Biodiversity of macrofungi from remote rainforests of the Guiana Shield


One of the most diverse, least
catalogued of all kingdoms


One of the most diverse, least catalogued of all kingdoms
All are microorganisms

What are they doing?

- Saprobes: Essential decomposers
- Symbionts: Essential partners for plants and animals
- Pathogens: Causal agents of global epidemics

- Food, medicines, biotechnology, etc.


Biodiversity

How many fungi?

Hawksworth 1995, 2001

- **6 species of fungi for every species of plant**
- **~250,000 species of flowering plants**
- **~1.5 million species of fungi**

- Based on temperate region
- Primarily macrofungi

As little as 5% of estimated species have been described (in the last 200 years)!

Where are the missing fungi?

Microfungi

Specialized niches

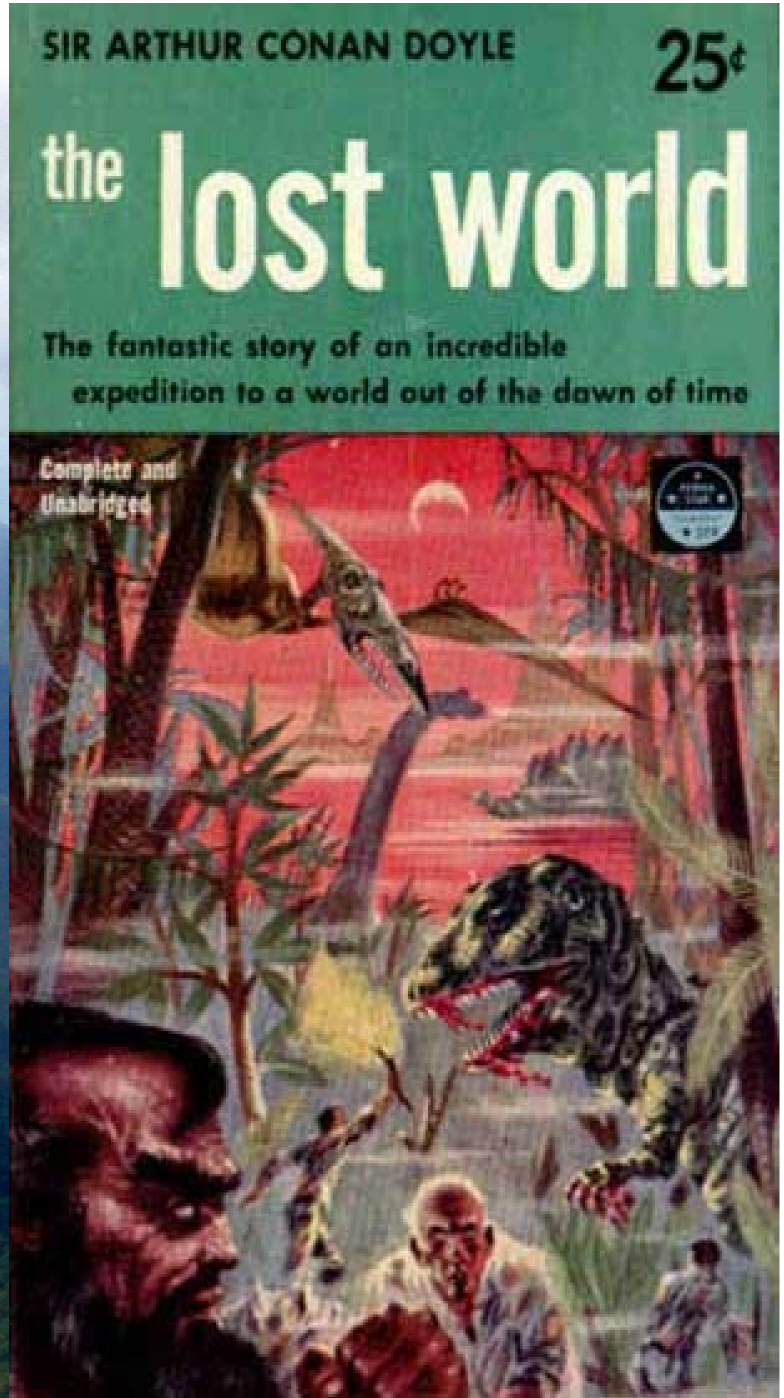

Tropical Fungi


Central America
Trinidad & Tobago
Guyana
Surinam
French Guiana
Venezuela
Colombia
Islas Galapagos
(Ecuador)
Ecuador
Peru
Brazil
Bolivia
Paraguay
Chile
Argentina
Uruguay
Falkland Islands
(UK)
South Georgia & South Sandwich Islands
(UK)
Map: www.all-hotels.com


TRINIDAD
AND
TOBAGO
North Atlantic
Ocean
VENEZUELA
Mabaruma
Parika
GEORGETOWN
New
Amsterdam
Bartica
Linden
Ituni
GUYANA
SURINAME
Lethem
B R A Z I L
0 75 150 km
0 75 150 mi
Map: http://i-am.org/images_country_cia

- two-billion-year-old Pre-Cambrian formation
- largest expanse of undisturbed tropical rain forest in the world

Maps: GraphicMaps.com


SIR ARTHUR CONAN DOYLE
25¢
the lost world
The fantastic story of an incredible expedition to a world out of the dawn of time
Complete and Unabridged

