**Important Dates**
- December 6\textsuperscript{th} – Last lecture.
- December 12\textsuperscript{th} – Study session at 2:30? Where?
- December 13\textsuperscript{th} – Final Exam: 12:00-2:00

---

**Fungi-Insect Symbiosis**

- Many examples of fungi-insect symbiosis.
- Cover the following examples
  - **Laboulbeniomycetes** – Class of Ascomycota. Mostly on insects.
  - **Septobasidium** – Genus of Basidiomycota

---

**Laboulbeniomycetes**

- Very poorly known example.
- Relationship between fungi and insects unclear. One species parasitic?
  - Species of this fungus probably occurs on all insects
  - Fungus is a member of Ascomycota

---

**Laboulbeniomycetes**

- Ascocarps occur on very specific localities in some species:
  - **Rickia dendroiuli** Only found on forelegs of millipedes
**Rickia dendroiuli**

- Low magnification showing three ascocarps as seen through the microscope.

**Rickia dendroiuli**

- High magnification showing two ascocarps, left is mature.

**Laboulbeniomycetes**

- In some species specific localities misleading. For example:
  - In some insects, "species A" may have ascocarps arising only on front, upper pair of legs of males.
  - However, "Species A" have ascocarps arising only on the back, lower pair of legs of females of same insect species.

**Laboulbeniomycetes**

- Variations were based on mating habit of insects involved.

**Peyritschiella protea**

- Ascocarps not always in specific localities.

**Peyritschiella protea**

- High magnification of ascocarps and ascospores.
**Stigmatomyces majewski**

- Ascocarps occur mostly on segment.
- Note one on wing.

**Laboulbenia cristata**

- Ascocarps occur on middle segment legs.

**Septobasidium**

- Genus of Basidiomycota that forms a symbiotic relationship with scale insects.
- Superficially, appears to be a wood decomposing fungus.

**Stigmatomyces majewskii**

- Low and high magnification of ascocarps.

**Laboulbenia cristata**

- High magnification of ascocarp with ascospores.

**Septobasidium**

- More examples:
**Septobasidium**
- More examples:

**Septobasidium**
- Much more complex.
  - Scale insects live within fungus fruitbody.
  - Scale insects are "sap suckers", parasitic on tree that they live.
  - Suctorial tubes enter wood and food conducting tissue.

**Development of Symbiosis**
- Fungus growth surrounds scale insects.
- Fungus obtains food from insects with haustoria.
- But...Not just a parasitic relationship:
  - Fungus protects and houses insect from harsh environment.
  - Insect protected from predator, i.e. birds.
  - Scale insects in relationship live longer than free counter-parts.

**Septobasidium**
- Fungus and insect can over winter.
- Spring time female lays eggs
- Larvae produced can do three things:
  - Go to adult stage and stay within original colony.
  - Leave and join another colony
  - When leaving colony, basidiospores will attach to insect and new colony will start if it does not join a pre-existing one.
Colonial Insects and Fungi

- Some social insects cultivate fungi as a source of food.
- Evolution of fungi cultivation parallels that of origin of agriculture:
  - Insects once gathered their food.
  - Evolved means of cultivating fungi.
  - Insects gather plant material to cultivate fungi and eat fungus.

Colonial Insects and Fungi

- Will look at two examples:
  - **Attine Ants** (Leaf Cutting Ants)
  - **Mound Building Termites**
- Both examples have complex society.
- Fungus is always a Basidiomycota and usually a mushroom species.
- Mycelium is utilized for food and not a mushroom.

Attine Ants

- Several species of ants that cultivate fungi, Attine Ants most highly evolved.
- Attine ants can devastate landscapes that are in their path of travel.
- Often strip bare area that they are going through:
  - Makes taking food back to colony easier.
  - Strip all leaves on trees for cultivating fungus.

Attine Ants

- Attine ants cleared path.
- Called Cutter Ants because they cut leaves into pieces before carrying them back to colony.
Attine Ants
- Complex caste system exist in this species of ants.
- There are several classes of soldiers.

From l-r: Soldier, and major, media and minor workers. Minim not shown.

Attine Ants
- Workers cut up plants and carry them back to colony.

Attine Ants
- Worker carrying a leaf back to colony.

Attine Ants
- Minim Workers protects larger workers from parasitic fly

Attine Ants
- Colony may consist of millions to tens of million workers.
- Colony several cubic meters, extending 100 to 200 meters along trails.
- Plant material taken to fungus farm and packed with ant feces onto fungus.
- Fungus farm is “pure culture” and kept clean by:
  - Workers weeding farm.
  - Antibiotics produced by gland on worker evolved to keep out weed fungi.

Attine Ant
- Workers caring for fungus farm.
Attine Ants

Why grow a fungus garden?
- Plant material cannot be used for food. Why?
- Fungus can utilize plant material for food and ants can then eat fungus.
- Fungus produce nutritional bodies called gongylidia or bromatia that are eaten by ants.

Attine Ants

- The queen stays in the fungus farms where she lays her eggs.
- When eggs hatch and larvae emerge, nurse workers feed larvae bromatia of fungus.
- Eggs hatch mostly into workers, but some reproductive males and new queens also produced.

Attine Ants

- Fungus does not produce mushrooms while colony active.
- After colony abandons nest, mushrooms can form:
  - Leucocoprinus luteus
  - Lepiota cristata

Attine Ant

Bromatia: nutritional bodies formed by fungus

- Fungus evolved bodies for feeding ants.

Attine Ant

Queen

- Queen (top-left), New queen and male right.

Mound Building Termites

- The mound building termites play an important role in recycling.
- Unlike Attine Ants, termites have symbiotic bacteria in gut that allows them to digest wood and other plant material.
- Native to old world tropic.
- Common name is from the large mounds they build.
- Important for maintaining temperature control.
As in case of Atta Ants, complex social system also exist.

- Soldiers and workers shown above.

- Queen surrounded by many workers.

Although they can eat wood, they grow fungi for additional food.
- Fecal material is saved in chamber for fungus growth.
- Some cellulose remains in feces.
- Fungus utilize remaining cellulose in feces and termites will eat fungus.

Formation of new colonies same as in ants:
- Most eggs will give rise to workers. They are females, blind and wingless.
- Some will be soldiers can see, females, but wingless and can produce acid in mandible areas.
- Reproductive have wings, can see and are male and female.
- Male and females, with fungus, swarm and start new colony.
Ambrosia Fungi

- So called ambrosia fungi symbiotic with scolytid beetles.
- Female beetles bore into living trees and take with them ambrosia fungus.
- Fungus is carried in specialized structure: mycangium.
- Location of mycangia differs in different species of beetles.
- Beetle prepares feces and wood litter for growing fungus, along tunnels.

Ambrosia Fungi

- Fungus (ambrosia) provides food for beetles as well as larvae that will hatch from eggs.
- Fungus species may be specific for species of beetles.
- Some species have proven harmful to some trees, e.g. Dutch Elm Disease.
- Fungus pure when beetles are maintaining it, but contaminated after leaving.

Ambrosia Fungi

- Asian Ambrosia Beetle larvae and ambrosia fungus

Ambrosia Fungi

- Adult and eggs

Ambrosia Fungi

- Beetle gallery