Fungus-growing ants and a story of symbiosis
Leaf-cutting ants
(Tribe: Attini, Genera: Acromyrmex, Atta)

• Symbiosis with Fungus - growing their food!
• Harvest green leaves to grow fungus
  – Ants cut up leaves, lick clean, cut to form mulch
  – Plant matter then covered with fecal droppings
  – Fungal hyphae placed on top of plant matter
  – Fecal matter - fertilizer for fungus growth
  – Fungus digest cellulose into carbohydrates, fats and proteins that the ants can utilize.
  – Also, part of the fungus is fed to ant larvae

❖ Vulnerable to parasites attacking their food source → fungal garden!
Can carry 20X their body weight!
“Fungus-growing ants use antibiotic-producing bacteria to control garden parasites.”

*Pseudonocardia* associated with fungus-growing ants play an important role in this symbiosis of suppressing growth of parasites.
Symbiosis

- Ants (Attine)
- Fungal gardens (Lepiotaceae family, Basidiomycotina)
- Filamentous bacteria (*Pseudonocardia*)
- Attacking fungal parasite (*Escovopsis*)
Originally classified as a “waxy bloom”, or cuticular exudate.

Actually, is a mass of filamentous bacteria (actinomycetes)!
• 22 species of ants studied from 8 genera
• ALL have the actinomycete bacteria
• Bacteria located on genus-specific regions of ant integument
• Location modified for growth, maintenance, distribution of bacterial metabolites?

<table>
<thead>
<tr>
<th>Attine genera*</th>
<th>Under forelegs on propodeum</th>
<th>Laterocervical plates of propodeum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myrmicocrypta</td>
<td>Yes</td>
<td></td>
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<tr>
<td>Apterostigma</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Mycocepurus</td>
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<td></td>
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<tr>
<td>Cyphomyrmex</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Trachymyrmex</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Acromyrmex</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Atta†</td>
<td>Not visible on exoskeleton</td>
<td>Not visible on exoskeleton</td>
</tr>
</tbody>
</table>

* Attine genera listed from most phylogenetically basal to most phylogenetically derived.†
† Although not visible on exoskeleton, Streptomyces was isolated repeatedly from intact Atta spp.
“Coevolved Crypts and Exocrine Glands Support Mutualistic Bacteria in Fungus-Growing Ants”
Currie et. al. Science 311, 81-3 (2006)

Housing and Maintenance of the bacteria

- Cuticle - exoskeleton
- Propleural plates
  - Fovea - crescent shaped cavity
    - Bacteria grow in these crypts
- Exocrine gland (near fovea, contains duct cells)- supports bacterial growth through glandular secretions
Transmission?

• Before mating flight - 74 queens, 15 males examined
  – Cuticular actinomycete found on females only
• Following mating flight
  – Cuticular actinomycete found on females only

❖ males do not engage in founding new colonies or tending fungal gardens. Transmission through females to daughter nest.

❖ Role of bacteria?
- *Pseudonocardia* isolates did not inhibit growth of other fungi

- Yet, showed inhibitory effects towards *Escovopsis*, a virulent parasite of Attine ant fungal gardens (zones of inhibition > 30 mm)
Growth-promoting effects?

- Increase in basidiomycelia biomass in the presence of actinomycetes.

- $47.9 \pm 7.6$ mg dry weight (biomass w/ actinomycete filtrate)

- $5.3 \pm 2.4$ mg dry weight (unamended controls)
Conclusions

• Bacterial symbiont present in ant/fungal symbiosis
• Associated with all Attine ant species and all colonies studied (located in various body regions)
• Evolved mutalist
  – inhibition of *Escovopsis*
  – ant provides support
Food for Thought

- Complexity of symbiosis
- Evolution of symbiosis between ants and bacteria to suppress parasites
- Microbial regulation of symbiotic relationships
- Future studies - chemical interactions between symbionts
Questions?
Army Ants vs. Leaf-cutters