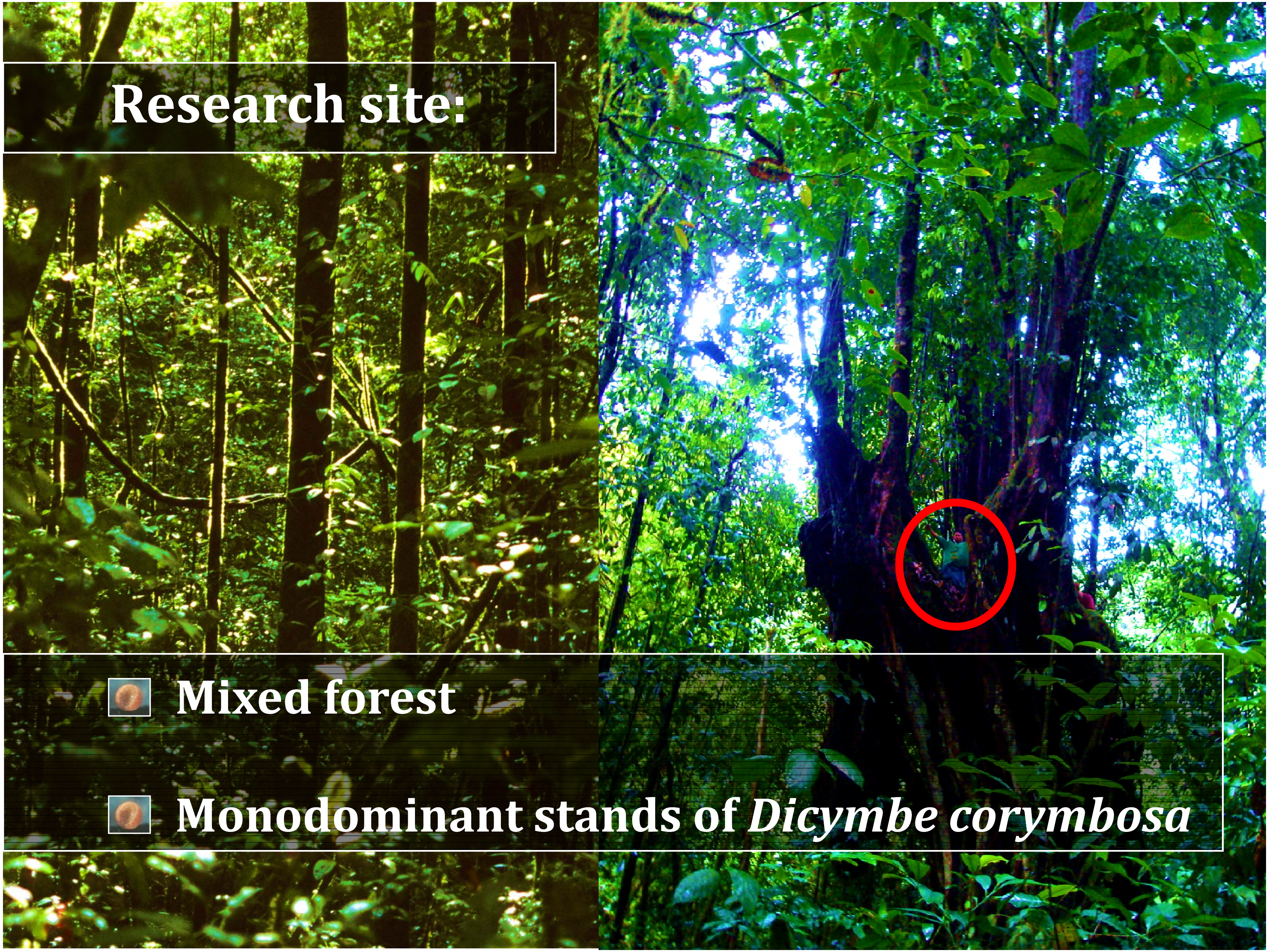


T. HENKEL
AYANGANNA
TRISCO
FOODS


COURTESY OF THE GUYANA ADVENTIST
MEDICAL AVIATION
SERVICE


Air Services Ltd



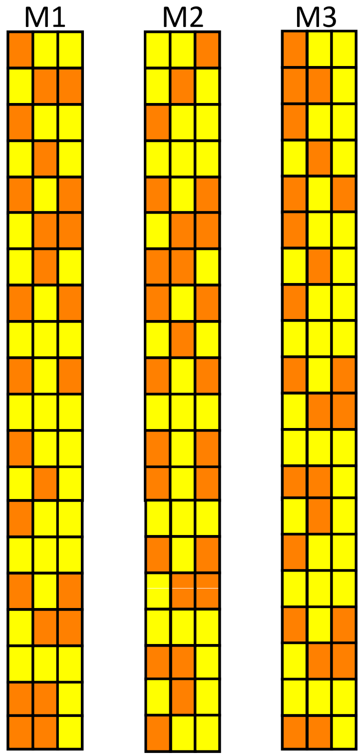



Research site:

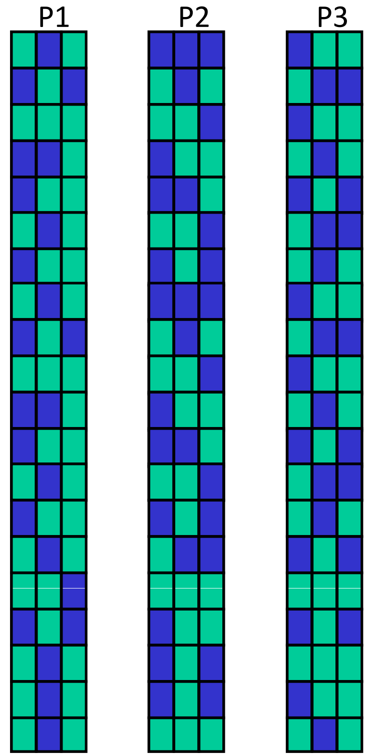
- Mixed forest
- Monodominant stands of *Dicymbe corymbosa*

Sampling: Plot Design

Mixed forest



Dicymbe forest



- 3 1-ha plots/forest type (Mixed and *Dicymbe* monodominant)
- each plot w/in 5 km radius of base camp, & each w/in larger >3 ha homogeneous primary forest
- Each subdivided in 100 10mX10m subplots
- randomly sample (without replacement) each season
- all macrofungi recorded

