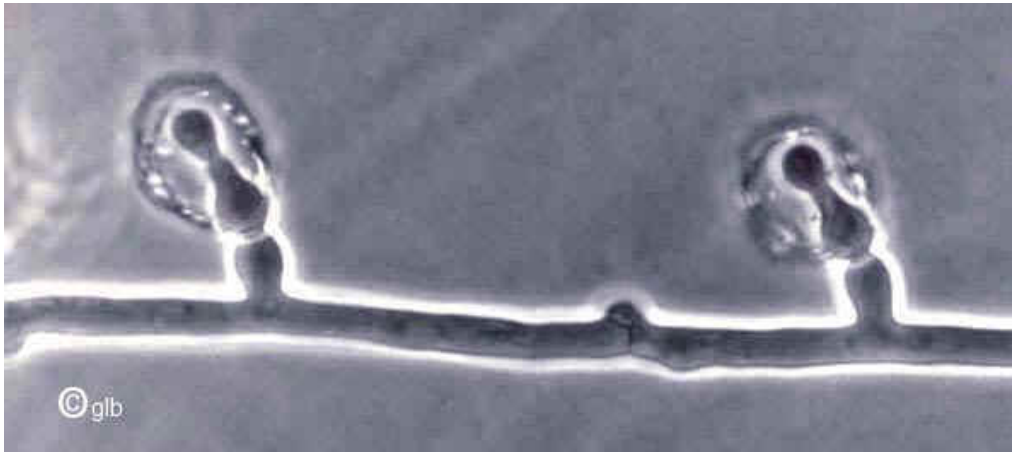
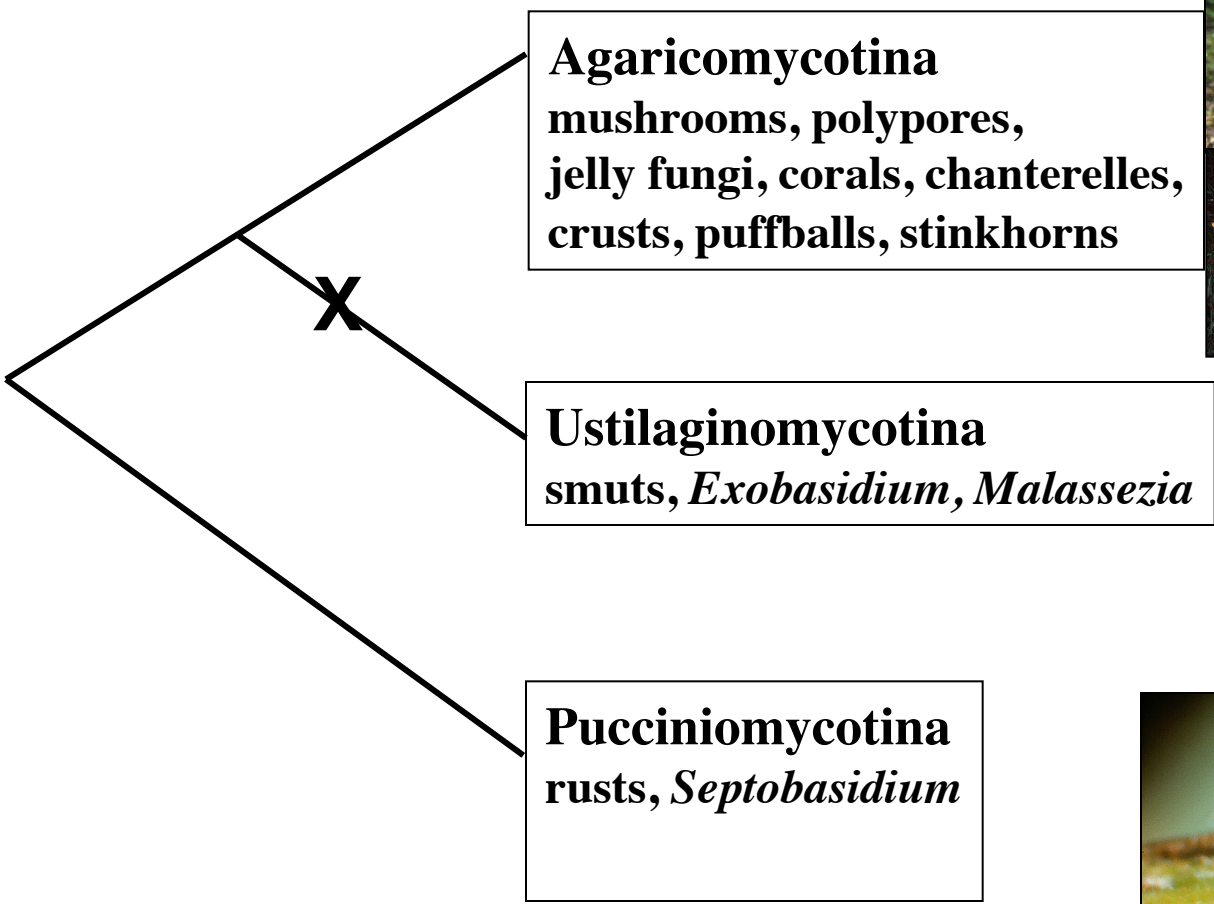
Basidiomycete-insect (& nematode) interactions

