Fifty Shades of Pollination

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Why is there a need for pollination?

Why do plants need a pollination agent?

Why trick another organism to carry around your sperm
“Thank a pollinator for 1 out of every 3 bites of food you eat.”

“Insect pollination is essential for 35% of global food production.”
Lecture Map

1) Context
2) Interactions
3) Plant-side
4) Pollinator-side
Major Players in Communities

Plants Roles in Communities
- Energy transformation
- Nutrient movement
- Erosion
- Carbon cycle
- Nitrogen cycle
- Soil formation
- Food

Insects Roles in Communities
- Pollination
- Decomposers
- Disease vectors
- Population control (herbivore, parasitoids)
- Soil formation
- Food for wildlife

Species interactions
A biological **community** consists of interacting species, usually living within a defined area.

Biologists want to know how communities work, thereby knowing how to manage them in a way that will preserve species and maintain healthy ecosystems.
Ecological interactions relationship between two species that influence the survivorship of each.
Species Interactions

Because the species in a community interact almost constantly, the fate of a particular population may be tightly linked to the other species that share its habitat.
The Process of Relationships

- Changes in the characteristics of a population of organisms that occur over the course of generations, that increase survivorship will be selected for and increase.
- These changes must have a genetic basis.

**Take Home:** Change of allele frequency over time = change populations.
I am more attracted to deep pink flowers, only pink flowers for me!

Change of allele frequency over time = basic idea of biological evolution.
The population’s characteristics will change over time as the individuals with the favorable traits increase in frequency.

I have called this principle, by which each slight variation, if useful, is preserved, by the term Natural Selection.

—Charles Darwin from "The Origin of Species"
Relationships between organisms occur in a continuum from antagonistic to cooperation to dependency (symbioses).

Parasitism

Commensalism

Mutualism

Antagonism

Cooperation

(+/−)

(+/0)

(+/+)

Biological interactions = Symbiosis
Animal-Plant Interactions

Two General Groups of Behaviors.

1. Phytophagy-Herbivory
2. Mutualisms

It all comes right down to exploitation symmetry.
Coevolution is the change of a biological object triggered by the change of a related object.

Building a Community
Anthophora affabilis

Apis millifera

Geodiscelis longiceps

Photography by Sam Droege, USGS
Animal-Plant Interactions

Two General Groups of Behaviors.

1. Phytophagy-Herbivory
2. Mutualisms as well as commensalism

<table>
<thead>
<tr>
<th></th>
<th># of US spp.</th>
<th># of pollinators</th>
<th>% contributing to pollination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insects:</td>
<td>91,000</td>
<td>3,500</td>
<td>4%</td>
</tr>
<tr>
<td>Birds:</td>
<td>914</td>
<td>20</td>
<td>2%</td>
</tr>
<tr>
<td>Bats:</td>
<td>40</td>
<td>2</td>
<td>5%</td>
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</tbody>
</table>
1. Carpels evolved from leaflike structures whose edges folded over ovules, protecting them.

2. Early carpels folded over ovules, with the seam closed by sticky secretions.

3. Later carpels were completely closed into a tube, by fusion of tissue.

4. Carpels developed specialized regions (stigma, style, and ovary) to form a pistil.

5. In many modern flowers, several to many carpels are fused to form a compound pistil.
• No longer in liquid media- terrestrial; life presents challenges to gamete transport.
• Plants are stationary and depend on external forces to bring gametes together.
  – 10-20% of plants use wind or water (rarely)
  – 80-90% pollination is animal assisted

Plants are:
  • Specialist-attract one pollinator
  • Generalist-attract wide range of pollinators
Agents of Pollination

• Pollination depends on pollinators visiting flowers of the same species in sequence.