Study area = 6 ha

Each year sample ca. 1/2 of each plot

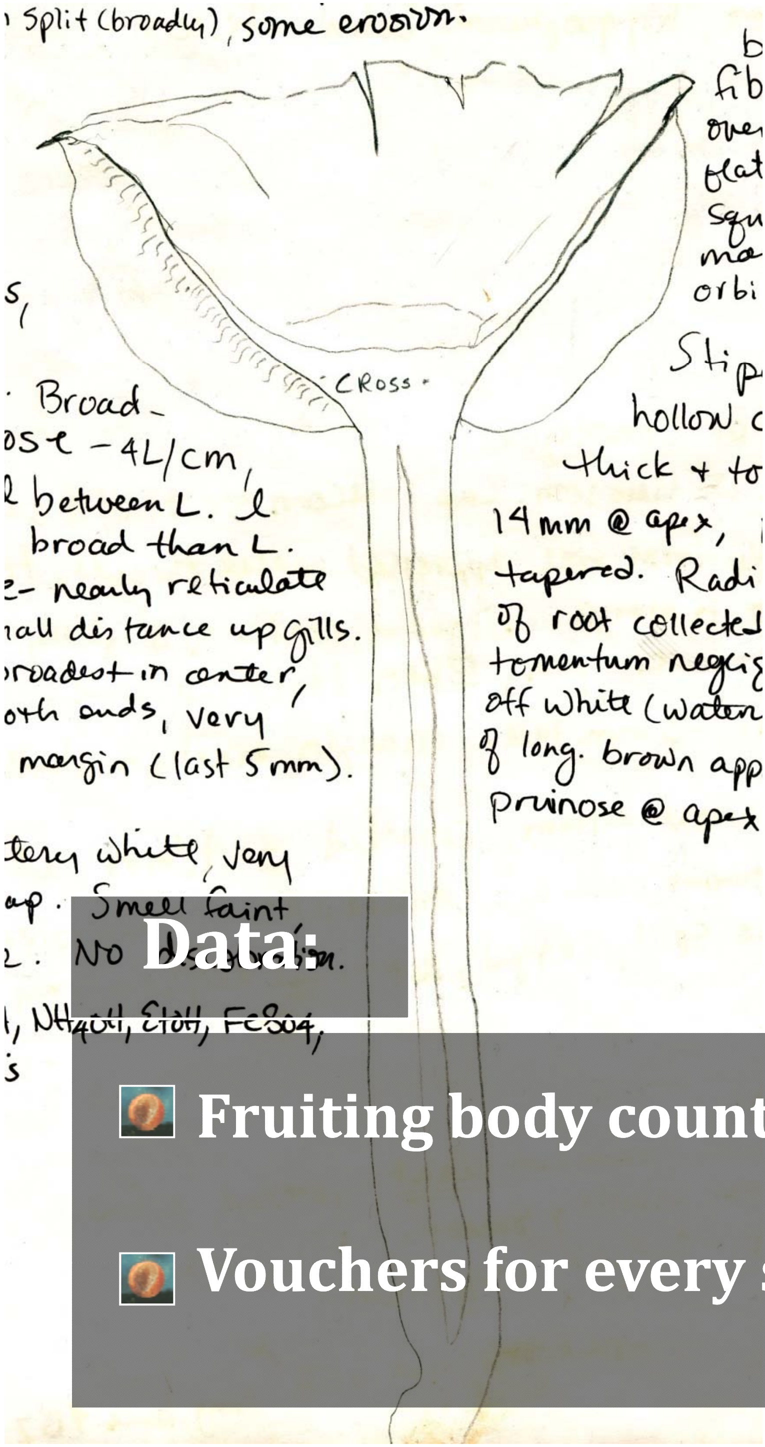
Strategy:

- 1x/year summer rainy season; 2000-2006, 2008-2010
- Macromycetes (ECM & saprotrophs) [basidomycete bias]







