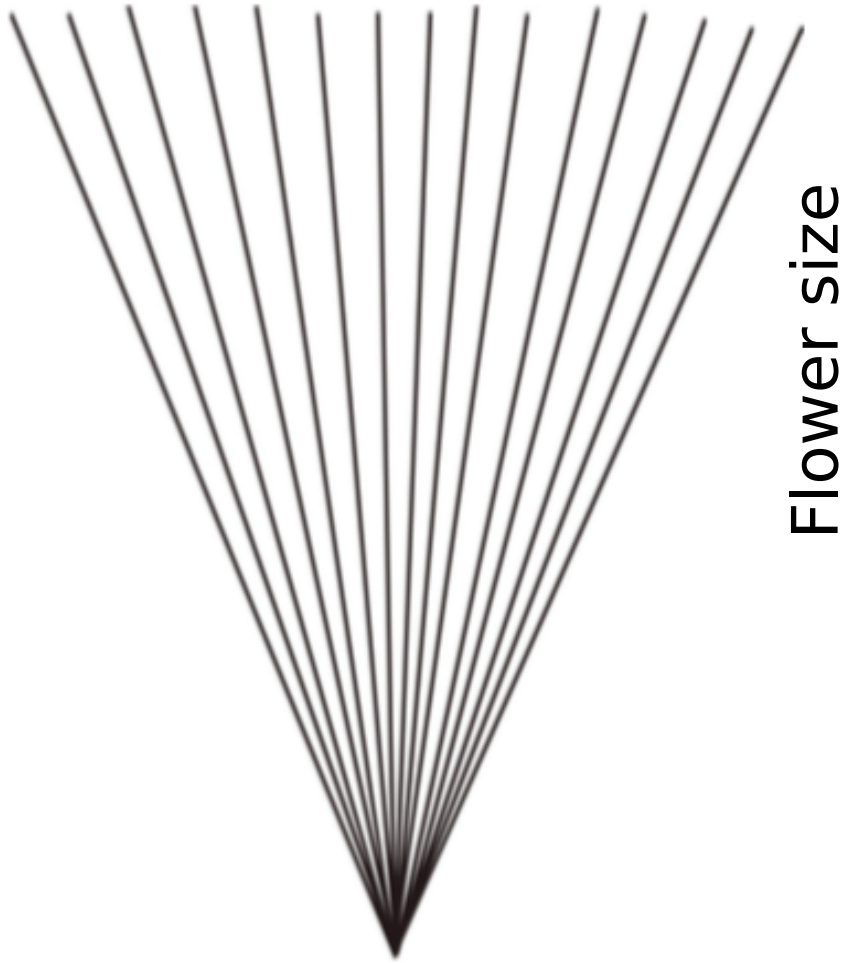Closely related species tend to have similar trait values.

The problem with species data

Non-independence of the species data points violates a major assumption of conventional statistical methods for data analysis.
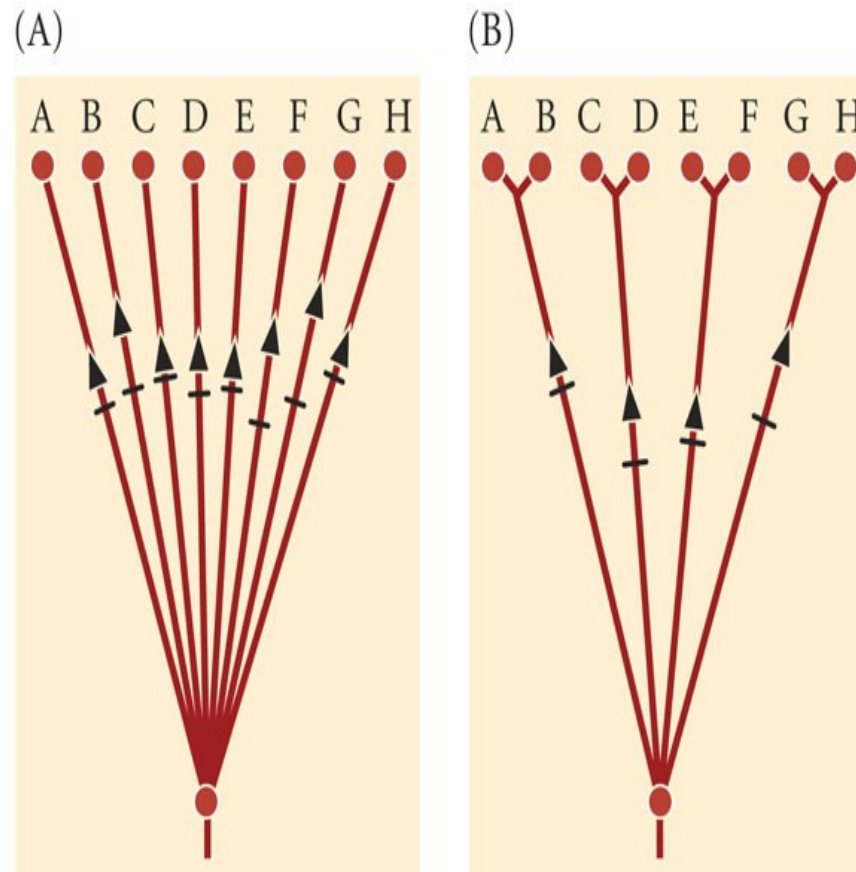
What we are really assuming when we ignore phylogeny
That the species are related as in a "star" phylogeny, which leads to no phylogenetic signal.

Independence assumption

EVOLUTION, Figure 11.21 © 2005 Sinauer Associates, Inc.

Characteristic evolved: 8 times
  4 times

Shared ancestry (branches) violates independence assumption!

Phylogenetic Independent Contrasts (PIC)

- A method that accounts for the phylogeny when analyzing data from populations/species
- Take contrast (A-B) divided by branch length, then 1-C, 3-2, etc.
  - Each contrast is independent
  - Never "double count" branches!
- Analyze the contrasts rather than the tip data