• To help ensure that this happens, the plants have various characteristics that aid pollinators including: color, size, shape, scent, as well as a food reward.
Animals as Pollinators

The majority of flowering plants rely on animals for pollination:

- **Insects** – bees, wasps, flies, butterflies, moths, and beetles
- **Birds** – hummingbirds and honey creepers
- **Mammals** – bats, mice, and even monkeys
The increase occurs in four clearly demarcated phases. The reasons for the end of a phase are most likely drought periods, i.e. climatic changes. The renewed increase in the number of species is caused by the coming into being of evolutionarily advanced plant groups that became dominant in their period of vegetation: a. primitive trachaeophytes, b. pteridophytes, c. gymnosperms, d. angiosperms. The abbreviations of the geological periods are: S: Silurian period, D: Devonian era, C: Carboniferous period, P: Permian period, R: Triassic period, J: Jurassic period, K: Cretaceous period, T: Tertiary period.

Key Angiosperm Pollinators (responsible for angiosperm radiation in Cretaceous)

Labandeira et al., 2001
Pollinator Syndrome

For Pollinator
COMPETITION
For Nectar

Pollen Distribution
MUTUALISM
High energy sugars and amino acids
Pollinator Syndromes

Flower characteristics, or traits, that may appeal to a particular type of pollinator.

Characteristics can be used to predict the type of pollinator that will visit flower.

Characters: combination of color, odor, quantity of nectar, location and type of pollen, and flower structure

Affect a potential pollinator’s ability to locate a flower and its food resources.
Bees-APIophily

**Flower Shape.** Shallow; with landing platform; tubular Opening.

**Color.** Bright white, yellow, blue, or UV

**Nectar guides.** Present

**Odor.** Fresh, mild, pleasant

**Nectar.** Usually present

**Pollen.** Limited; often sticky, scented
Butterflies-Psychophily

Flower Shape. Narrow tube with spur; wide landing pad
Opening. Day
Color. Bright red and purple
Nectar guides. Present
Odor. Faint but fresh
Nectar. Ample; deeply hidden
Nectar Comp. Sucrose-rich
Pollen. Limited
Moth-Phalaenophily

**Flower Shape.** Regular; tubular without a lip

**Opening.** Night

**Color.** Pale red, purple, pink or white

**Nectar guides.** None

**Odor.** Strong sweet; emitted at night

**Nectar.** Ample; deeply hidden

**Nectar Comp.** Sucrose-rich

**Pollen.** Limited
Fly-Myophily

**Flower Shape.** Shallow; funnel-like or complex with trap opening.

**Color.** Pale, or dark brown, purple.

**Nectar guides.** None.

**Odor.** Putrid.

**Nectar.** Usually absent.

**Nectar Comp.** Amino acid-rich.

**Pollen.** Limited.
Amorphophallus titanum

Spadix releases chemicals
- Benzyl alcohol - sweet floral scent
- Dimethyl disulfide - limburger cheese-like
- Trimethylamine - rotting fish
- Isovaleric acid sweaty socks
- Thermogenic heat of 98-100°F
**Beetle-Cantharophily**

**Flower Shape.** Large and bowl-shaped

**Opening.** Day/night

**Color.** White or green

**Nectar guides.** None

**Odor.** None to strongly fruity or foul

**Nectar.** Sometimes present

**Pollen.** Ample
**Bird-Ornithophily**

**Flower Shape.** Large, funnel-like; strong perch support

**Opening.** Day

**Color.** Scarlet, orange, red or white

**Nectar guides.** None

**Odor.** None

**Nectar.** Ample; deeply hidden

**Nectar Comp.** Sucrose-rich

**Pollen.** Limited
Bats-Chiropterothy

**Flower Shape.** Bowl shaped; closed during day

**Opening.** Night

**Color.** White, green or purple

**Nectar guides.** None

**Odor.** Strong and musty, emitted at night

**Nectar.** Abundant; somewhat hidden

**Nectar Comp.** Sucrose Rich

**Pollen.** Ample
A Pollinator’s View

- Nectar - Energy
- Pollen - Nutrients
- Petals - Nesting Material

(Megachile)