Dong Lin



3 Major Clades - Subphyla - of the Basidiomycota
Insect symbionts occur intwo of them



Agaricomycotina
mushrooms, polypores,
jelly fungi, corals, chanterelles,
crusts, puffballs, stinkhorns

Ustilaginomycotina
smuts, *Exobasidium, Malassezia*

Pucciniomycotina
rusts, *Septobasidium*

Fungus-insect interactions in Basidiomycota

Septobasidiales (Pucciniomycetes/Urediniomycetes):
-Septobasidium scale insect parasite
Pucciniales (Pucciniomycetes/Urediniomycetes):
-movement of spermatia (pycniospores) by insects, floral mimicry
-rust spores used as food by bees
Russulales (*Amylostereum*):
-Wood wasp symbionts, wood decomposers
Agaricales (*Athelia*,*Termitomyces*, *Leucoagaricus*, *Lepiota*)
-associations with termites and leaf-cutting ants
-"carnivorous" Agaricales e.g. *Pleurotus* (toxin), *Hohenbuelia* and *Resupinatus* (adhesive knobs) predaceous on nematodes in rotting wood*, Coprinus* "spiny balls", *Hyphoderma* stephanocysts
Athelia/*Fibulorhizoctonia* "termite ball" sclerotia
Various uses of fungi as food by insects
rusts by bees
basidiocarps by various beetles, flies

Septobasidium: three-way fungal parasitism plant-insect-fungus

Septobasidium is a crust-like basidiomycete common in the SE USA, Asia, Australia, New Zealand.