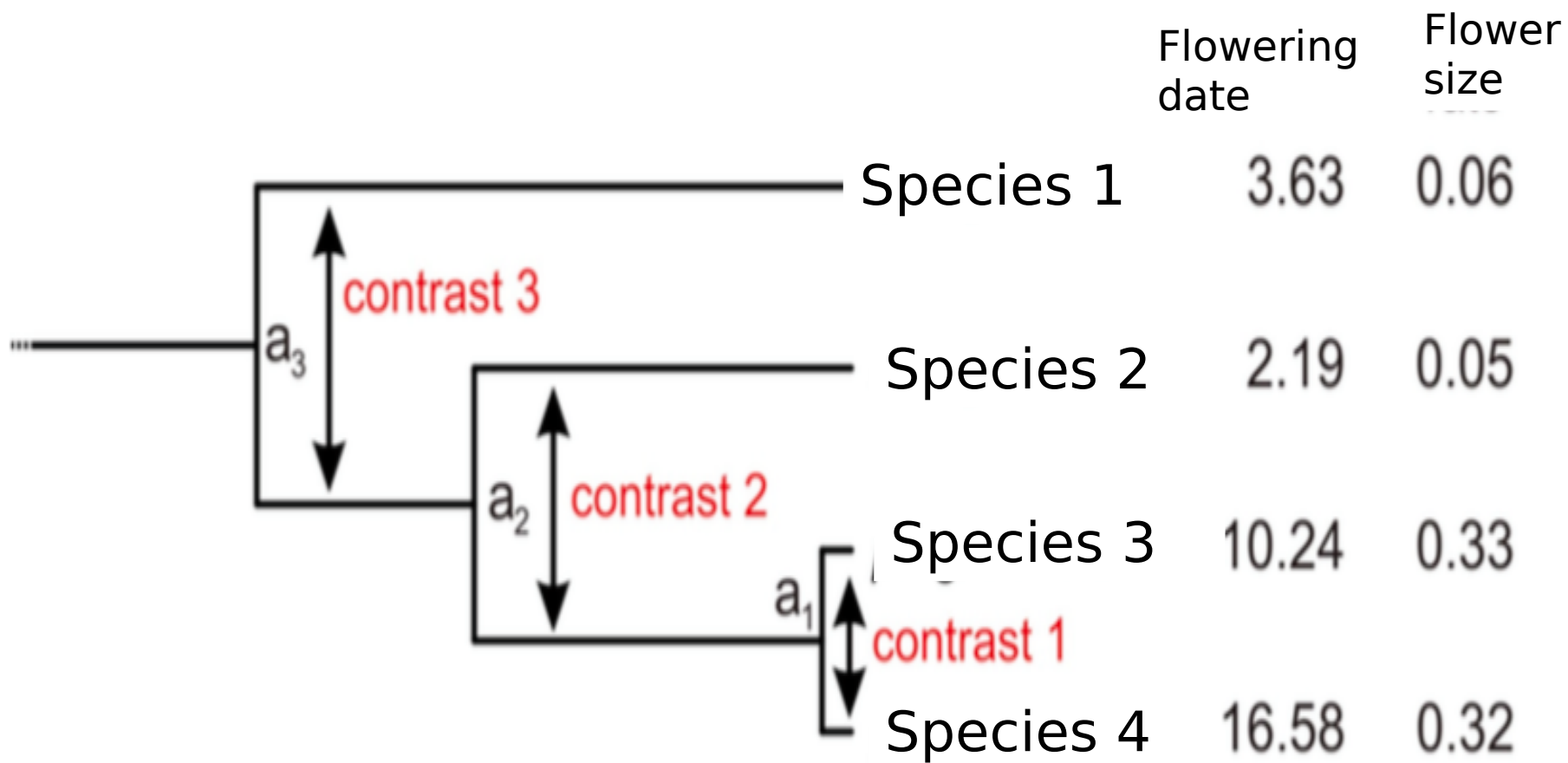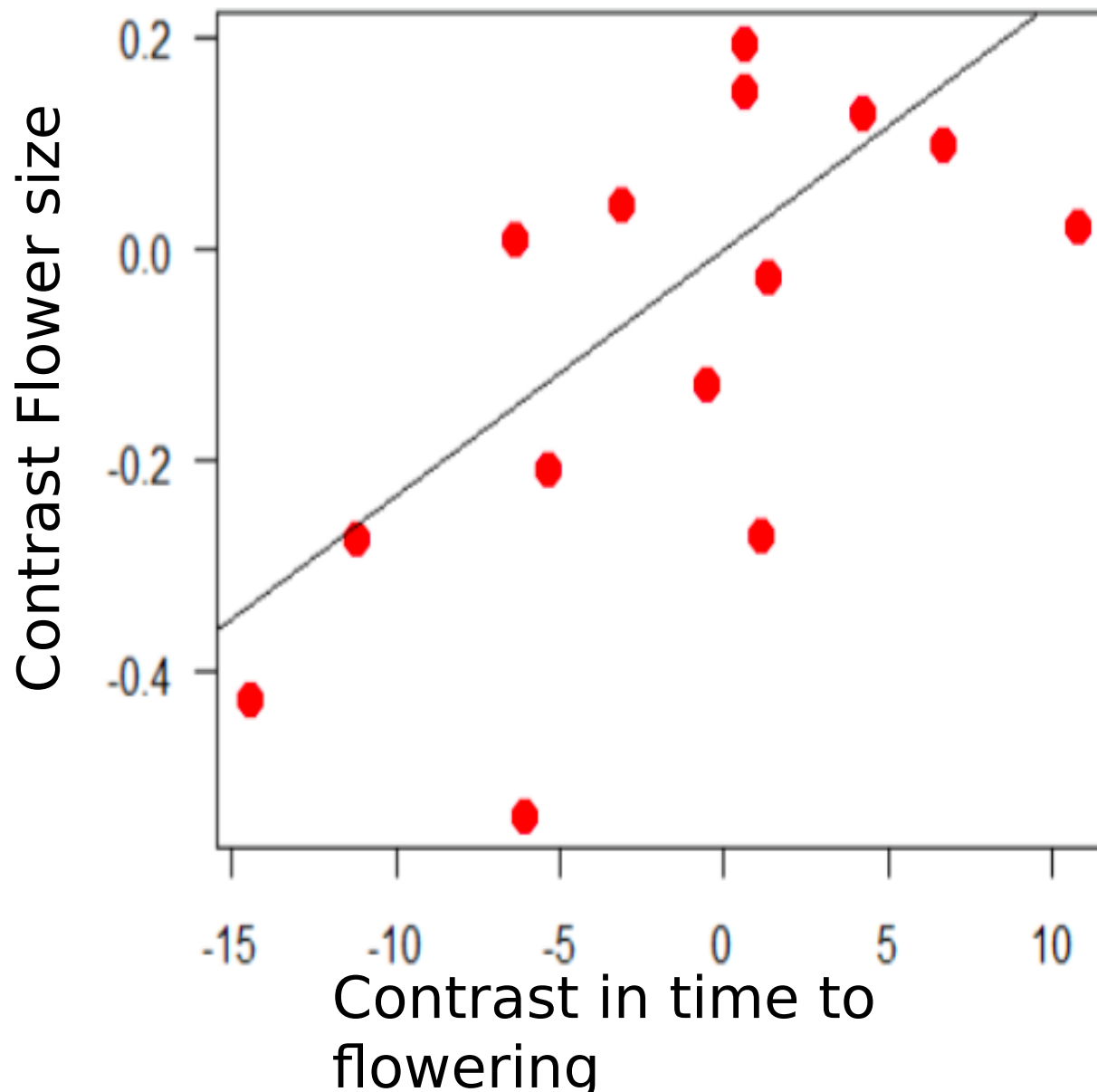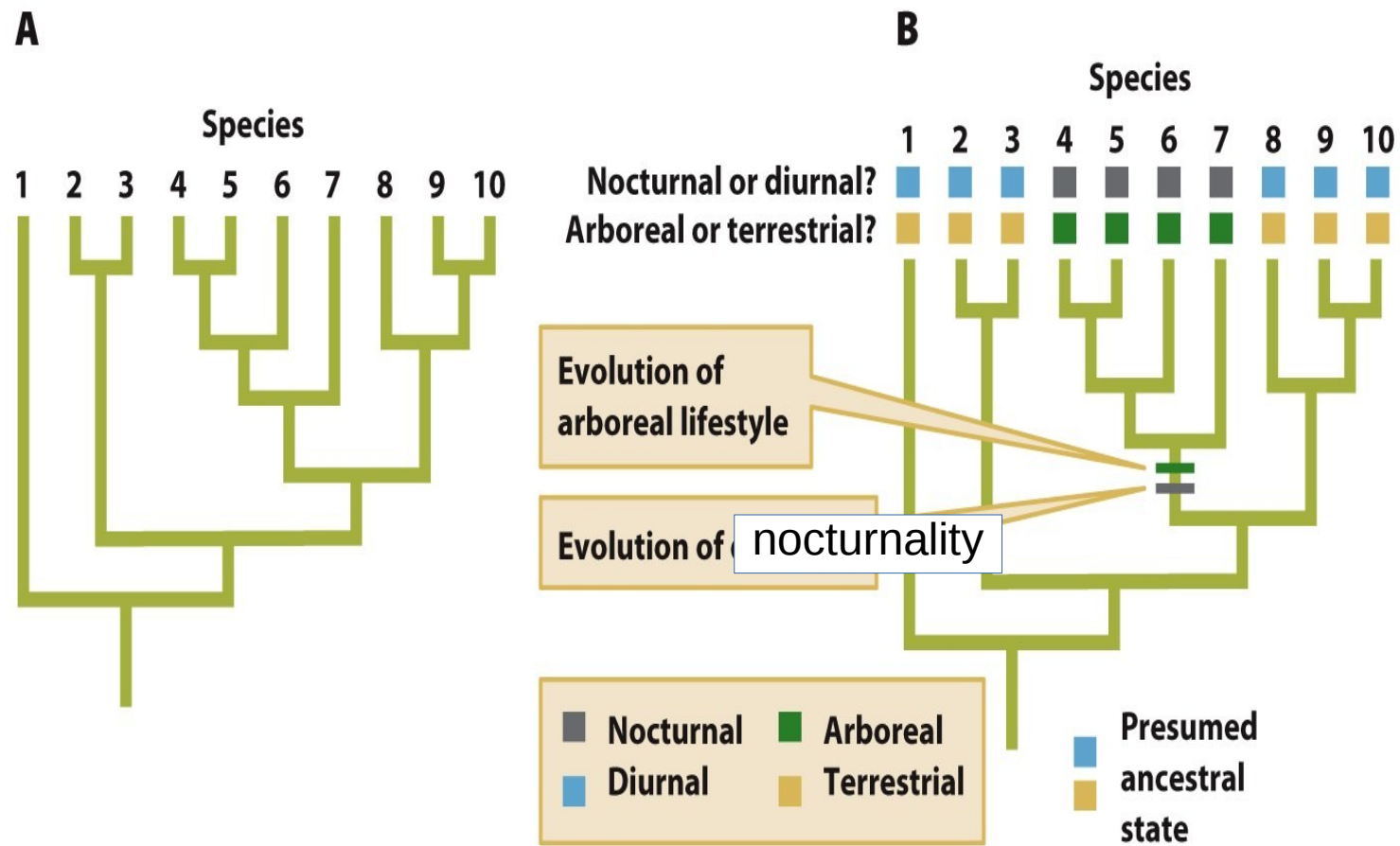|	Flowering date	Flower size
Species 1	3.63	0.06
Species 2	2.19	0.05
Species 3	10.24	0.33
Species 4	16.58	0.32
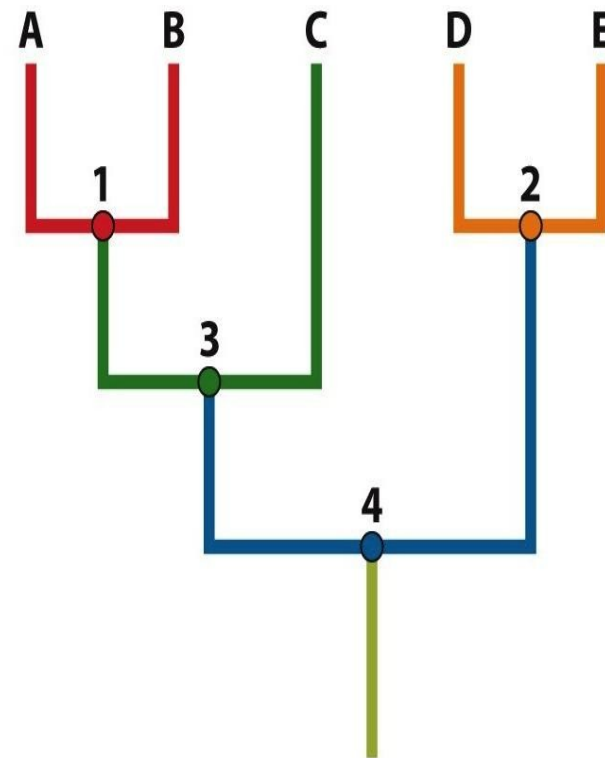
Phylogenetically independent contrasts