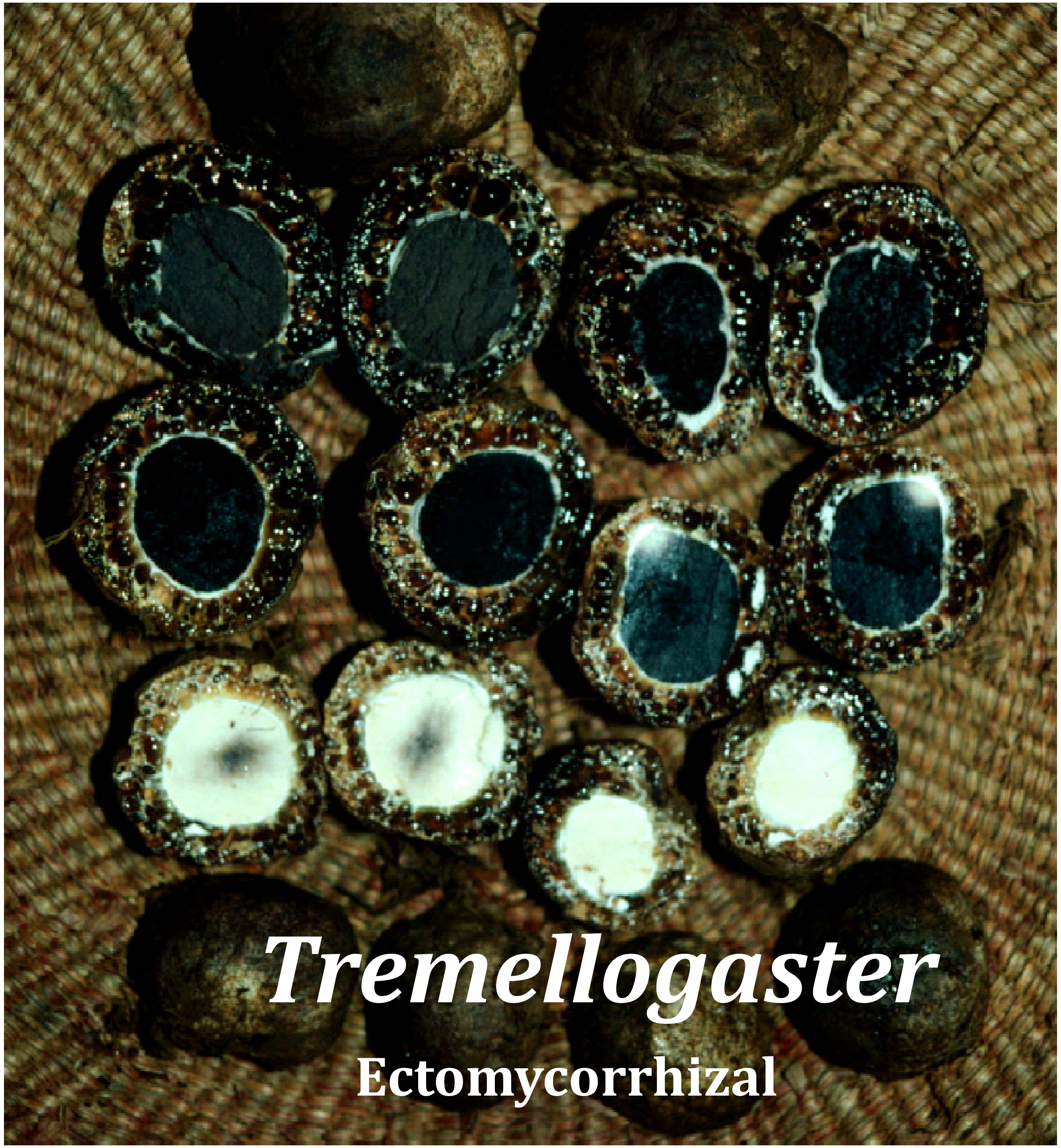


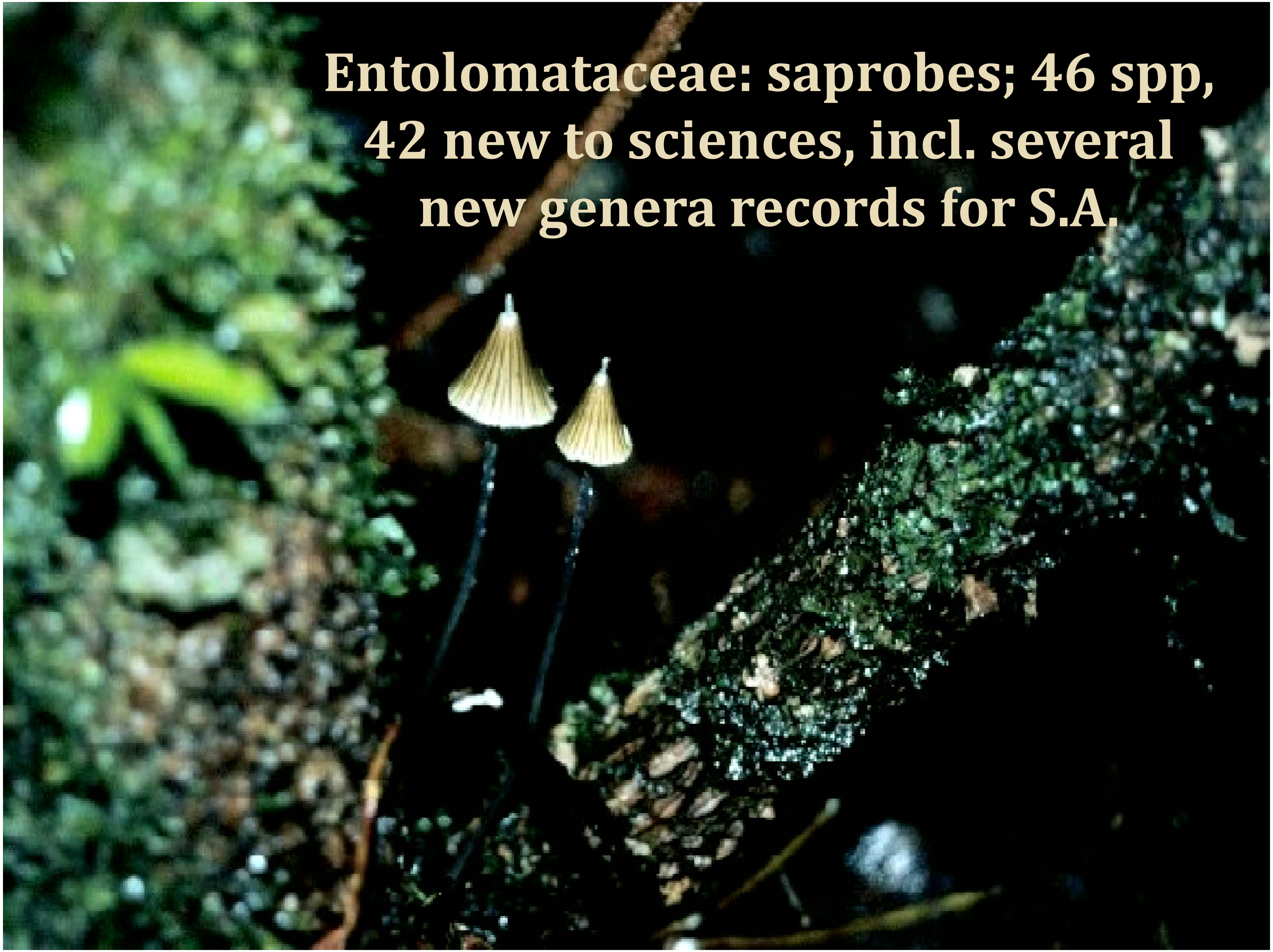
Data:

- Fruiting body counts
- Vouchers for every species (photos, descriptions, DNA)

1.

