Pollination

The transfer of pollen from anther to stigma of same or different flower
One of the two most well known mutualisms
The most beautiful kind
Some pollination related concepts

- Self pollination
  - Autonomously self
  - Assisted self pollination
    - Abiotic (wind or rain)
    - Biotic (animals)

- Cross pollination
  - Assisted pollination
    - Abiotic (wind or rain)
    - Biotic (animals)

- Self compatible
- Self incompatible
Selfing has great advantages...

- Independent, especially if you can autonomous self pollinate
- Pass down two copies of your genes into the next generation, in stead of just one when you outcross
- So why not all plant species self mating?

To avoid inbreeding depression

The orchid family exemplifies how far plants can go to promote outcrossing
Generalist vs. specialist in pollination from who’s perspective?

How generalized or specialized you are is all relative...

Female *Calliphora vomitoria* (hoverfly)

*Amemone* sp.

*Ranunculas* sp.

*Andrena* sp. (small solitary bees)

*Cypripedium yunnanense*

*Cypripedium flavum*
Diversity and patterns in orchid pollination

“I was never more interested in any subject in my life than this of orchids”
--Charles Darwin (1861)
Angraecum sesquipedale and its predicted long-tongued hawkmoth pollinator as illustrated in the Alfred Russel Wallace’s essay *Creation by Law* (1867)

This orchid play a vital role in Darwin’s thinking in the concept of coevolution -- “a pretty case”
Four decades after the prediction

Xanthopan morganii praedicta was discovered and named
A. *Coelonia fulvinotata* visiting flowers of *Aerangis brachycarpa*

B, C. *Angraecum striatum* and its bird-pollinator *Zosterops borbonicus* (grey white-eyes) with pollinaria attached on its beak

D. *Angraecum cadetii* and its raspy cricket-pollinator *Glomeremus orchidophilus* with pollinaria attached on its head

Micheneaus et al. in press
Evolution is evident but no evidence of coevolution!
Reproductive success in the angraecoid orchids (Micheneau et al. in press)
Fruit set rates have no relation with spur length or nectar volume or concentration

Table 2. Summary of pollination records, floral features, and reproductive success according to spur length.

<table>
<thead>
<tr>
<th>Spur length</th>
<th>Spur &gt; 20 cm</th>
<th>Spur ~ 10 cm</th>
<th>Spur ~ 5 cm</th>
<th>Spur &lt; 2 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollinator groups</td>
<td>Hawkmoths</td>
<td>[Auto-pollination]</td>
<td>Hawkmoths</td>
<td>Birds</td>
</tr>
<tr>
<td>Genera</td>
<td>Angraecum&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Angraecum, Aerangis, Jumellea&lt;sup&gt;b&lt;/sup&gt;, Jumellea, Neobathiea, Rangaeris&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Aerangis, Mystacidium&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Angraecum&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Distribution</td>
<td>Madagascar</td>
<td>Africa – Madagascar</td>
<td>Reunion</td>
<td>Kenya – South Africa</td>
</tr>
<tr>
<td>Pollinator species</td>
<td>Xanthopan morgani</td>
<td>Xanthopan morgani, Panopidae lings, Agris convolvuli, Coelonia fulvinotata</td>
<td>na</td>
<td>Hippotion celerio, Daphnis neri, Nephele accentifera</td>
</tr>
<tr>
<td>Pollinaria attachment</td>
<td>Proboscis</td>
<td>Head/proboscis</td>
<td>na</td>
<td>Proboscis</td>
</tr>
<tr>
<td>Flower Colour</td>
<td>White</td>
<td>White</td>
<td>Cream-white</td>
<td>White</td>
</tr>
<tr>
<td>Spur length (cm)&lt;sup&gt;g&lt;/sup&gt;</td>
<td>29.8</td>
<td>13.7</td>
<td>13.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Spur shape</td>
<td>Filiform</td>
<td>Filiform</td>
<td>Filiform</td>
<td>Filiform</td>
</tr>
<tr>
<td>Spur opening</td>
<td>Narrow</td>
<td>Narrow</td>
<td>Narrow</td>
<td>Narrow</td>
</tr>
<tr>
<td>Nectar Volume (µL)&lt;sup&gt;h&lt;/sup&gt;</td>
<td>136.0</td>
<td>13.9</td>
<td>6.1</td>
<td>4.3</td>
</tr>
<tr>
<td>% sugar&lt;sup&gt;i&lt;/sup&gt;</td>
<td>13.4</td>
<td>15.3</td>
<td>10.7</td>
<td>16.5</td>
</tr>
<tr>
<td>Floral scent (human nose)</td>
<td>Strong in the evening</td>
<td>Strong in the evening</td>
<td>Not detectable</td>
<td>Strong in the evening</td>
</tr>
<tr>
<td>Fruit set (%)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>20.0</td>
<td>18.1</td>
<td>62.8</td>
<td>13.1</td>
</tr>
</tbody>
</table>

<sup>a</sup> Angraecum
<sup>b</sup> Jumellea
<sup>c</sup> Jumellea, Neobathiea, Rangaeris
<sup>d</sup> Aerangis, Mystacidium
<sup>e</sup> Angraecum
<sup>f</sup> Angraecum
<sup>g</sup> Spur length (cm)
<sup>h</sup> Nectar Volume (µL)
<sup>i</sup> % sugar
<sup>j</sup> Fruit set (%)
Fragrance as floral reward

- Unique to tropical American androeuglossophilous orchids ("perfume orchids" by some)
  - Offer cocktails of volatile perfume compounds
  - No nectar or loose pollen
  - Non-nutritional

- Are collected exclusively by males of euglossine bees
Androeuglossophilous orchids and euglossine bees are species rich

- Androeuglossophilous orchids include ~600 spp.
  - All subtribes Stanhopeinae and Catasetinae, a few clades of Oncidiinae (Notylia, Macroclinium), and some Zygopetalinae

- Euglossine bees includes ~ 200 spp.