Because the direction of the contrast is arbitrary, the correlation or regression using independent contrasts is forced through origin (0,0).

Positive correlation confirmed!

Did evolution of nocturnality select for an arborial lifestyle?

A

Species
1 2 3 4 5 6 7 8 9 10

B

Species
1 2 3 4 5 6 7 8 9 10

Nocturnal or diurnal?
Arboreal or terrestrial?

Evolution of
arboreal lifestyle

Evolution of   nocturnality

Nocturnal	Arboreal	Presumed
Diurnal	Terrestrial	ancestral
		state

Evolution, 1/e Figure 5.44
© 2012 W. W. Norton & Company, Inc.

Being nocturnal and arboreal evolved once
You have little statistical power to say that the two are related

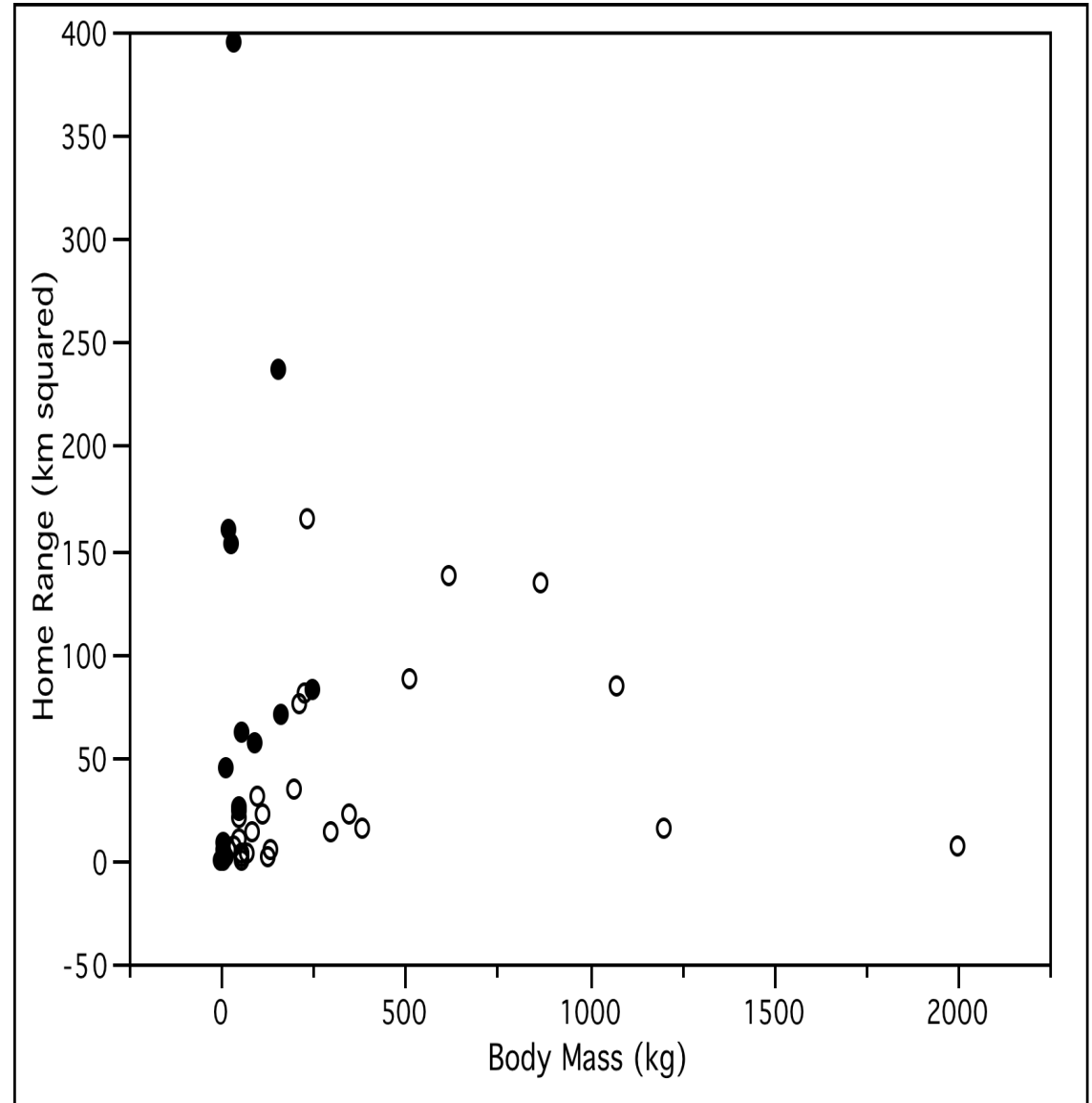Evolution, 1/e Figure 5.44
© 2012 W. W. Norton & Company, Inc.
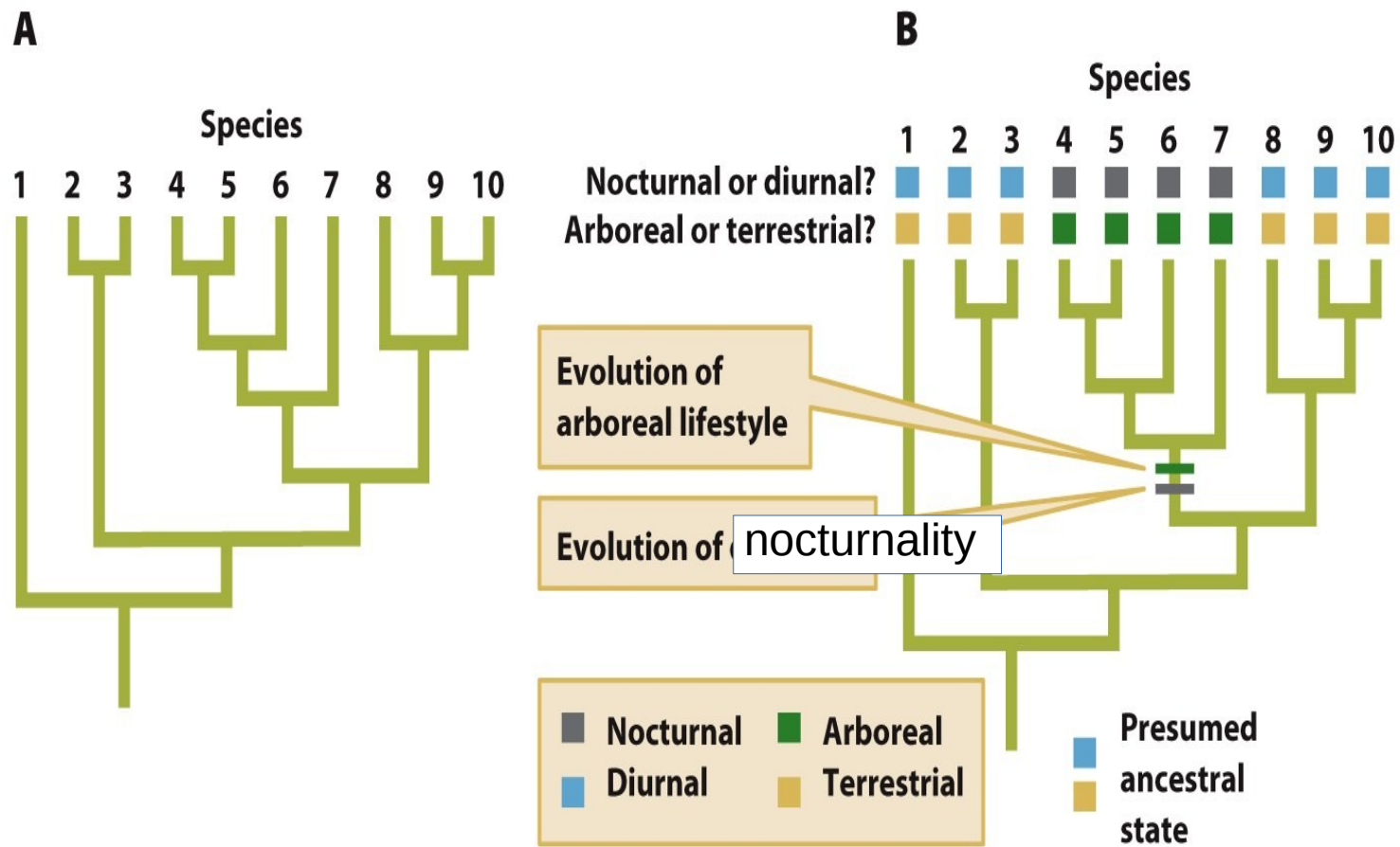
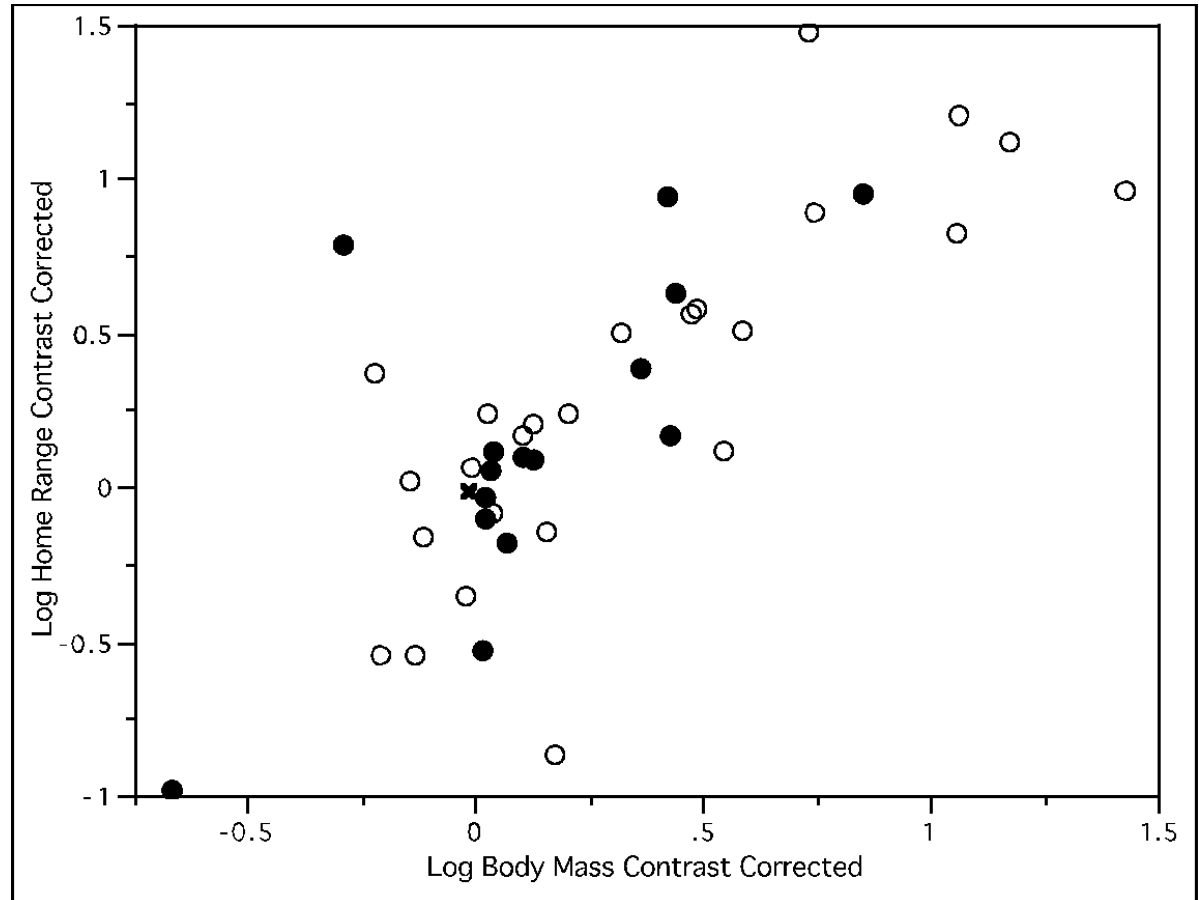# PIC Example: Home Range Size