It grows on the branches/trunks of hardwood trees and shrubs

Basidiomycota

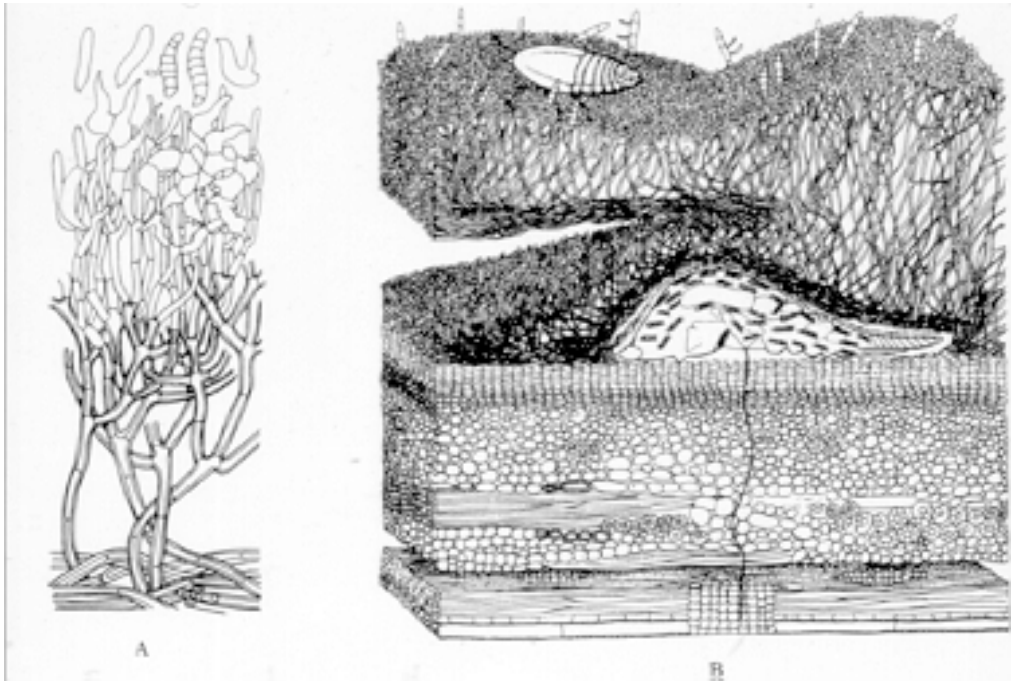
Pucciniomycetes, Septobasidiales

about 170 species

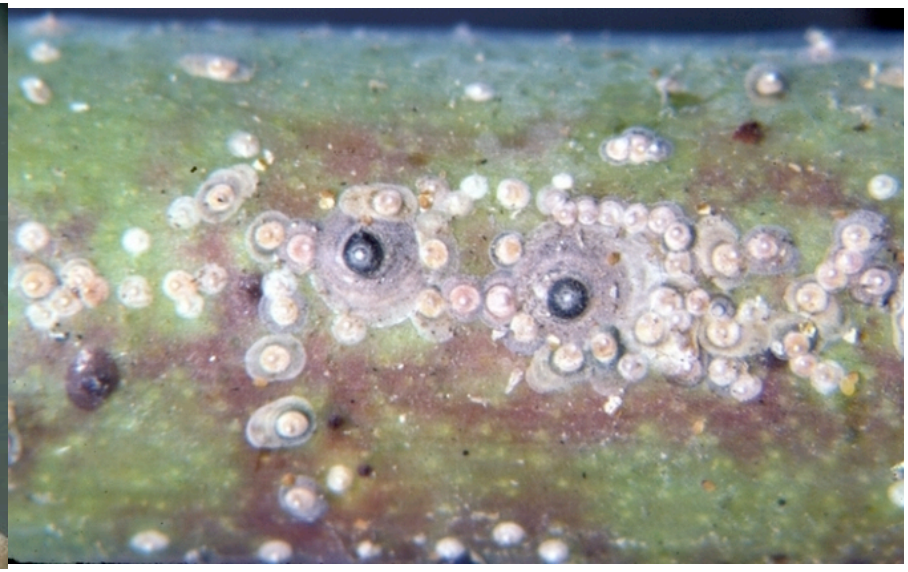
Septobasidium is related to rust fungi

only group of Pucciniomycetes that are not (directly) plant parasites

- Basidia transversely septate
- Parasite of scale insects, which do not die but become reproductively sterile