Expanding ranges/records

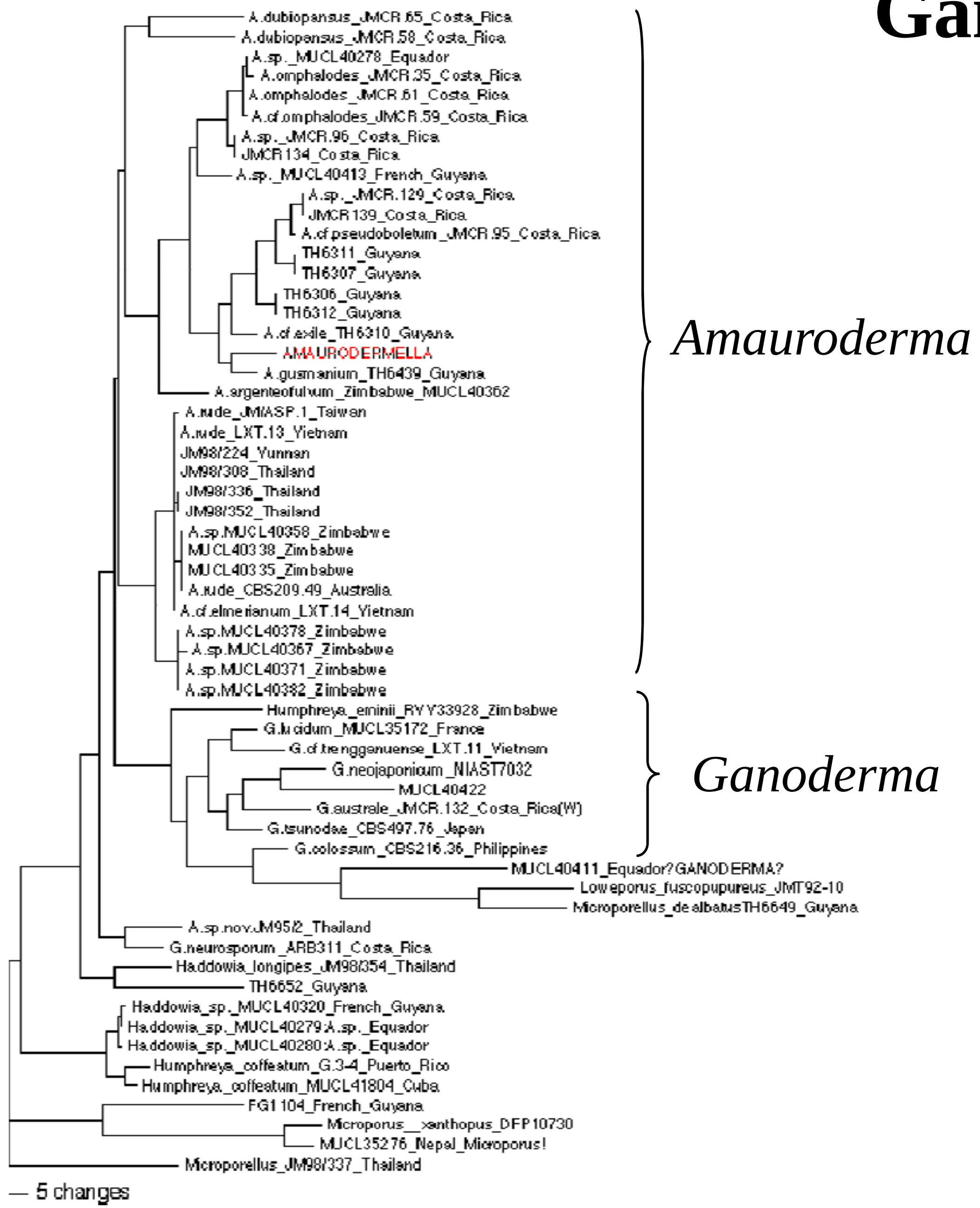



Entolomataceae: saprobes; 46 spp,
42 new to sciences, incl. several
new genera records for S.A.