Carnivores ●

have larger home range sizes than

ungulates ○
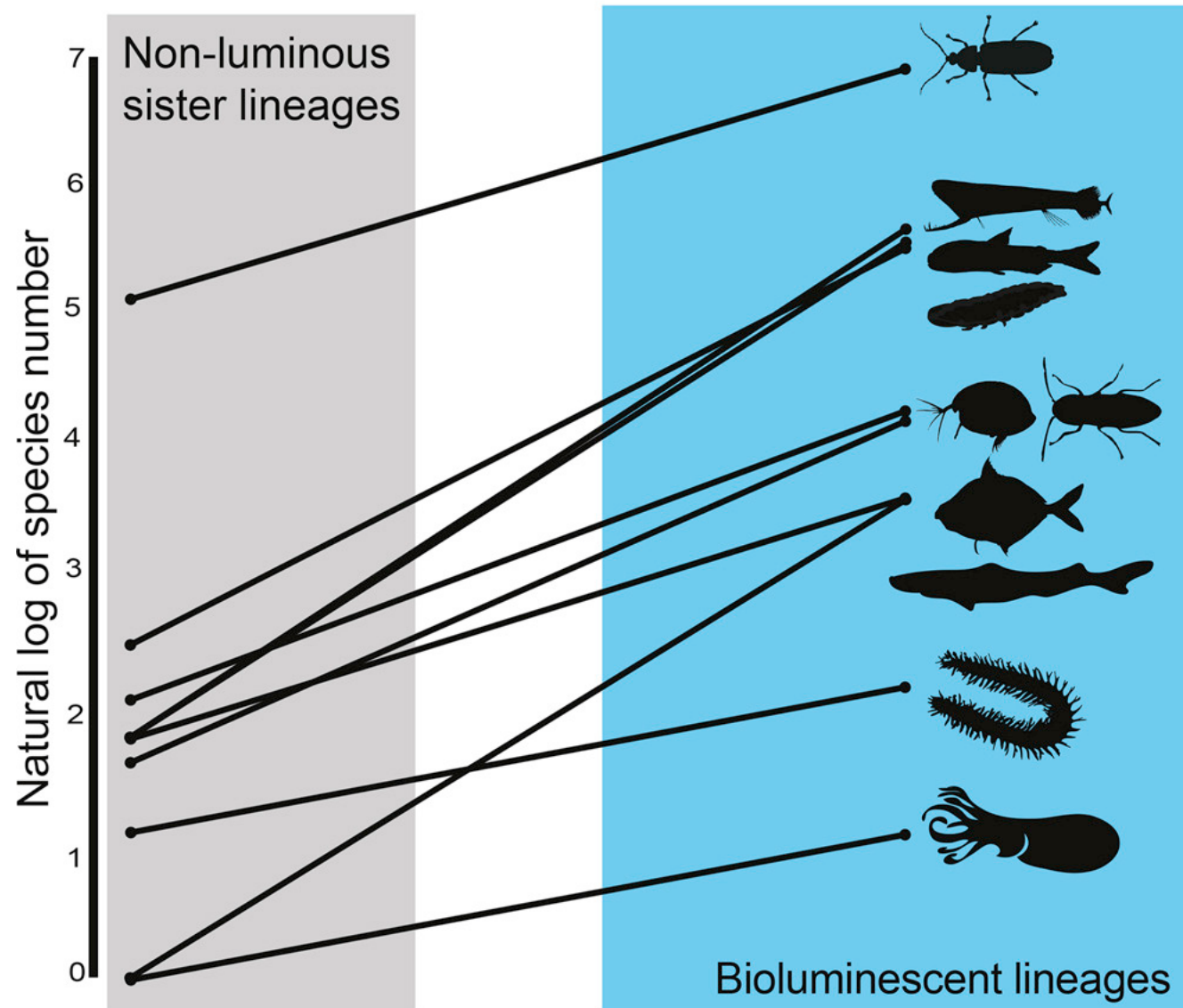
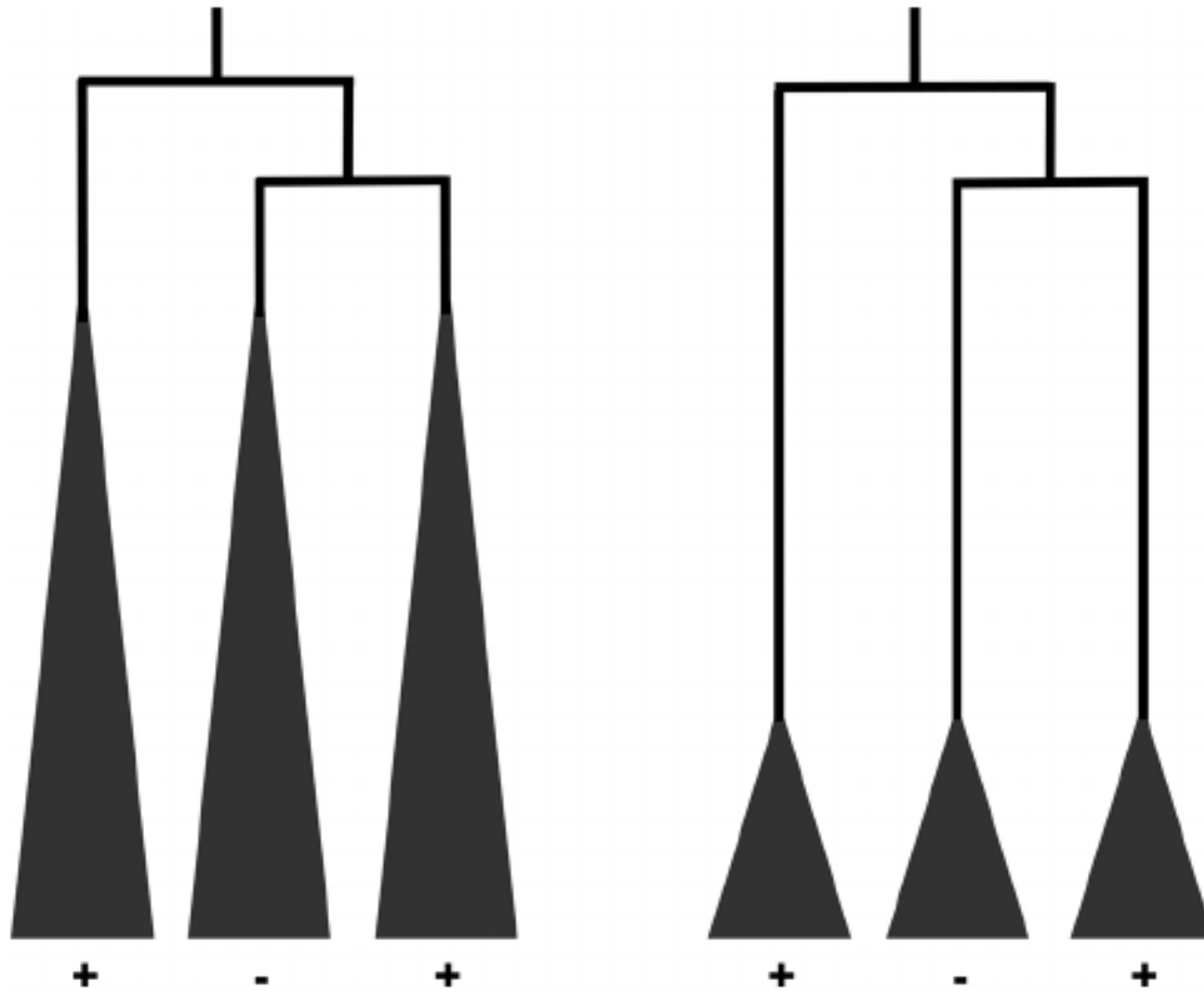# PIC Example: Home Range Size

But not when you account for phylogeny!

Sexually-selected bioluminescence leads to more species

Ellis & Oakley, 2016, Current Biology 26, 1916–1921

Which tree has a higher probability of convergence?

1. Hahn MW, Nakhleh L. Irrational exuberance for resolved species trees. Evolution. 2016;70:7–17.

long branches provide more opportunity for trait evolution and less diversification
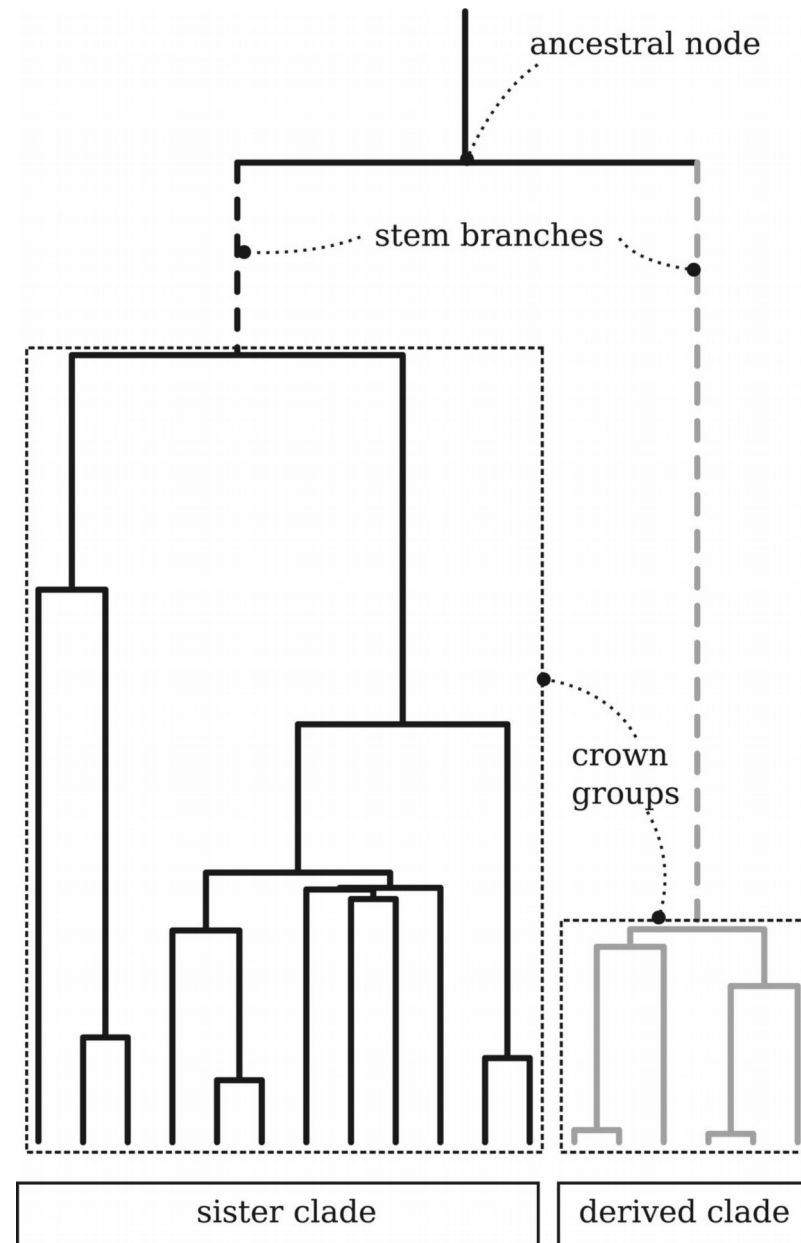
ancestral node