Adult female scale insects

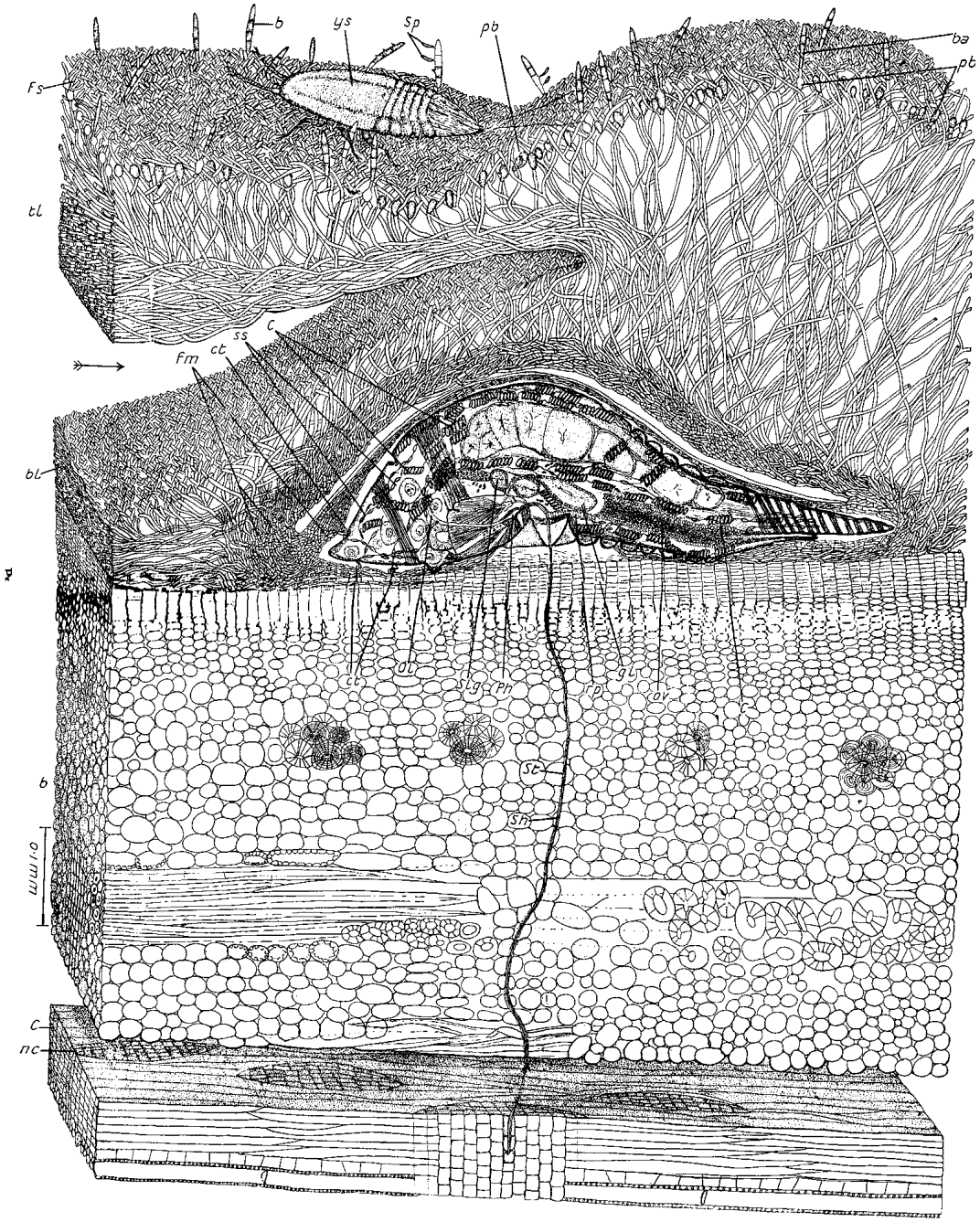


Parasitoid wasp

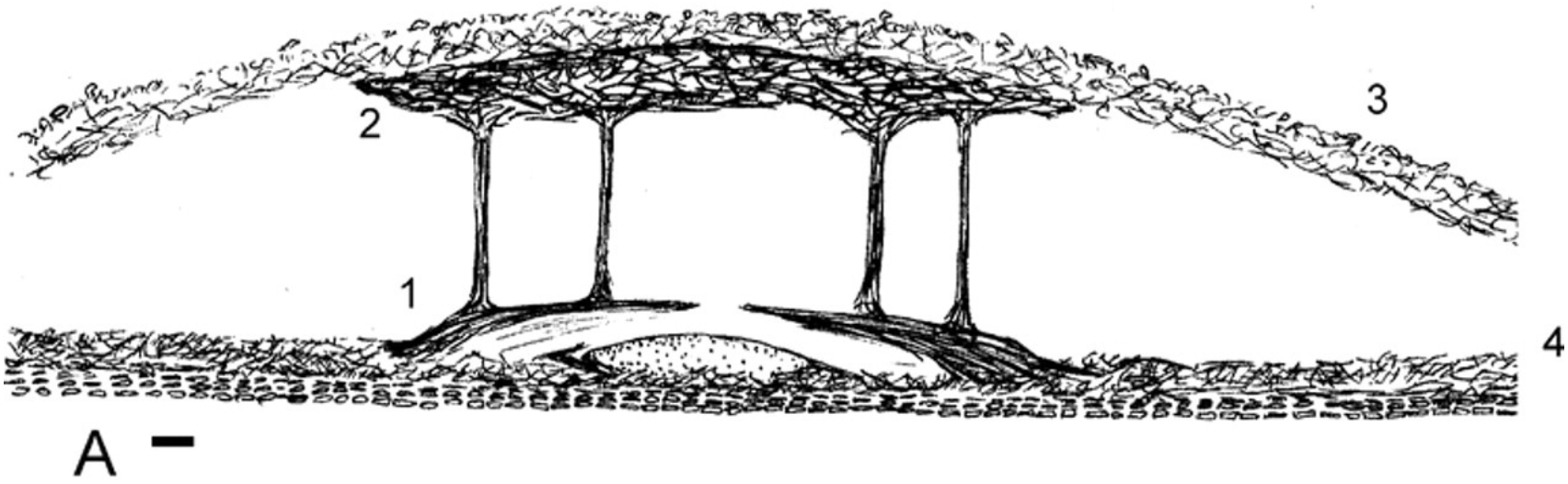
Cross section through a *Septobasidium* thallus showing a young crawler stage scale insect, a parasitized scale insect and the infective basidia on the surface of the colony.

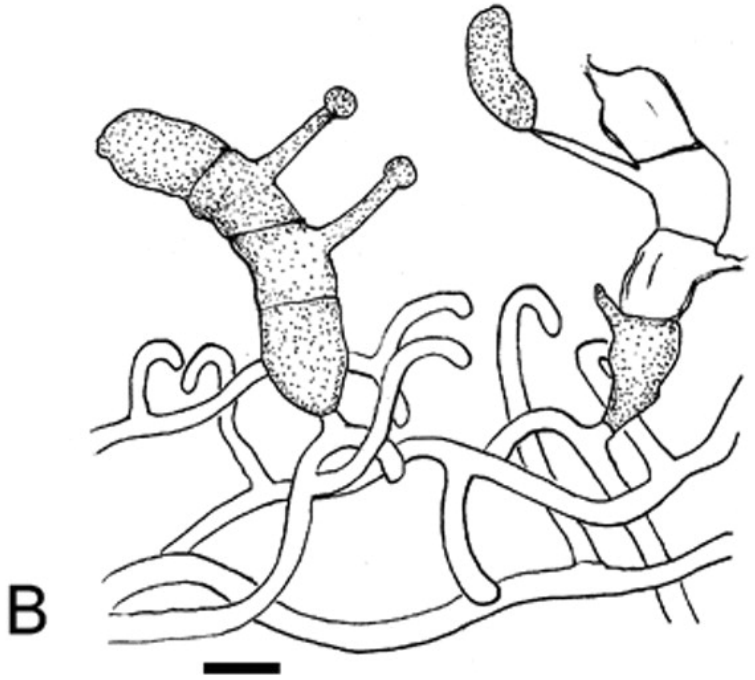
Basidia, basidiospores only on upper surface