- Their interactions are highly specific
Single bee may carry pollinaria of 3-5 different genera of orchids

Photo credit: Mark Whitten
• Is there coevolution between androeuglossophilous orchids and euglossine bees?
Diversification in this specialized plant-pollinator mutualism is asynchronous!

The relationships are also lopsided, i.e. the orchids need the bees, but the bees don’t need the orchids! (as much)
Cheating orchids

• 1/3 of all orchids offer no reward of any kind
  – That translates to ~10,000 species

Photo credit: Mark Whitten
Generalized food deception

Nectarless orchid (Anacamptis israelitica)

Nectar plant (Bellevallia flexuosa)

Nectarless orchid (Dactylorhiza sp.)

Nectar plant (Viola sp.)
Rewardless Orchids

- **Cyrtopodium punctatum**
- **Cyrtopodium flavum**

Oil reward plant

- **Byrsonima lucida**
- **Stigmaphyllon sp.**

Oil collecting bee

- **Centris errans**
- **Centris nitida**
Carrion mimicry in a South African orchid: flowers attract a narrow subset of the fly assemblage on animal carcasses

Satyrium pumilum

Rotting animal carcass attracts flies with *Satyrium* pollinaria

Slide credit: Mark Whitten
Brood site deception

- Not well studied, but probably not rare
- Possible examples:
  - *Dracula* -- pollinated by Drosophilid flies; mimicry of yeast?
  - *Paphiopedium* -- some pollinated by syrphid flies; mimicry of aphids (prey for larvae)?
Pollination of *Paphiopedilum dianthum* in China. Pollination by Hoverflies: Seeking aphids as food source for larvae.
Hoverfly eggs beside the black warts on the flower of *Paphiopedilum dianthum*. 

Pollination of *Paphiopedilum dianthum* in China. 
Shi Jun, Chen Jin, Shangguan Gazhi, Deng Zhenhai, Luo Yibo. 2008 
Die Orchidee
Dracula chestertonii

Lip mimics mushroom
--visual, chemical mimicry
--pollinated by Zygothrica (Drosophilidae) that breed in mushrooms

Slide credit: Mark Whitten
Lip of *Dracula* sp. at Finca Dracula, Panama

Slide credit: Mark Whitten
sexual deception

Flowers mimic mating signals of female insects and are pollinated by deceived males while they attempt to copulate with the flower.
Chiloglottis reflexa pollinated by male thynnid wasp Neozeleboria

Photo copyright Ray Kearney
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Attractant: Chiloglottone

Nuptual gift: regurgitation of nectar
Pseudocopulatory pollination of *Lepanthes gleicensteinii* by fungus gnats (Diptera: Sciaridae)

Sexual deceit doesn’t have to be perfect—just enough to be convincing!

“I don’t care if she is a tape dispenser. I love her.”

S. Gross
Australia has many pseudocopulatory orchids!
A, *Cryptostylis subulata* with pollinator, a male orchid dupe wasps (*Lissopimpla excelsa*, Ichneumonidae), in copula.

D, *Cryptostylis erecta* flower after pollinator visit. Note blob of pollinator ejaculate, plus removal of pollinia and deposition of pollen on stigma.

Can these fooled males learned from their mistakes?

Pollinator behavior matters for pollination success

1 = pseudocopulate with ejaculation, e.g. Cryptostylis
2 = pseudocopulate without ejaculation e.g. Ophrys, Geoblasta
3 = grip the orchid’s hinged major petal, i.e. Caladenia, Chiloglottis, Drakaea
4 = briefly trapped before collecting the pollinia on departure, i.e. Pterostylis

What kind of insects are targeted by deceptive orchids?

Almost all sexually deceptive orchid species are pollinated by solitary, haplodiploid insect species from 11 hymenopteran families (Gaskett et al. 2008)
Orchid interference in haplodiploid pollinators’ sexual reproduction could generate abundant male insects to act as pollinators because females deprived of males and matings due to orchid interference can produce only male offspring.

Conversely, the mating system of diploid species would be less resilient to interference, so orchid exploitation could depress pollinator availability and reduce pollination success over time. (Gaskett et al. 2008)
Pollinator conservatism among *Chiloglottis* (sexual deceptive orchids)


Fig. 2. Phylograms of the orchid *Chiloglottis* and its wasp pollinators estimated by maximum parsimony (MP). The wasp tree is based on combined 16S and wingless data (one of two trees at length 378, 121 parsimony informative characters, CI = 0.45, RI = 0.54). The orchid tree is one of 21 MP trees recovered from the analysis shown in Figure 1. Note the arrangement of taxa in the autumn flowering *Chiloglottis* clade A varies among the 21 MP trees and reduces to polytomy in the strict consensus (Fig. 1). Bootstraps are given above the line. Relative branch lengths are different in the orchid and wasp trees.
Cheating has consequences

A 40-fold difference!

Data from FIU Restoration Ecology class 2012
Cheating has consequences

Why Cheat?

Figure 2. The frequency of deceptive and rewarding plants that fail to set fruits. Data are from Table 3. Means + SE; N = 44.
Pollinator limitation is the norm in non-autogamous orchids

Does this pattern have anything to do with the success of the orchid family (in number of species?)
Evolution by natural selection vs. genetic drift