stem branches

crown groups

sister clade

derived clade

A COURTSHIP

Sister Lineage   Luminous Lineage

Natural log of species number

f
d,g,h
*** b,c
i,j
e
a

B COUNTER-ILLUMINATION

Sister Lineage   Luminous Lineage

Natural log of species number

F
B
A,C,I
K
D,G
J
E,H

C

Difference in ln(N) between lineages

a b c d e f g h i j   A B C D E F G H I J K

D

Sister Lineage   Luminous Lineage

Ellis & Oakley, 2016, Current Biology 26, 1916–1921
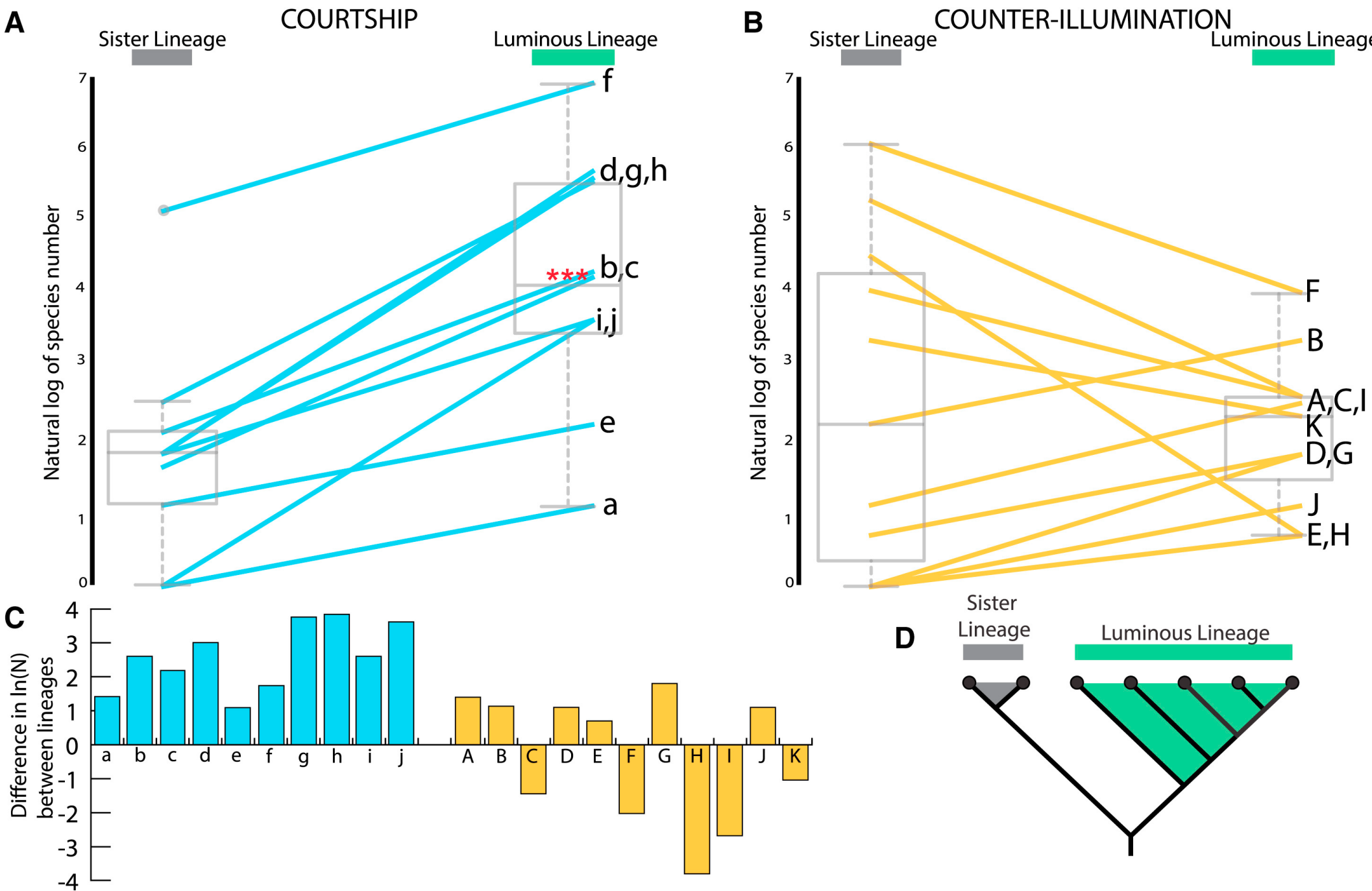
Ancestral state reconstruction

(a)

(b)