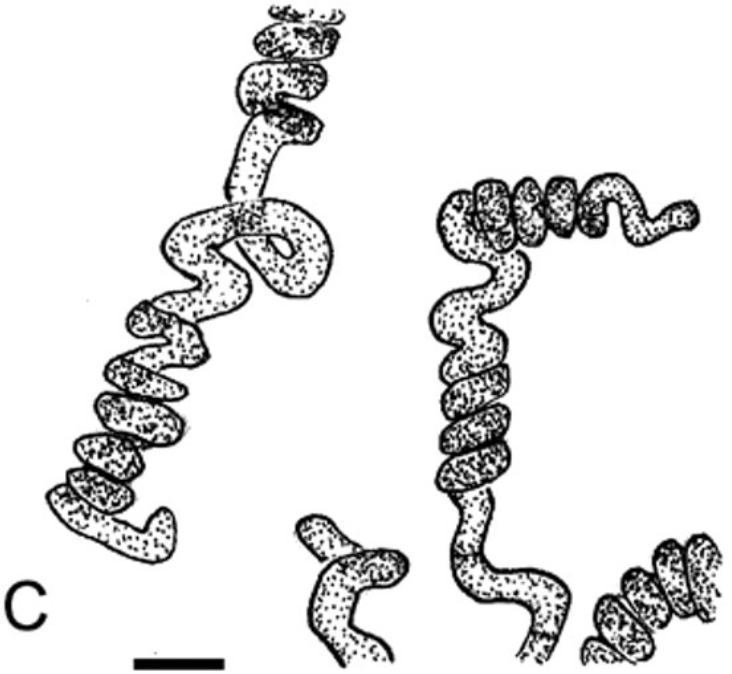
Septobasidium obtains its food from the host tree by way of the body of a sucking insect



Some species produce an elevated canopy over the scale insect







Life cycle of *Septobasidium* and its insect host

- Young “crawler” stage scale insects emerge and settle, insert sucking tube
- If they contacted fertile surface with basidiospores before settling they may become infected
- Young that emerge through fissures in colony and do not contact spores are uninfected, typically settle near edge of colony
- Uninfected scale insects remain reproductively viable, produce next generation of insects to maintain colony
- Scale insects are not infected directly by hyphae, only basidiospores while they are in crawler stage
- Parasitized adults are smaller, sterile, coiled hyphal haustoria in circulatory system, but are not killed
- After infected individuals settle, fungus inside the circulatory system spreads and hyphal tips emerge from body openings and fuse with larger colony mat as it grows
- Fungal mat grows over and protects uninfected scale from predation by parasitoid wasps

Termite egg mimicry by the “termite ball fungus”
*Fibulorhizoctonia (*teleomorph *Athelia sp.?)*
found in nests of *Reticulotermes speratus*

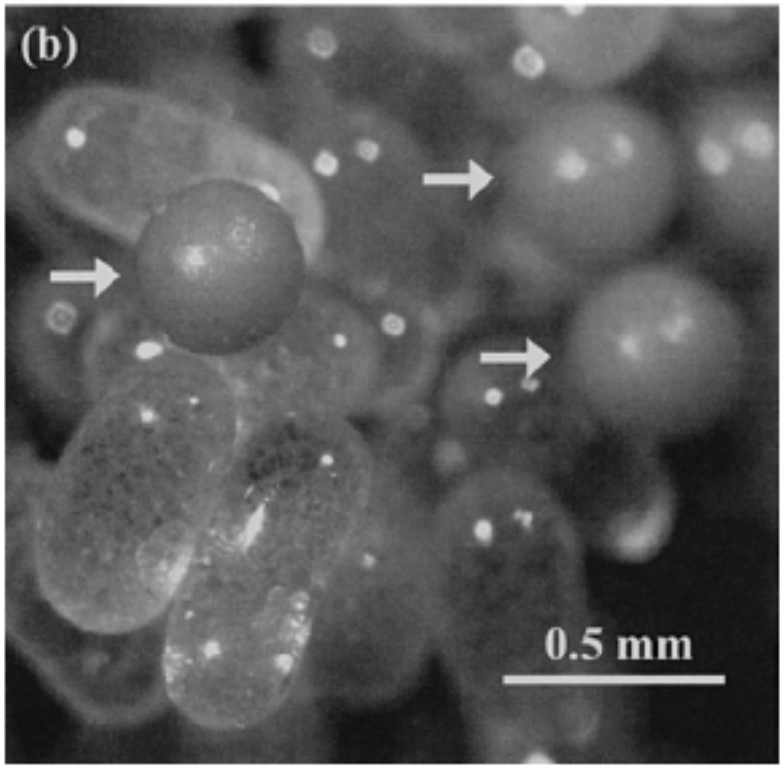
Athelia (= Sclerotium) rolfsii is a basidiomycete plant pathogen

Figure 28. Sclerotia, the small seed like structures, serve as overwintering bodies.

Courtesy Texas Agricultural Extension Service - 1995.