a
b
c
d
e

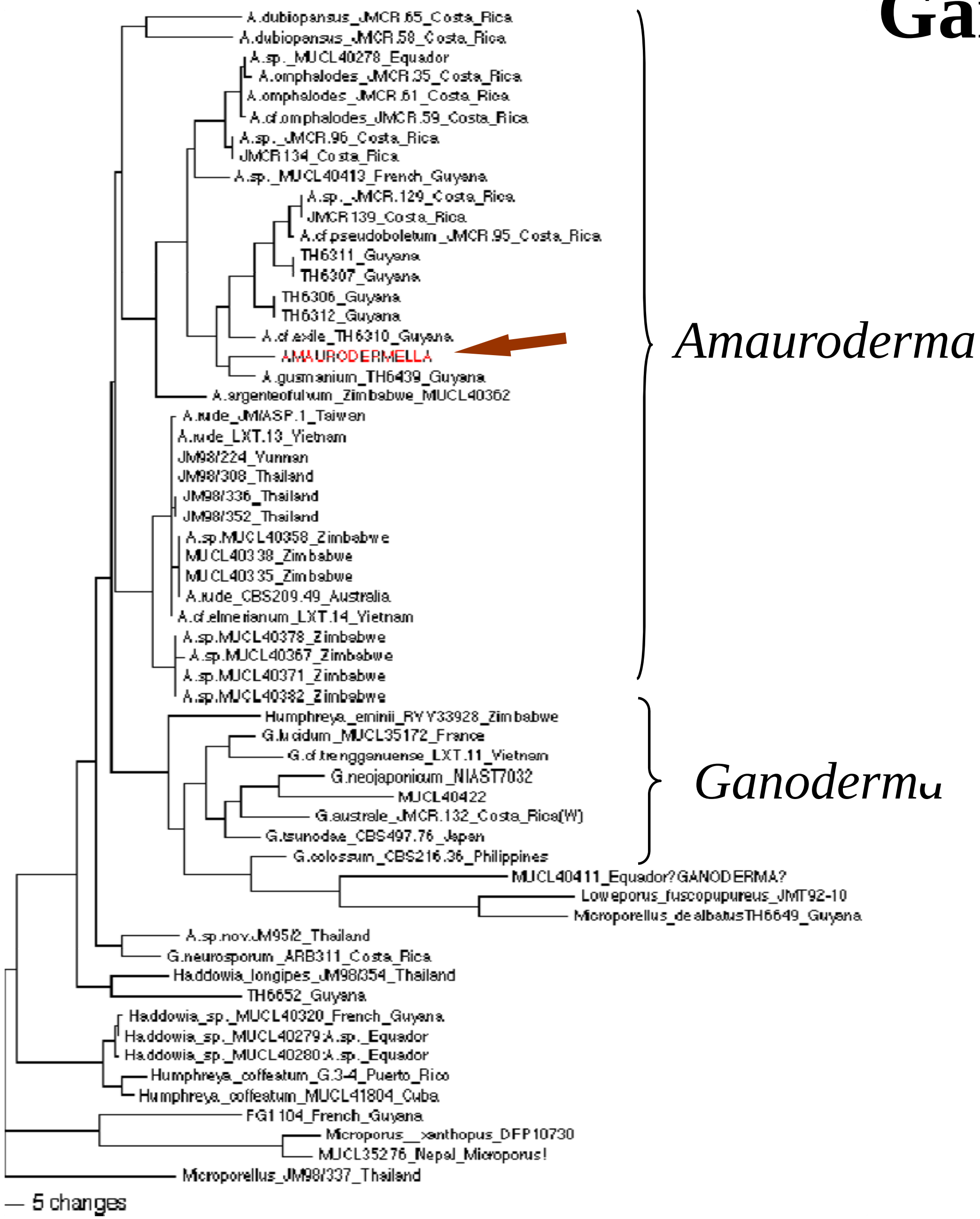
2. Expanding taxonomic concepts

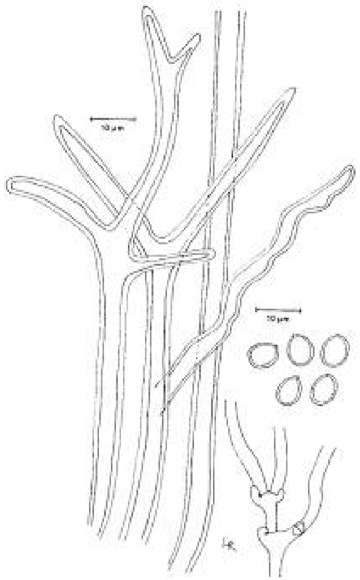
Ganodermataceae:
ITS dataset

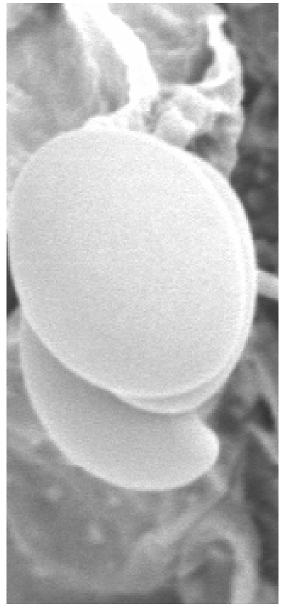


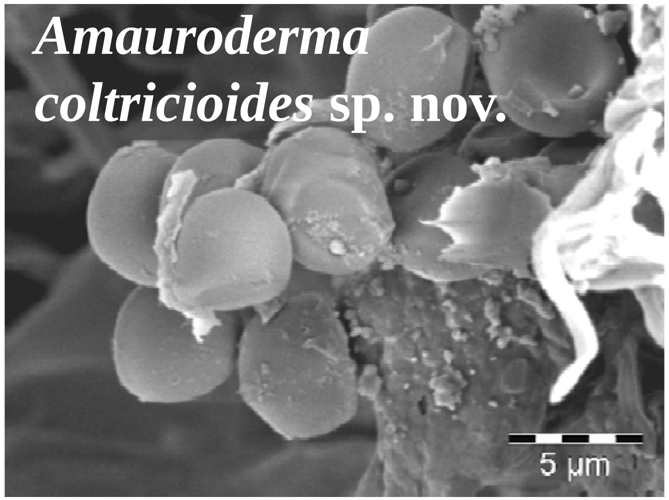
Ganodermataceae:

