The use of Phylogenies for Conservation purposes

Arnica

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Overview

- Biological distinctivness
- Measures of diversity
- Example: Malvaceae
- *Arnica* evolution
Criteria for prioritizing threatened species

- Threat
- Ecological importance
- Economical importance
- Charisma
- Biological distinctiveness
Biological distinctiveness

- Traditional classifications
- Phylogenetic distinctness
  - Tree based measures
Tree-based diversity measures

- **Topology based**
  Taxonomic diversity (Vane-Wright & al 1991, Williams & al 1993)

- **Topology & branch lengths**
  Phylogenetic diversity PD (Faith 1992)
  Evolutionary Distinctiveness ED (Isaac & al. 2007)
  EDGE - includes extinction risk
**Taxonomic diversity**

- Topology based

<table>
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<th>T/#</th>
<th>V</th>
<th>%</th>
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<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>3.5</td>
<td>1</td>
<td>10.7</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>3.5</td>
<td>1</td>
<td>10.7</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>4.7</td>
<td>1.3</td>
<td>14.3</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td>21.4</td>
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<tr>
<td>E</td>
<td>1</td>
<td>14</td>
<td>4</td>
<td>42.9</td>
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**Total**

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<tr>
<td></td>
<td>14</td>
<td>32.7</td>
<td>9.3</td>
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Vane-Wright & al. 1991
Phylogenetic diversity, PD

- Based on topology & branch lengths

Faith 1992
Phylogenetic diversity, PD

\[ PD = \text{Minimum spanning path for } B, C, D \]

PD for B, C, D: \( \Sigma \) lengths of branches that are members of the minimum spanning path for B, C, D plus root
Evolutionary Distinctiveness, ED

- Species terminal branch & its species-weighted shares of ancestral branches

- EDGE includes extinction risk

Isaac & al. 2007
Heightened Evolutionary Distinctiveness, HED

- Expected terminal branch lengths based on extinction probabilities (CR: 0.9 → LC: 0.001)

- HEDGE weighted by current extinction risk

Steel & al. 2007
Prioritize between species based on PD

- Common species represent assured PD
- Threatened species have to be prioritized
- Priorities are based on the gain in PD by adding a threatened species, the $G$-value
PD for threatened taxa

Two species pairs:
A common & a threatened species

Malvaceae:
- Eremalche
- Sidalcea

Are the species distinct?
YES S. keckii
NO E. kernensis

How should they be prioritized?

## PD & G-values

### Taxa

<table>
<thead>
<tr>
<th>Taxa</th>
<th>G-values/round</th>
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<tbody>
<tr>
<td><strong>S. stipularis</strong></td>
<td>64</td>
</tr>
<tr>
<td><strong>S. keckii #101</strong></td>
<td>30</td>
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<tr>
<td><strong>S. cusickii</strong></td>
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<tr>
<td><strong>S. hickmanii</strong></td>
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<td><strong>S. hickmanii anomala</strong></td>
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<td><strong>S. hickmanii parishii</strong></td>
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<td><strong>S. malachroides</strong></td>
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<td><strong>S. covillei</strong></td>
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<td><strong>S. robusta</strong></td>
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<td><strong>S. oregana valida</strong></td>
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<td><strong>S. nelsoniana</strong></td>
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<tr>
<td><strong>S. oregana</strong></td>
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<tr>
<td><strong>E. kernensis #5</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>E. kernensis #7</strong></td>
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</tr>
</tbody>
</table>

### Lower G-value & Lower priority

**Sidalcea stipularis**
Programs for analyzing priorities

- Program Conserve 3.2.2 (Agapow & Crozier 1998)
- Tuatara package of Mesquite (Maddison & Mooers 2007)
- MrTWIG (Wallberg)
Arnica: Hybridization, polyploidy & apomixis

- Hybridization hypotheses
- Di-, tri- & tetraploids $X=19$
- Polyploidy correlated to apomixis
- Correlation glaciated areas and polyploidy
- Polyploids more widespread than diploids

Arnica angustifolia
Biogeography

Circumboreal & montane

Widespread taxa

Disjunct taxa
Chloroplast regions in Arnica

- Sequenced >3700 cp nucleotides
- Only 45 informative characters
- Results in low support & low resolution
- Suggested subgenera are not supported

Agamospermy (asexual seed production)

Polymorphic nrDNA in Arnica

Ekenäs et al. 2009
Lineage sorting:
the process of fixation of gene lineages along a species lineage

Incomplete lineage sorting:
- Failure of allele fixation
- Retention of ancestral polymorphisms
- Deep coalescence
- More likely if time between divergences is short & population sizes large
RPB2-phylogeny in *Arnica*

D-copies

A': A: A A''  A''''

B

C

outgroups
Conclusions: Arnica evolution

• The 5 subgenera are not supported
• Results support a hypothesis of an origin in temperate western North America & subsequent dispersal to northern regions

• Polymorphisms in ribosomal DNA & low copy DNA may be caused by polyploidy, agamospermy, incomplete lineage sorting and hybridization
• The fact that the diploid species lack polymorphisms supports this
Collaborators & funding

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