relative rates matter

Cunningham et al. 1998 http://sites.biology.duke.edu/cunningham/pdfs/science%202.pdf
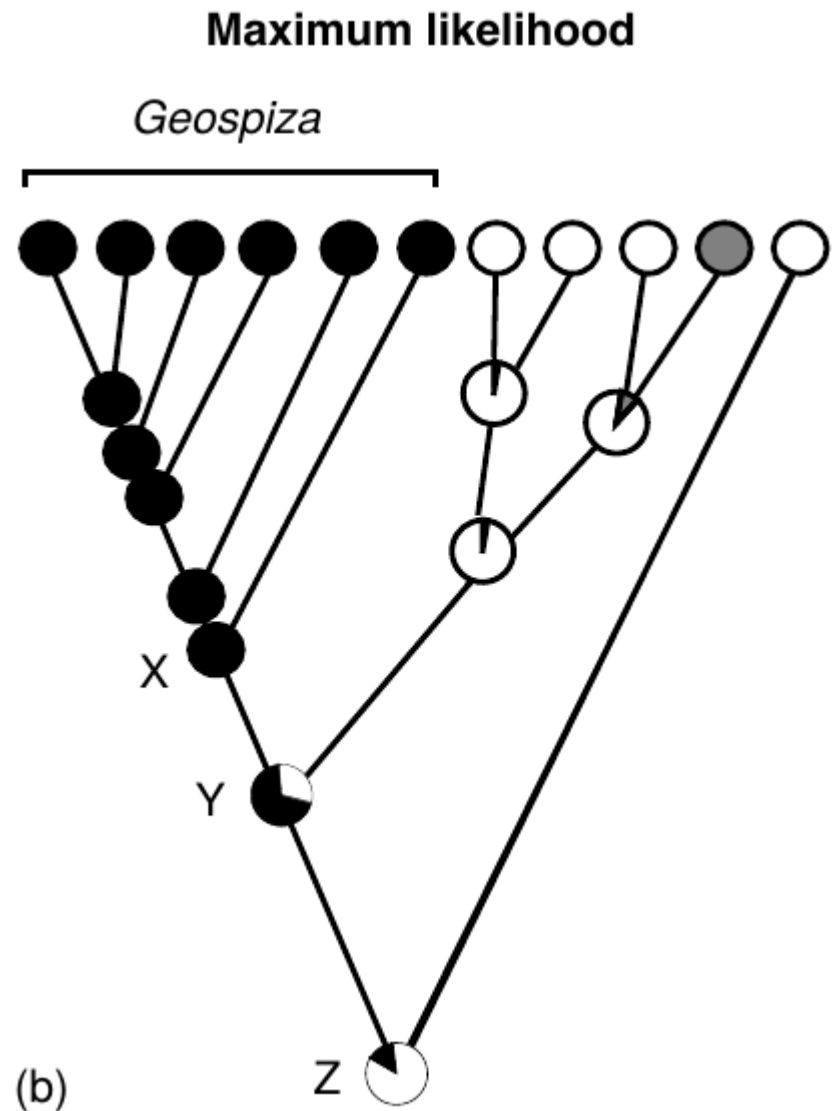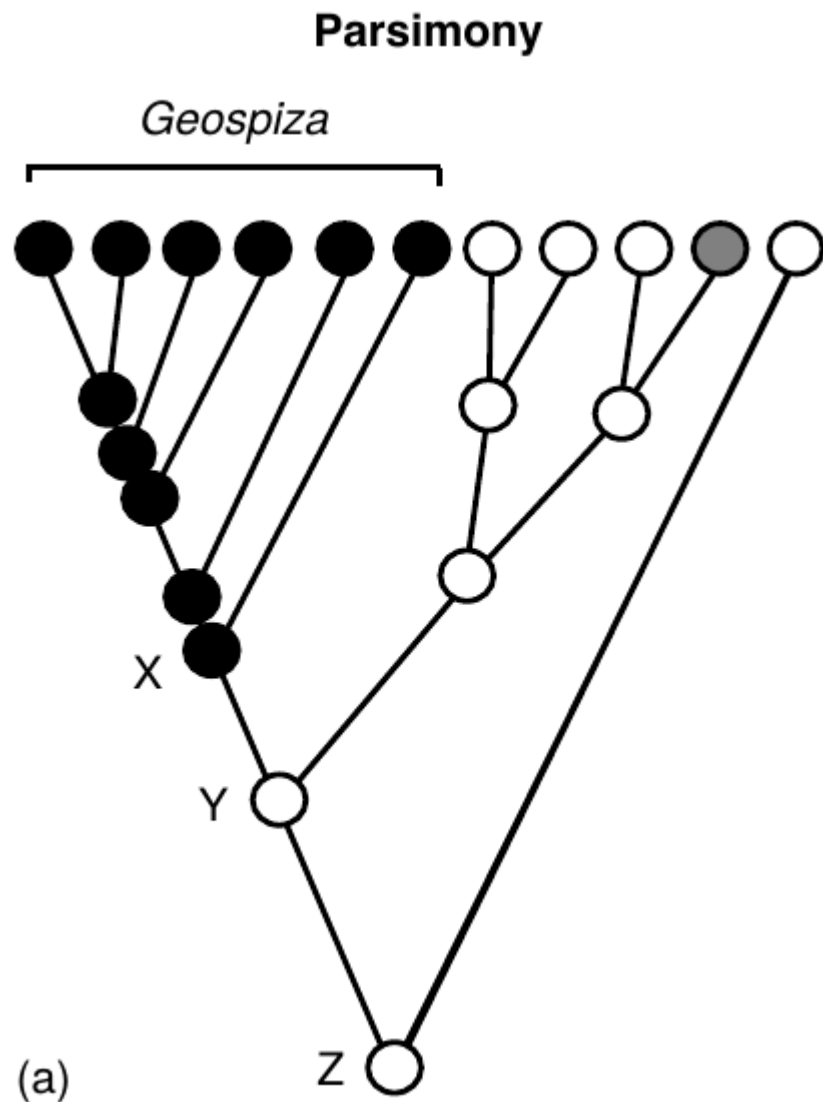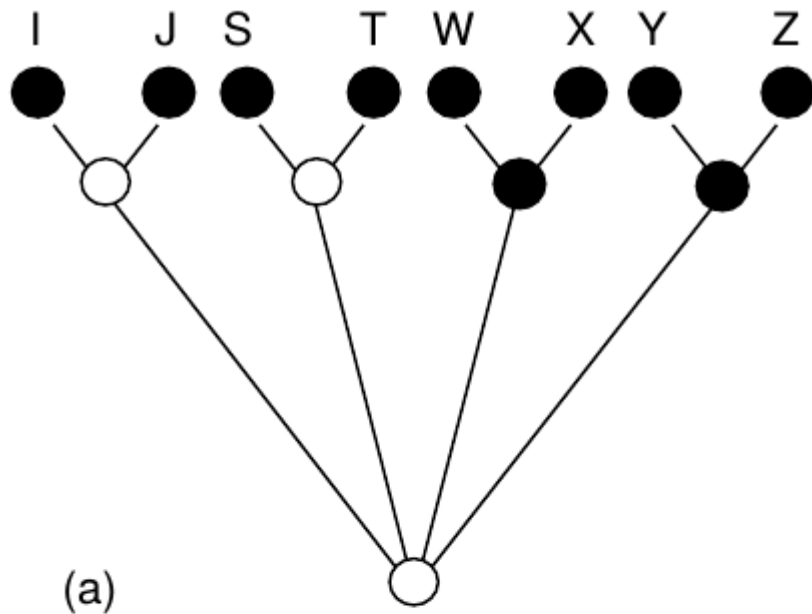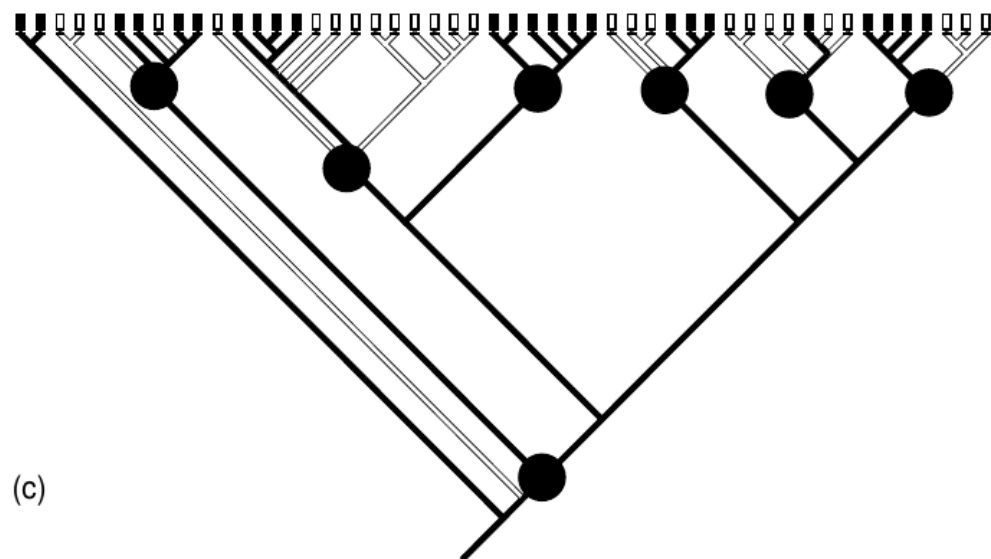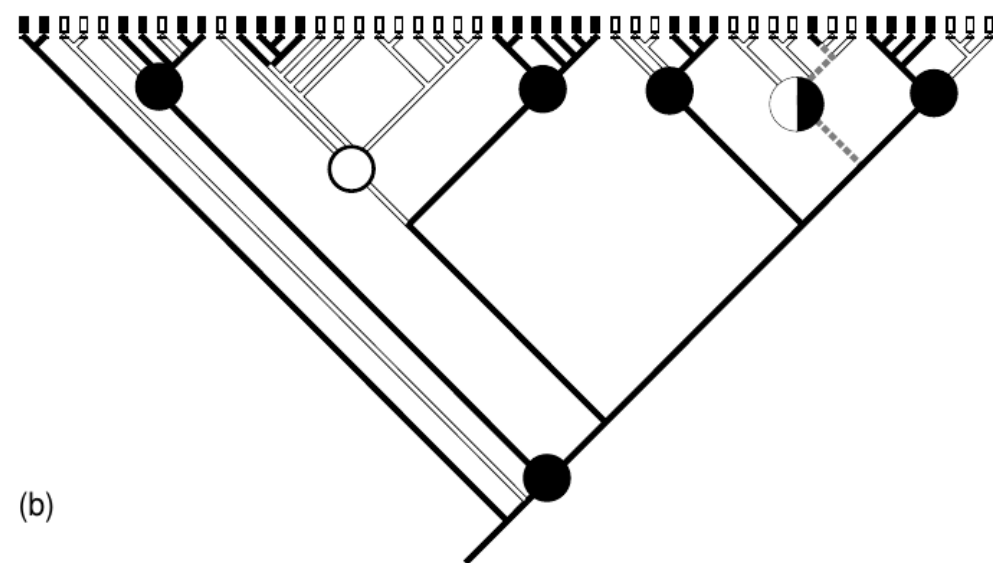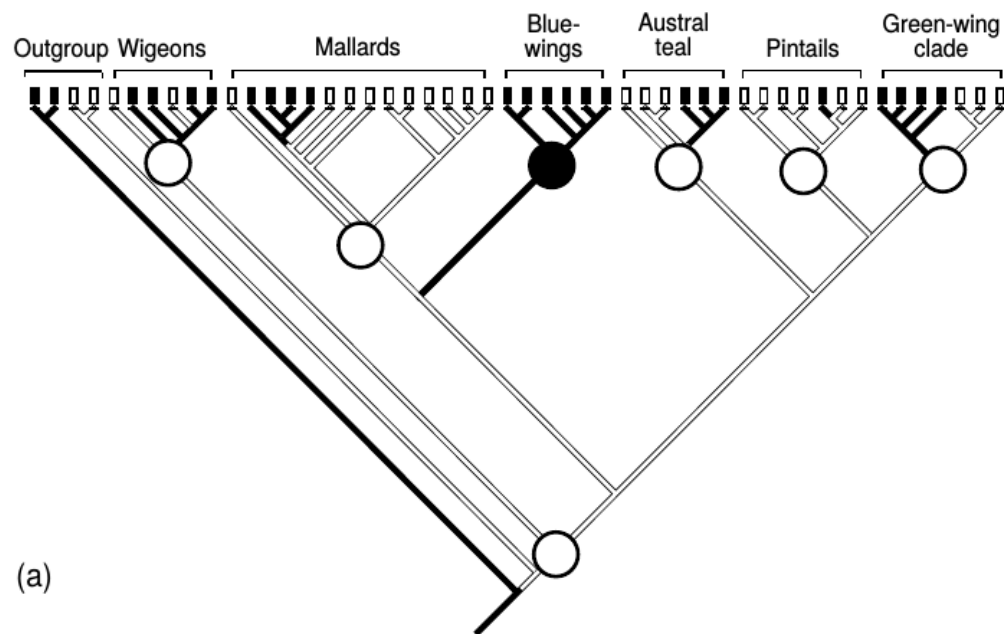
Fig. 2. Evolution of plumage dimorphism in dabbling ducks (*Anas*). White indicates monochromatic species, black indicates dichromatic, and grey broken lines indicate ambiguous reconstructions. (a) Parsimony reconstruction of ancestral characte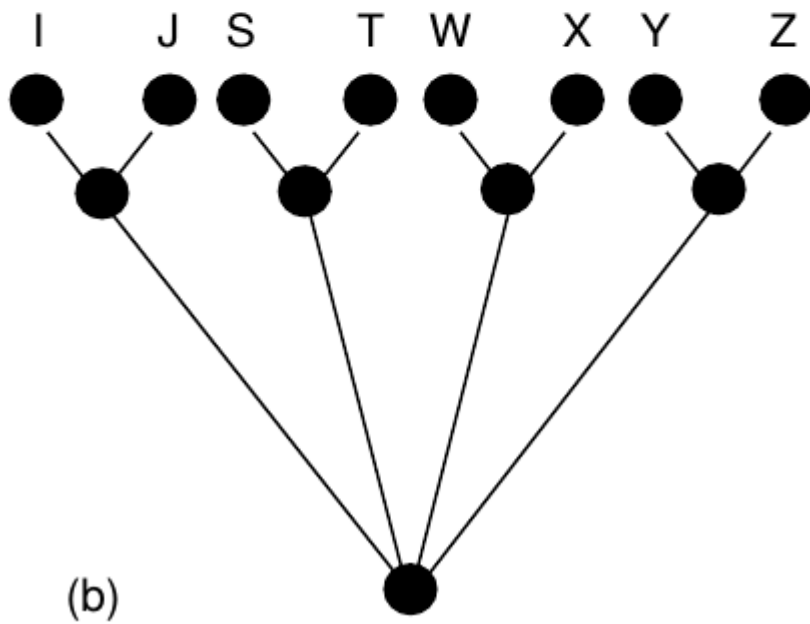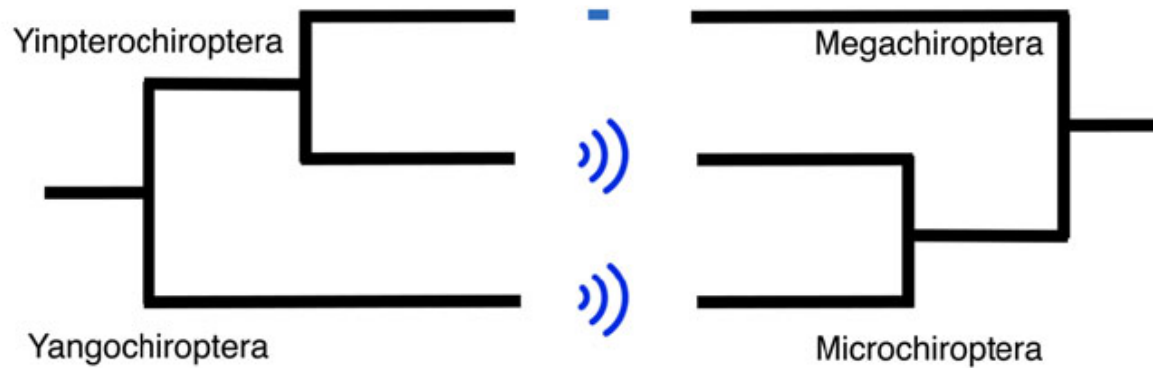r states. Reconstructed ancestral character states are shown in circles for the six main groups of dabbling ducks and for their common ancestor. Ancestral states for other nodes are indicated by shading within branches. Each terminal taxon is a species with its character state shown in the box at the top of the phylogeny. As with most parsimony reconstructions, this reconstruction allows equal weights for gains and losses. This reconstruction contradicts the widely held hypothesis that dichromatism has been lost many times. (b) When gains are three times more likely than losses, the number of independent origins of dichromatism decreases. (c) When gains are five times more likely than losses, the number of independent origins matches the widely held hypothesis. *Reproduced, with permission, from Ref. 16.*

