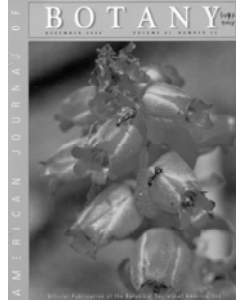


Mycorrhizae of the Ericaceae

- Anatomy
- Ecology
- Evolution



Subfamilies in the Ericaceae

Ericoideae
Calluna, Erica

Vaccinoideae
Gaultheria, Lyonia, Vaccinium (blueberry)

Rhododendroideae
Andromeda, Kalmia, Rhododendron

Arbutoideae
Genera: *Arctostaphylos* (bearberry), *Arbutus*, *Epigaea* (trailing arbutus)

Pyroloideae
Chimaphila, Pyrola

Monotropoideae
Monotropa (indian pipe), *Pterospora* (pinedrops), *Sarcodes* (snowplant)



Mycorrhizal types in Ericaceae

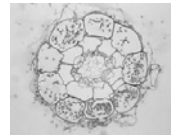
Ericoid = Ericoideae, Rhododendroideae, Vaccinoideae

Fungi = *Hymenocyphus erica*, *Oidiodendron* sp.,
and molecular data suggest others including
basidiomycetes

Arbutoid/Monotropoid = Arbutoideae, Pyroloideae,
Monotropoideae

Fungi = Typical ectomycorrhizal fungi

Ericoid anatomy



Hyphae colonize epidermal cells of
extremely fine roots called hair roots;
note the cortex is only one layer thick

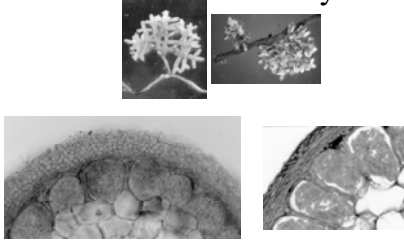
Heathlands are dominated by ericoid mycorrhizal plants



Ericoid plant communities

- Dominate in soils that are extremely nutrient poor, with high pH and C:N ratios
 - Dominate in high alpine and northern boreal regions
 - But also a dominant understory in conifer forests of the Pacific Northwest
- The fungi are able to access nitrogen bound to tannins and organic nitrogen sources (amino acids)

Arbutoid anatomy



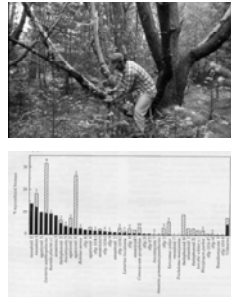
Like typical EM, there is a well defined mantle and Hartig net but...hyphae also penetrate epidermal cells.

Arbutoideae



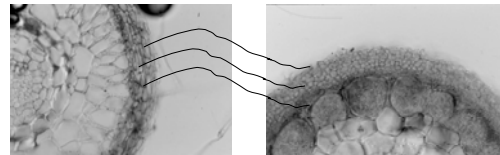
Arbutoid communities

- Forest practices use herbicides after a harvest to remove *Arctostaphylos* (competition w/Douglas-fir)
- Evidence that *Arbutus* and *Arctostaphylos* support fungi that are good for Douglas-fir



Douglas-fir
Ectomycorrhizae

Manzanita
Arbutoid mycorrhizae

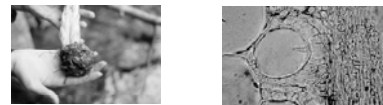


The fungi formed very different morphologies on the two plants - the morphology is controlled by the plant

The Monotropoideae



Monotropoid anatomy



Root mass is an extremely tight cluster in some species, and quite diffuse in others.

Cross-section reveals that this is a variant of the arbutoid EM type, but now only a 'penetration peg' is seen in the epidermal cells. Note the Hartig net.

The peg has been shown to burst into the plant cell -- 'With friends like that, who needs parasites?'