“What?! I am player in the not-so secret sex-lives of plants”
In North America there are a little over 4,000 species of bees. The majority of these occur in five common families: *Andrenidae*, *Apidae*, *Colletidae*, *Halictidae*, and *Megachilidae*.
Bumble bees of Illinois

Color Group 1

- B. impatiens
- B. bimaculatus
- B. griseocollis
- B. vagans
- B. affinis
- B. fraternus

Color Group 2

- B. auricomus
- B. fervidus
- B. pensylvanicus
- B. citrinus

Cuckoo Bumble bees

To complete Matterhorn, bundle bees often require one another to form patterns, which can be difficult to distinguish from one another, especially in the wild as they are from flowers in bloom and in their nests.
Besides systematics organization, bees can be organized by ecology.

**Major Groups of Bees.**

- **Parasitic**
- **Free-living**

**Cleptoparasitic** (Cuckoo Bees)
lays eggs w/in nest related bee species

**Free-living Bees**
A continuum of solitary nest-building bees to eusocial nesting-bees
**Solitary Nest-Building**
- Nesting is soil 2/3 Nest plant material
- Provisioned cells with pollen & nectar
  - **Leaf-cutting Bee** - Flower-lined cell
  - **Mason Bee** - Cell walls mud leaf pulp
  - **Carpenter Bees** - Wood fibers cell walls
  - **Masked Bees** - Cellophane-like material: secreted

**Social Nest-Building**
- 50 US spp.
- Provisioned cells with pollen & nectar, in collaboration with daughters and sisters
- Soil:
  - Underground Tunnels
  - Dry cavities (Bumble Bee)
Flower Selection

Polylectic

Classified by Range of Plants

generalist, gathering pollen from multiple genera in one family

gather pollen from two to several species in one family

Vulnerability to Change

Wide range of plants-most stable

Various plants but focus-semi-stable

Specialist- very vulnerable

Oligolectic

Monolectic

a single species
Aster Family (Asteraceae, 28 dependent bee species): One leaf-cutter bee, *Megachile apicalis*, specifically benefits from *Centaurea*, while the long-horned bee *Melissodes desponsa* specifically benefits from *Cirsium*. The other 26 bee species seem to have relatively broad tastes within the Aster Family.

Cabbage Family (Brassicaceae, 1 dependent bee species): The miner bee *Andrena arabis* is also very rare and has not been observed for several decades.

Dogwood Family (Cornaceae, 3 dependent bee species): Plants in the genus *Cornus*, in particular, are preferred by three rare species of miner bee (genus *Andrena*).

Heath Family (Ericaceae, 4 dependent bee species): Plants in the genus *Vaccinium* (*blueberries*) are primarily used by the miner bee *Andrena carolina* and the Southeastern Blueberry Bee *Habropoda laboriosa*. *Rhododendron* is utilized by *Andrena cornelli*.

Geranium Family (Geraniaceae, 1 dependent bee species): This miner bee, *Andrena distans*, is very rare.

Mallow Family (Malvaceae, 1 dependent bee species): As its common name suggests, *Ptilothrix bombiformis*, the Hibiscus Bee, specifically prefers *Hibiscus*.

Water-lily Family (Nymphaceae, 1 dependent bee species): The small sweat bee *Lasioglossum nelumbonis* depends on flowers from water-lilies.

Evening Primrose Family (Onagraceae, 1 dependent bee species): *Lasioglossum oenotherae*, a small sweat bee, is dependent on evening primrose and other flowers in the genus *Oenothera*.

Rose Family (Rosaceae, 1 dependent bee species): The one dependent species is a miner bee, *Andrena melanochroa*. 
Flower Selection

**Classified by Range of Plants**

- **Polylectic**
  - generalist, gathering pollen from *multiple genera* in one family

- **Oligolectic**
  - gather pollen from two to *several species* in one family

- **Monolectic**
  - a *single species*

**Flower Constancy**
- Bees attend to a particular plant species on any given foraging trip.

Plants want efficient pollen transport (Monolectic & Oligolectic)
Numerous Ant-Plant Interactions but…

Poor Pollinator!

