Reconstructing the Evolutionary History of Reproductive Characters in *Anthurium* (Araceae)

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Anthurium (Araceae)

- 912 species (and counting)
- Large Neotropical distribution
- Present in a variety of ecosystems
- Variable vegetative and reproductive morphology
- Usually bee, beetle or fly-pollinated
- Epiphytic, lithophytic, or terrestrial
- Some members economically important
Characters and Classification

Grayum (1990)

• For classification, reproductive morphology is generally more useful than vegetative morphology

• Reproductive morphological changes $\rightarrow$ reproductive isolation $\rightarrow$ speciation

Carlsen & Croat (2013)

• “Reproductive characters…seem to be more reliable to characterize clades within Anthurium”
II. Research Goals

Research Goals

1. Use reproductive morphology to characterize clades proposed by Carlsen & Croat (2013)
2. Evaluate the importance of reproductive character shifts in the evolution of *Anthurium*
Materials and Methods: Data Collection

Reproductive morphology:
• 32 characters
• 98 species

Pollen:
• 15 characters
• 60 species
Inflorescence Data Collection

Observation of specimen under dissecting scope

Berries  Spadix  Epiphytic bryophyte

A. antioquiense  A. andicola  A. oltersianum
## III. Methods

### Reproductive characters (32)

<table>
<thead>
<tr>
<th>Inflorescence (18)</th>
<th>Fruit (6)</th>
<th>Flower (8)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantitative (6)</strong></td>
<td><strong>Qualitative (12)</strong></td>
<td><strong>Quantitative (2)</strong></td>
</tr>
<tr>
<td>Peduncle length</td>
<td>Inflorescence length/leaf length</td>
<td>Berry length</td>
</tr>
<tr>
<td>Spathe length</td>
<td>Peduncle thickness /petiole thickness</td>
<td>Berry width</td>
</tr>
<tr>
<td>Spathe width</td>
<td>Peduncle length/petiole length</td>
<td>Berry color</td>
</tr>
<tr>
<td>Stipe length</td>
<td>Spathe shape</td>
<td>Shape of berry tip</td>
</tr>
<tr>
<td>Spadix length</td>
<td>Spathe 3D-shape</td>
<td>Berry seed abundance</td>
</tr>
<tr>
<td>Spadix diameter</td>
<td>Spathe disposition at anthesis</td>
<td>Spathe persistence when plant is in fruit</td>
</tr>
<tr>
<td>Spadix shape</td>
<td>Spathe color</td>
<td>Presence of punctations on spathe</td>
</tr>
<tr>
<td>Spadix position</td>
<td>Presence of stipe</td>
<td></td>
</tr>
<tr>
<td>Spadix color</td>
<td>Spadix diameter</td>
<td></td>
</tr>
</tbody>
</table>

- *A. moodeanum*
- *A. muyunense*
- *A. buganum*
- *A. wagenurianum*
- *A. crenatum*
Collecting Pollen Data

III. Methods

Pollen from herbarium specimens

Removal of anthers

Eppendorf tubes

Kimwipes™ packets

Dehydration series

Pollen from pickled collections

Sputter-coater (Denton Vacuum Desk V)

Critical-point dryer (Emitech K850)

Scanning electron microscope (JCM 5000 Neoscope)
### III. Methods

#### Pollen Characters (15)

**Quantitative (5)**
- Lumen size
- Pollen range of sizes
- Pollen size
- Pollen range (variability)
- Aperture number

**Qualitative (10)**
- Pollen unit
- Pollen shape
- Pollen symmetry
- Pollen polarity
- Pollen aperture type
- Pollen aperture shape
- Exine ornamentation
- Muri type
- Presence of crystals
- Other characters
Materials and Methods: Data Analysis

- Mesquite software (Maddison & Maddison 2011) used to map character states onto molecular phylogeny (Carlsen & Croat 2013), for 47 different characters
- Trace Character History function used under Maximum Parsimony
- Synapomorphies identified for each clade
IV. Results

Results: Clade synapomorphies

Tepal protuberances: present or absent
Results: Best characters

- Fifty-eight synapomorphitic character states identified
- Twenty-nine (62%) useful characters
- 100% fruit characters, 67% general inflorescence characters, 63% flower characters, and 40% pollen characters yielded synapomorphies
- Berry color, spadix color, peduncle/petiole length ratio, and berry width were most important
IV. Results

Each clade was supported by 1-9 synapomorphies.

Clades A, 3, 4 and 7 were best supported.
IV. Results

**Clade A**
- *A. flexile*
- Synapomorphy: orange, pointed berries
- http://sura.ots.ac.cr/

**Clade 3**
- *A. digitatum*
- Synapomorphy: large pollen grains
- 25 µm

**Clade 7**
- *A. bakeri*
- Synapomorphy: spinulose muri

**Clade 13**
- *A. huixtlense*
- Synapomorphy: white/lavender spadix
Conclusion

Since all 17 clades could be identified with reproductive character shifts, we conclude that reproductive changes have played a major role in the diversification of *Anthurium*, as proposed by Grayum (1990).
Future Studies

• Increase sample size, given that current datasets include only ca. 7-11% of *Anthurium* species (some characters may be more or less important when sampling size is increased)
• Include more characters
• Redefine some character states (e.g. colors)
• Pollination and fruit dispersal could be compared to morphological data
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