Our local version
Indian pipe or *Monotropa uniflora*

Carbon movement between plants

Cullings et al. 1996

Parasites tend to specialize on their victims

Bilaltondo et al. 2002

Extreme specificity

Bruns and Read 2000

- These plants produce 'dust seed' by the thousands per capsule -- disperse far and wide.
- Snow plant and pinedrops associate with related but different species of *Rhizopogon*
- Seeds of the two plant species will germinate in the presence of each other's fungus, but...
- Germinants die unless they are with the correct fungus

Case Study: Pinedrops in NY

30 populations in 20 counties recorded in the early 1900s

Only 4 known locations left, all at Letchworth State park

A similar story for New England states: one population left in New Hampshire and 2 in Vermont

Bakshi 1959

Pinedrops (Ericaceae, Monotropoideae)

Cullings et al. 1996

Field Sites

New York - The Empire State

- 3 pinedrops sites in NY and Michigan
- 3 white pine sites in NY and Michigan

Fungal Symbiont and Pinedrops Haplotype I.D.

METHODS

- Collect pinedrops root tips
- PCR, RFLP, and Sequence DNA
 - Fungus = ITS
 - Plant = plastid trn locus
- Genbank blast search
- Phylogenetic analysis

Fungal - RFLP

Pinedrops - RFLP

The Fungus

Eastern *Rhizopogon* species
This is a new species!!

Rhizopogon salebrosus group

Rhizopogon arctostaphyli

The Plant

One eastern pinedrops haplotype

One of several western pinedrops haplotypes

Frequency of fungus in dormant spore banks

METHODS

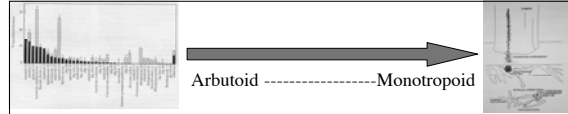
- Collect soil samples
- Bioassay with white pine
- Harvest seedlings and collect root tips
- Identify fungi

The fungal host of pinedrops (*Rhizopogon*) is common out west but relatively rare in the east

- 6% of eastern soils yielded the eastern *Rhizopogon* sp.
 - All 4 matches were from pinedrops plots - 0 from non-pinedrops plots
 - 2 each from Letchworth Park, NY and Michigan
- 20-60% of western soils yielded the western *Rhizopogon* spp.

Kjoller and Bruns 2003

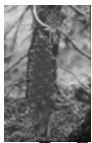
Species radiated after the loss of chlorophyll



Plant-centric question: Why be host specific?

- The association is beneficial to the fungus
 - But this is no different than the normal mutualism. Why avoid carbon sources?
- Tap into the best source of carbon, that is, a fungus with a high carbon availability
 - Perhaps some fungi get more carbon than others, and can afford to loose a little.
- ✓ Specialize on a fungus that is commonly encountered in both space and time
 - Specializing on a rare fungus seems to be a doomed strategy from the outset. This makes sense, but probably does not drive specificity.
- ✓ The plant is a parasite on the fungus
 - Most fungi evolve defenses against parasitic plants. But the plants evolve ways around the defense with some fungus species. Partners lock in combat in an arms race towards specificity.

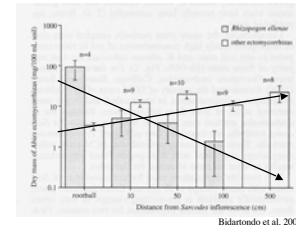
A look at the EM community in and around *Sarcodes*



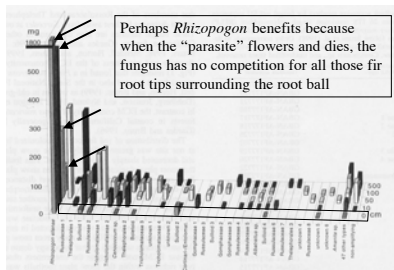
Bidartondo et al. (2000) sampled EM roots of red fir at increasing distances from *Sarcodes* root balls.



Rhizopogon on red fir proliferate around *Sarcodes* root mass



Is *Sarcodes* a parasite on *Rhizopogon*?

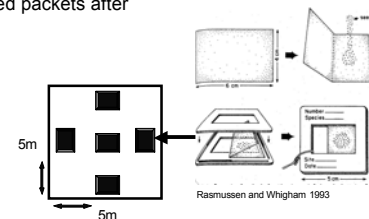
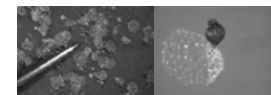


Bidartondo et al. 2002

Frequency of active fungal symbiont *in situ*

Method

- Collected pinedrops seeds
- Out-planted seed packets
- Harvested seed packets after 1 year



Rasmussen and Whigham 1993