Cunningham et al. 1998 http://sites.biology.duke.edu/cunningham/pdfs/science%202.pdf

what about the coalescent?

A

Yinpterochiroptera

Megachiroptera

Yangochiroptera

Microchiroptera

The evolution of echolocation in bats.

(A) Species re-lationships between echolocating and nonecholocating bats (af-ter Teeling 2009). T he left-hand species tree shows the relation-ships inferred from DNA sequence data, putting both echolocat-ing and nonecholocating taxa in the suborder Yinpterochiroptera, with the other echolocating bats in the suborder Yangochiroptera. The right-hand tree shows the traditional species relationships in-ferred from morphological characters (and limited sequence data).
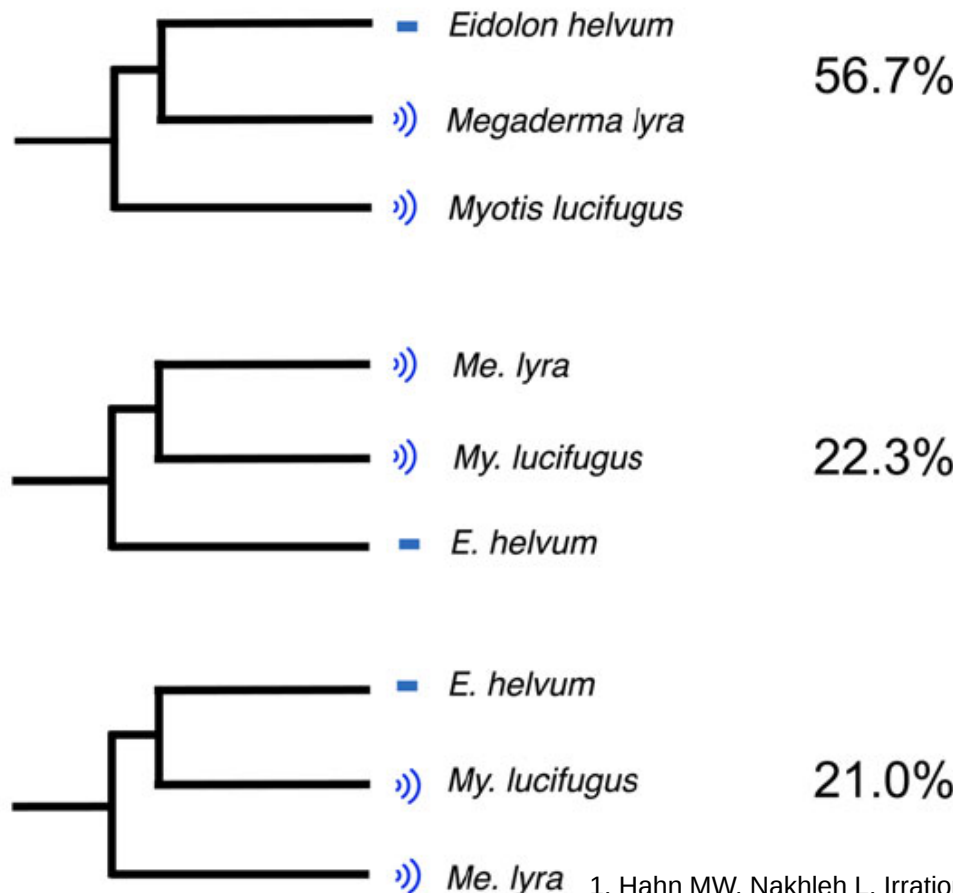
(B) Tree topologies inferred from 2083 genes using alignments from Tsagkogeorga et al. (2013) and Parker et al. (2013). Propor-tions shown are for the subset of genes (out of n = 2320 total)

B

Eidolon helvum
Megaderma lyra
Myotis lucifugus

56.7%

Me. lyra
My. lucifugus
E. helvum

22.3%

E. helvum
My. lucifugus
Me. lyra

21.0%

1. Hahn MW, Nakhleh L. Irrational exuberance for resolved species trees. Evolution. 2016;70:7–17.