Using Phylogenies to Understand Biodiversity: Patterns and Processes in the (mostly) Andean genus *Bartsia* (Orobanchaceae)

Simon Uribe-Convers

[www.simonuribe.com](http://www.simonuribe.com)
Biodiversity?
Aristotle’s *Scala Naturae*

http://www.mlahanas.de/Greeks/Evolution.htm

Didacus Valades, *Rhetorica Christiana* 1579

http://en.wikipedia.org/wiki/
Charles Bonnet’s
Great Chain of Being - 1745

http://en.wikipedia.org/wiki/Charles_Bonnet

Charles Bonnet's
Great Chain of Being - 1745

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Charles Darwin - 1859

First to suggest that any classification should be genealogical and naturally hierarchical.

“It is a truly wonderful fact - the wonder of which we are apt to overlook from familiarity - that all animals and all plants throughout all time and space should be related to each other in groups, subordinate to groups, in the manner in which we everywhere behold...The several subordinate groups in any class cannot be ranked in a single file, but seem to be clustered round points, and these around other points, and so on in almost endless cycles. If species had been independently created, no explanation would have been possible of this kind of classification...The affinities of all the beings of the same class have sometimes been represented by a great tree. I believe this simile largely speaks the truth...The green and budding twigs may represent existing species; and those produced during former years may represent the long succession of extinct species...As buds give rise by growth to fresh buds, and these, if vigorous, branch out and overtop on all sides many a feebler branch, so by generations I believe it has been with the great Tree of Life, which fills with its dead and broken branches the crust of the earth, and covers the surface with ever-branching and beautiful ramifications.”
Natural classification - reflects the nature of evolutionary relationships
Monophyletischer Stambaum der Organismen from *Generelle Morphologie der Organismen*
Today we call this **phylogeny**, and phylogenetic relationships shape our classifications and the way we interpret biological diversity.
Although phylogenies are real, we can only infer and hypothesize the relationships from the available data.
Types of Data

Morphological

- Hairs: present
- Leaf length: 2 cm.
- Leaf margin: crenate

Molecular
DNA Sequences
DNA Sequences
Phylogenetic Relationship

Two species (B and C) are more closely related to each other than they are to a third species (A), if and only if they share a more recent common ancestor.
Father of “Phylogenetic Systematics”: derived attributes are evidence of shared ancestry.
http://www.bidorbuy.co.za/item/6292359/Nymphaea_caerulea_Seeds.html

http://www.writespirit.net/blog/archive/2007/10/05/like-a-lotus


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Afrotheria
You are here

The cotton in your shirt came from here

The mushroom on your pizza came from here

The *E. coli* in your gut is here

Zwickl and Hillis, 2003 (see Science 300:1692-1697)
Angiosperms

>300,000 species

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Species analyzed to date

300,000 Flowering Plants

http://www.peabody.yale.edu/exhibits/treeoflife/challenge.html
Páramos

- South America
- Most biodiverse montane ecosystem
- 9000 - 15,000 ft in elevation
- ~3700 vascular plants
- High levels of endemism (~27%)
- Movements from different environments
- North American pre-adaptations to montane environment
- Young environment, ~4 - 2 Myr old
Bartsia

- Linnaeus
- Herb
- Generalist hemiparasite
- Montane genus in the Alps, Afromontane, Páramos
- ca. 49 species
- ca. 45 species in South America
- 2 species in Africa
- 1 species in Europe and northeastern North America
- 1 species in the Mediterranean
- No montane representatives in North America
Back in 1990...

Molau, 1990
Odontites holliams (R. Lowe) Benth.
det. M. Bolliger 1992
Is *Bartsia* a good genus?
-Monophyletic?

nrDNA: ITS, ETS
cpDNA: rps16, *trnT-L, trnL-F*

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Dating the Tree

2 - 4 MA

30.82 MA

2.65 MA

7.01 MA
North Atlantic Land Bridge 50 - 12 MYA
Bering Strait 40 - 5 MYA

NALB
BERINGIA

Bartsia crenoloba
Euphrasia stricta
Rhynchocorys stricta
Parentucellia viscosa
Bartsia decurva
Rhynchocorys orientalis
Odontites linkii
Bornmuellerantha aucheri
Bartsia tenuis
Bartsia laniflora
Melampyrum lineare
Tozzia alpina
Bartsia sericea
Bartsia thiantha
Lathraea squamaria
Hedbergia abyssinica
Rhinanthus cristagalli
Euphrasia mollis
Rhynchocorys elephas
Bartsia stricta
Odontites vulgaris
Bartsia longiflora
ssp. longiflora
Hedbergia abyssinica
var. petitiana
Bartsia alpina
Bartsia trixago
Hedbergia abyssinica
var. nykiensis
Rhinanthus kyrollae
Rhynchocorys maxima
Euphrasia alsa
Bartsia melampyroides
Euphrasia regelii
Melampyrum sylvaticum
Odontites maroccanus
Rhynchocorysodontophylla
Bartsia sp 5
Rhinanthus freynii
Odontites corsicus
Rhinanthus serotinus
Euphrasia collina
Bartsia laticrenata
Bartsia pedicularoides
Bartsia santolinifolia
Odontites vulcanicus
Bartsia ramosa
Melampyrum carstiense
Bartsia pyricarpa
Rhynchocorys kurdica

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Conclusions

- The current classification of *Bartsia* does not correspond to the evolutionary relationships of the group

- Revised classification

- The timing and historical biogeography suggest that land bridges and not a long distance dispersal may be responsible for the South American *Bartsia* group
¡VIVA LA EVOLUCIÓN!