- Soil borne pathogen of numerous food crops,
- Diagnostic character is formation of spherical, light brown sclerotia
- overwintering structures

“Termite balls” are sclerotia that are similar in size to termite eggs. First discovered in termite nests in Japan, also later found in N. America (MA, VA, LA,TX) but not in CA. Found in 70% of *Reticulotermes* colonies



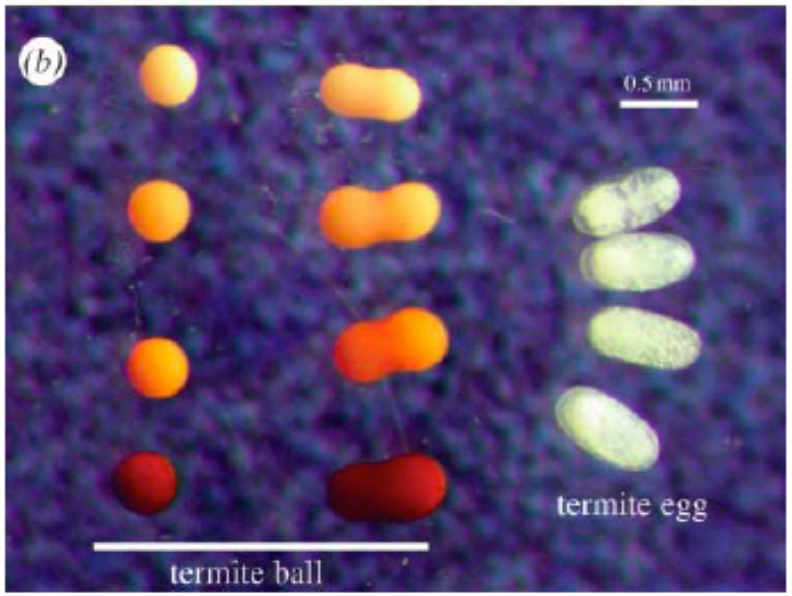
•Termite balls (sclerotia) are groomed by workers and carried with true eggs by workers

•Mechanism of transmission between colonies not known
- spore producing stage not known
- infection or phoretic movement by winged reproductive termites?

•TMBs enhance egg survival but also germinate and parasitize eggs that are not actively groomed by workers

Grooming of the TMBs by workers prevents them from germinating, but when workers are removed the TMBs germinate and parasitize the eggs.

mound of termite eggs with termite ball sclerotia



comparison of termite eggs and ‘termite balls’

Cultivation of fungi by termites

Termites - fungus cultivation only in old world termites

subfamily Macrotermitinae in Africa and Asia, India, Indonesia
large, elaborately constructed mounds with ventilation shafts

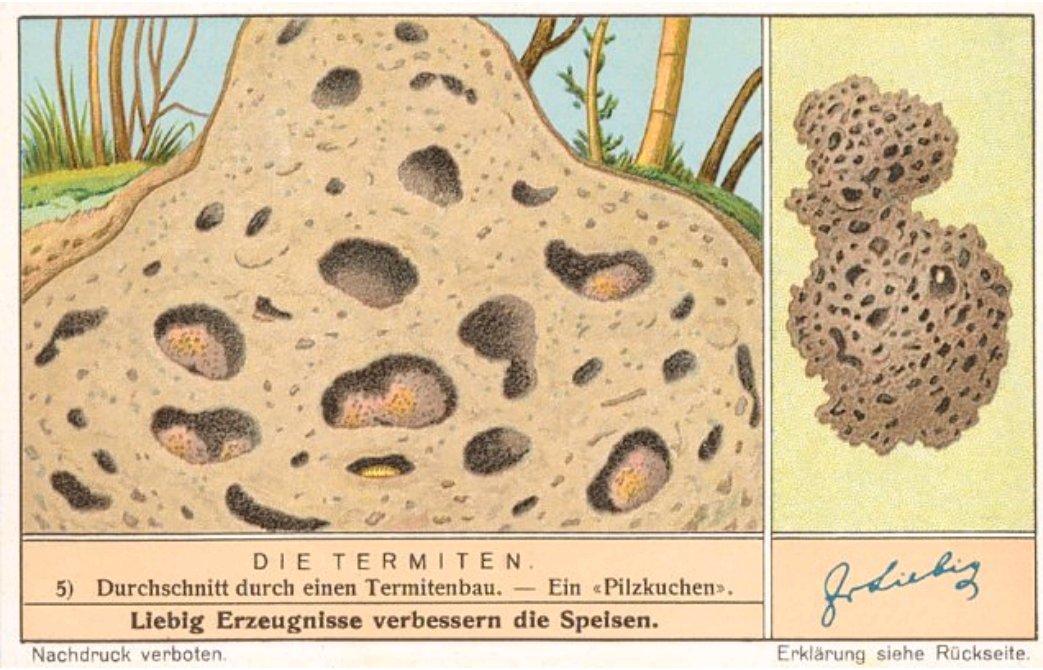
Termites forage for plant debris which they eat and digest with the aid of fungal cellulases

Termite mound has areas where the termites defecate, colonized by various fungi, primarily species of the agaric *Termitomyces*. Groomed to form a basket-like "comb". Termites graze on conidia produced by the *Termitomyces*

Cellulolytic enzmes of *Termitomyces* remain active in termite guts, so by nibbling the conidia produced on the surface of the garden the enzymes are maintained in the termite gut, culture of fungus maintained.