Ants feed on nectar however,

- Not so hairy
- Chemical factories
- High morality

But still important for plants—a whole other story.
Poor Pollinators too!

Wasps feed on nectar and pollen however,
- Not hairy, hairs not plumose
- Opportunistic
- Little Flower Constancy
Beetles

- 30,000 US spp. Many considered pollinators
- 1st insect pollinators?
- Little flower-adaptation in beetles
- Important pollinators “primative-flowers” Magnolias
- Families include Soldier (Cantharidae), Long-horned (Cerambycidae), Scarab (Scarabaeidae), Flower (Melyridae), and Pollen Beetles (Nitidulidae)
- Larval tunnels in wood create nesting sites for solitary bees.
Tetraopes melanurus

T. tetraophthalmus

T. quinquemaculatus

Asclepias tuberosa

A. syriaca

A. amplexicaulis

A. hirtella
• A few families: Flower Fly (Syrphidae), Bee Fly (Bombyliidae), Big-headed Fly (Acroceridae).

• Some flies are better pollinators than others
  – Most flies are less hairy than bees, but what they lack in hair they make up for in numbers

Syrphid) and Bee Flies are parasites of insect larvae notably butterflies and ground nesting bees.
Flies

Platanthera obtusata

Stinking Benjamin *Trillium erectum*

Arisaema triphyllum
Lepidoptera-Butterflies and Moths

Butterfly ~196 spp. Moth 692 spp. Rough 861 species in the state (a lot of difference in resources vary). 20+ families

In addition to feeding on nectar and pollen this group also utilizes vegetation as host for larvae.
Yucca is a genus of perennial shrubs and trees in the family Asparagaceae a family of monocots. Its 40-50 species are notable for their rosettes of evergreen, tough, sword-shaped leaves and large terminal panicles of white or whitish flowers.
ON THE VARIOUS CONTRIVANCES BY WHICH BRITISH AND FOREIGN ORCHIDS ARE FERTILISED BY INSECTS

AND ON THE GOOD EFFECT OF HYBRIDISING

CHARLES DARWIN

NATURAL HISTORY MUSEUM
LONDON
Orchids

• 19.5 thousand spp. of orchids, 8,000 or 41% do not offer nectar
• Rather the plant short circuit pollination system
• Using various chemical attracts, shapes, and lures to trick bees

Calopogon
Cheating the System

- Nectar-robbing
- Nest-parasites
- Cleptoparasitism
Cheating the System
Ecosystem Economics

Ecosystem Services:
- Supporting:
  - Habitat for Species
  - Nutrient Cycling
  - Soil Formation
- Regulating:
  - Local Climate
  - Disease Regulation
  - Carbon Storage
  - Pollination
  - Biocontrol
- Provisioning:
  - Food
  - Raw Materials (wood)
- Cultural:
  - Tourism
- Medicinal Resources:
  - Seeds
  - Raw Materials (wood)
  - Medicinal Resources
- Aesthetic & Spiritual:
  - Education
  - Aesthetic & Spiritual

Ecosystem Functions:
- Primary Production
- Provisoning
- Supporting
Habitat Lost

Habitat Fragmentation

Habitat Degradation

Political Influence

Economic Influence

Social Influence

Pesticide Poisoning
Small area can help with pollinators, most of us live in a pollinator desert, i.e. areas that are not suitable to support pollinator populations.
Creating small islands of resources can support limited populations.

**Food resources**
- Water
- Shrubs
- Vines
- Wildflowers
- Ground cover
- Night Garden

**Nesting resources**
- Wood piles
- Purchase bee homes
- Cleared areas
Sometimes to find understanding, you need to stop looking up and start looking down.

Thank you