Evolution of Body Size in Bears

How to Build and Use a Phylogeny
Lesson II

Using a Phylogeny
Objectives for Lesson II:

1. Overview of concepts

1. Simple ancestral state reconstruction on the bear phylogeny
   o class activity

1. Ancestral state reconstruction of polyploidy in birches.
   o In pairs

Students will use the following example:

• Examining frequency of polyploidy in *Betula* (birches), based on Mayrose *et al.* (2011) *Science*
Character Evolution

- Character evolution is the study of how a trait like color has evolved across a phylogenetic tree.
- Character states impact an organism's ecology - where it lives, what it eats, how often it reproduces etc...
- Understanding the evolution of a trait through time reveals the origin of current biodiversity.
Terms Review:

- A *phylogeny* describes the evolutionary relationships of a set of organisms. It is often based on morphological traits or, more commonly, DNA sequences.

- Species B and C are *sister taxa*.

- Species E is an *outgroup* to ABCD.

- Node Y is the *ancestor* to A, B & C.
Terms cont...

- *Ancestral state reconstruction* is a method to estimate the character state of an ancestor based on phylogenetic relationships and character states of present-day organisms.

- In this example, the *character* is color & the *character state* is red or black.

- Species A, B & C share the same character state (red). In this reconstruction, the character state red evolved in the ancestor at Node Y.
Ancestral state reconstruction

- There are multiple methods to reconstruct ancestral states.

- *Parsimony* is one of the simplest methods.

- Parsimony attempts to minimize the number of character state changes across the phylogeny.
- Character state change

• One character state change

• Three character state changes

Most parsimonious
Ancestral state reconstruction

• All methods of ancestral state reconstruction have assumptions

• *Parsimony* assumes that characters have evolved in a way that involves the fewest possible changes.

• There are examples when parsimony reconstruction is NOT the most likely
Ratite Birds

Non-parsimonious reconstruction - most likely
Ancestral state reconstruction

• The data used to generate a phylogeny and the character mapped onto the tree must be *independent*.

• You cannot use ancestral state reconstruction for a character you used to build the tree (circular).
Uses of ancestral state reconstruction

• Indicate character state of ancestor

• Does a trait change often or rarely across the tree? Is a trait *labile* (changes frequently/easily) or *conserved* (changes infrequently)?

• Is the state change associated with an increase or decrease in diversification rates?
Examples...
What is the character state of the ancestor?

Examples...
Is a character labile or conservative?

Eg. Are behavioral traits more or less conserved than morphological and physiological characters? (Blomberg et al. 2003. Sys.Bio. 57: 717-745)
Examples...
Is a character state change associated with a change in diversification rate?

Eg. Are key innovations in angiosperms associated with an increased rate of diversification?
Biology of Bears

- 8 living species (and many extinct species)
- Widespread (mostly Northern Hemisphere and parts of Southern Hemisphere)
- Carnivores
- Closest relatives are dogs (canids) and seals
* = extinct species
1. MOM v4.1.

Global database of late Quaternary mammal body mass arranged by continent.
• Body mass is a *continuous* trait. For simplicity, we are going to lump bears into two groups: **large** and **small**.

• **large** bears > 200 lbs
• **small** bears < 200 lbs

• We will then conduct a simple ancestral state reconstruction of body mass in bears.
** Average masses (male + female) are shown. Masses for extinct species are estimates based on the fossil record. See MOM metadata for more information.
• Based on our parsimony approach, the ancestor of all bears appears to have been a small-bodied bear (that is, <200kg).

• Now form a hypothesis for why some bears have evolved larger body sizes.

• Any ideas??
Evolution of large body size could be due to:

• adaptation to high-latitude environments

• adaptation to ice-age climates
  (larger size aids in retention of body heat)

OR

• adaptation to larger prey sizes
The End