Fungus produces basidiocarps on neglected or deserted mounds.

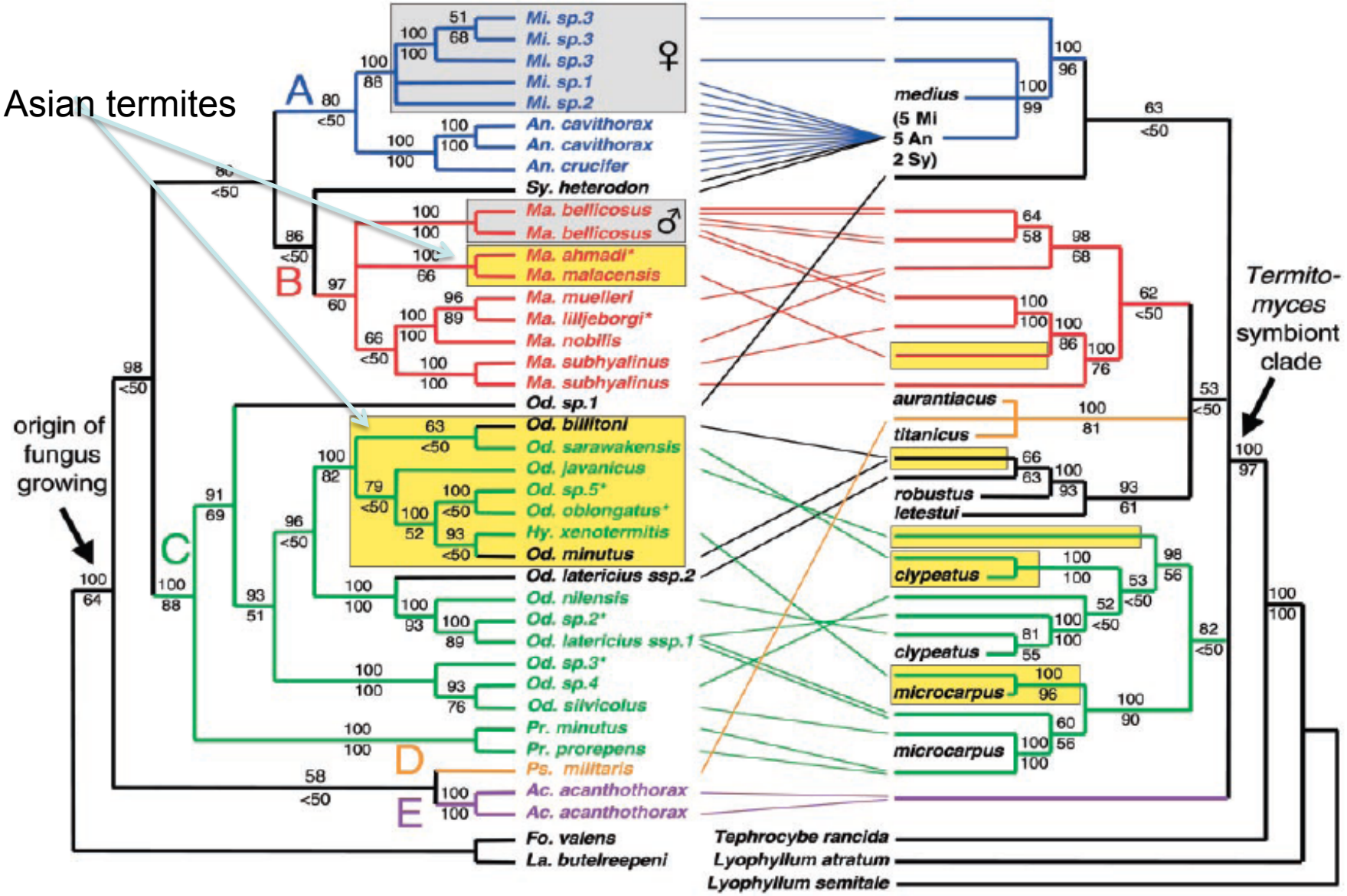
Cross section through a termite mound showing the fungus comb



Termitomyces, the termite mound fungus


Termitomyces
umkowaani

Termitomyces with comb



Comparative phylogenies of fungus cultivating termites and Termitomyces

Symbiosis between termites and fungi resulted from a single evolutionary event. Both *Termitomyces* and fungus colonizing termites are monophyletic.

Symbiotic species of termites and fungi each evolved from a single ancestor in Africa and then spread into Asia. Two different genera of fungus growing termites spread to Asia. Two other genera from Africa probably also spread to Asia.

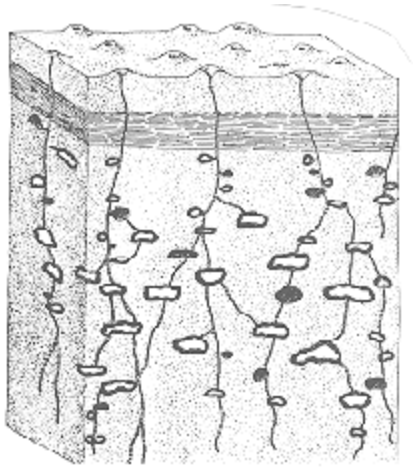
Certain clades (broad taxonomic groups) of fungus-farming termites apparently prefer to farm certain clades of fungi. Within clades, however, different termite species appear to have repeatedly exchanged fungal symbionts.

These findings suggest that termites tend to acquire fungal crops "horizontally" from other related termite species, rather than "vertically" from their parents.

Fungus farming by ants, the most ancient agriculture?

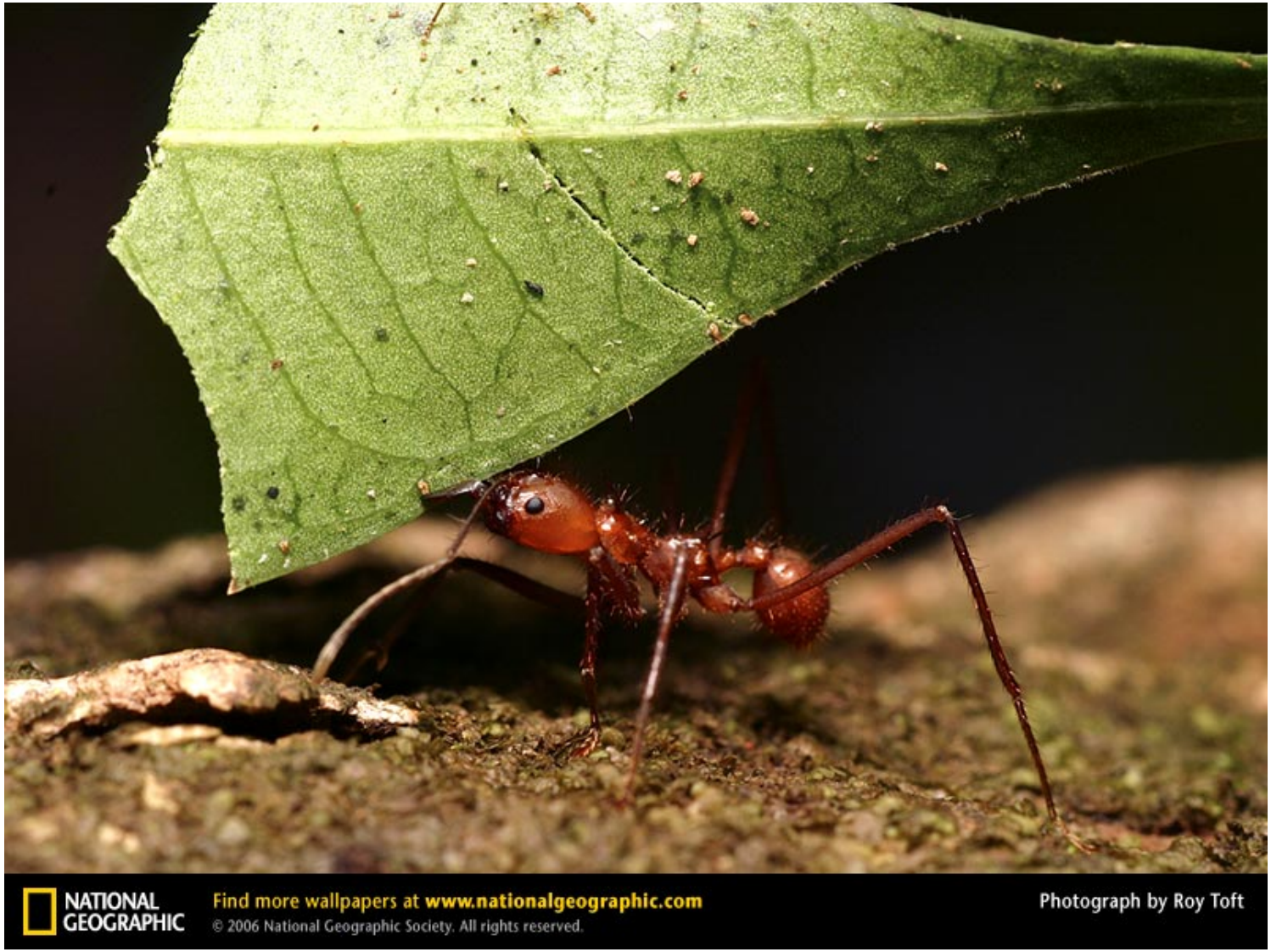
cultivation of fungi by ants began about 50-60 MY before human agriculture

Attine ants, new world, Central and South America
12 genera, 200 spp



Leaf cutter ant workers harvest plant material to compost in the nest

Because of their numbers, leaf cutting ants are the dominant herbivore in the Neotropics



In the nest the plant material is used to grow a specific fungus which nourishes the colony