ITS dataset



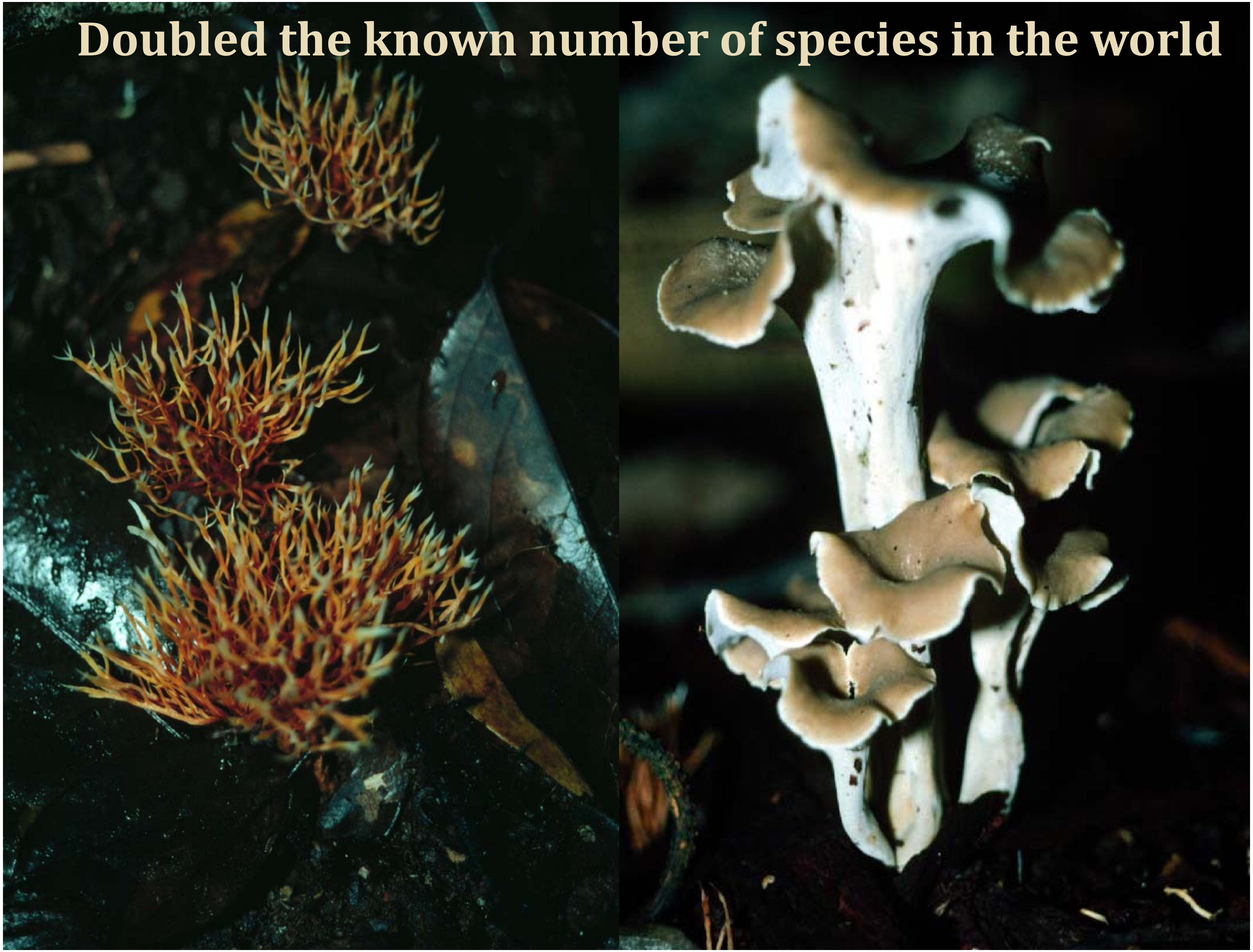


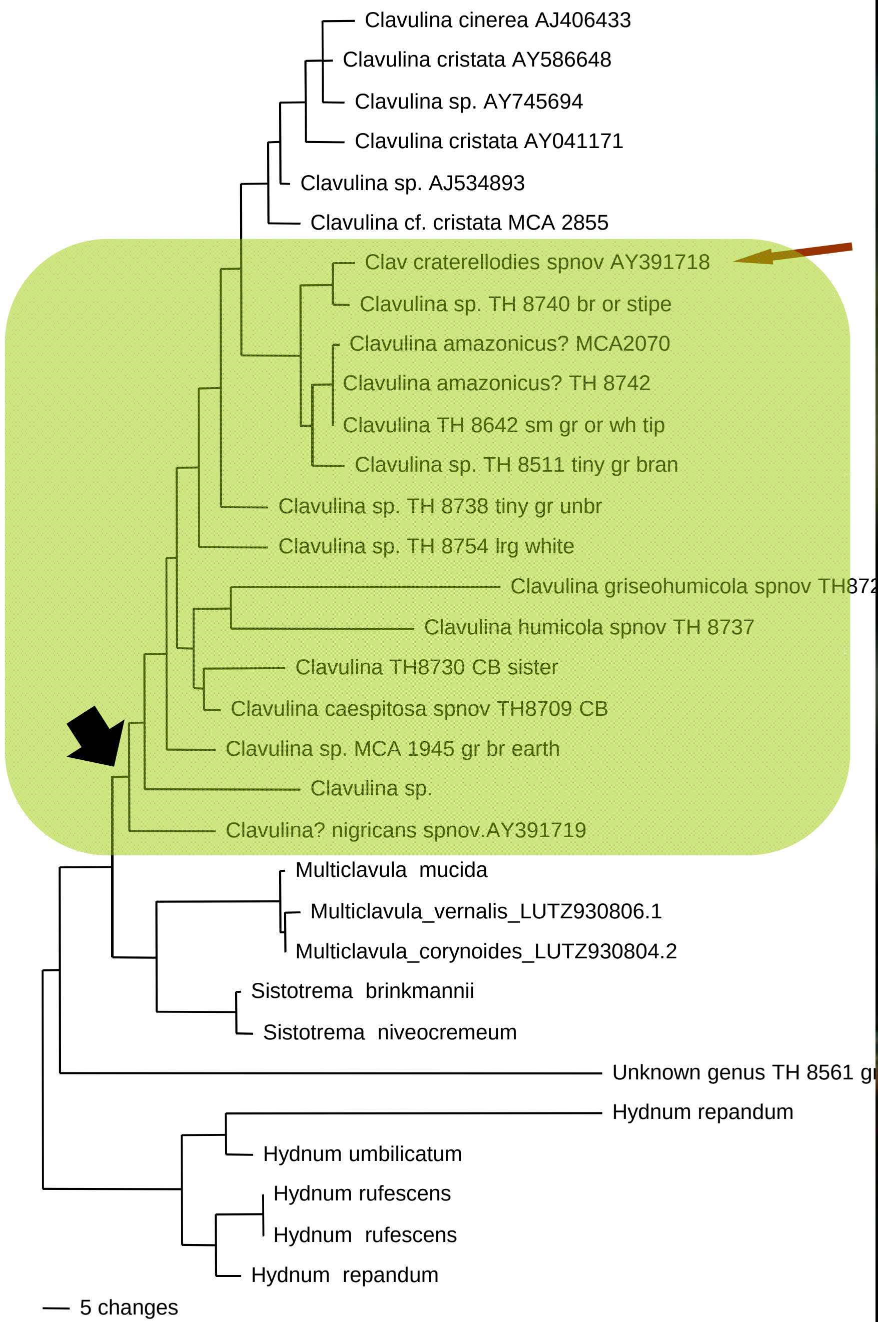




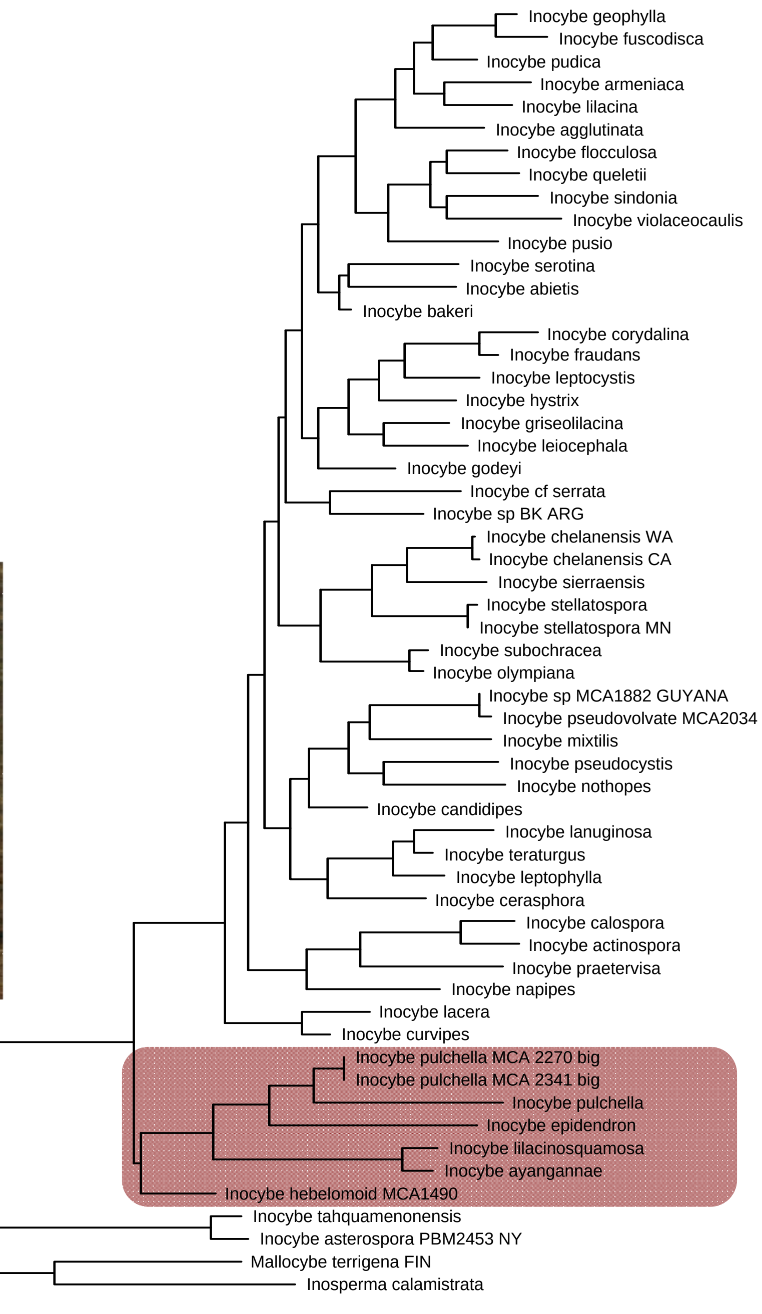
Drawings & SEMs: Leif Ryvarden


Clavulina:
ECM


Doubled the known number of species in the world


Clavulina cinerea AJ406433
Clavulina cristata AY586648
Clavulina sp. AY745694
Clavulina cristata AY041171
Clavulina sp. AJ534893
Clavulina cf. cristata MCA 2855
Clav craterellodies spnov AY391718
Clavulina sp. TH 8740 br or stipe
Clavulina amazonicus? MCA2070
Clavulina amazonicus? TH 8742
Clavulina TH 8642 sm gr or wh tip
Clavulina sp. TH 8511 tiny gr bran
Clavulina sp. TH 8738 tiny gr unbr
Clavulina sp. TH 8754 lrg white
Clavulina griseohumicola spnov TH872
Clavulina humicola spnov TH 8737
Clavulina TH8730 CB sister
Clavulina caespitosa spnov TH8709 CB
Clavulina sp. MCA 1945 gr br earth
Clavulina sp.
Clavulina? nigricans spnov.AY391719
Multiclavula mucida
Multiclavula_vernalis_LUTZ930806.1
Multiclavula_corynoides_LUTZ930804.2
Sistotrema brinkmannii
Sistotrema niveocremeum
Unknown genus TH 8561 gr
Hydnum repandum
Hydnum umbilicatum
Hydnum rufescens
Hydnum rufescens
Hydnum repandum
5 changes

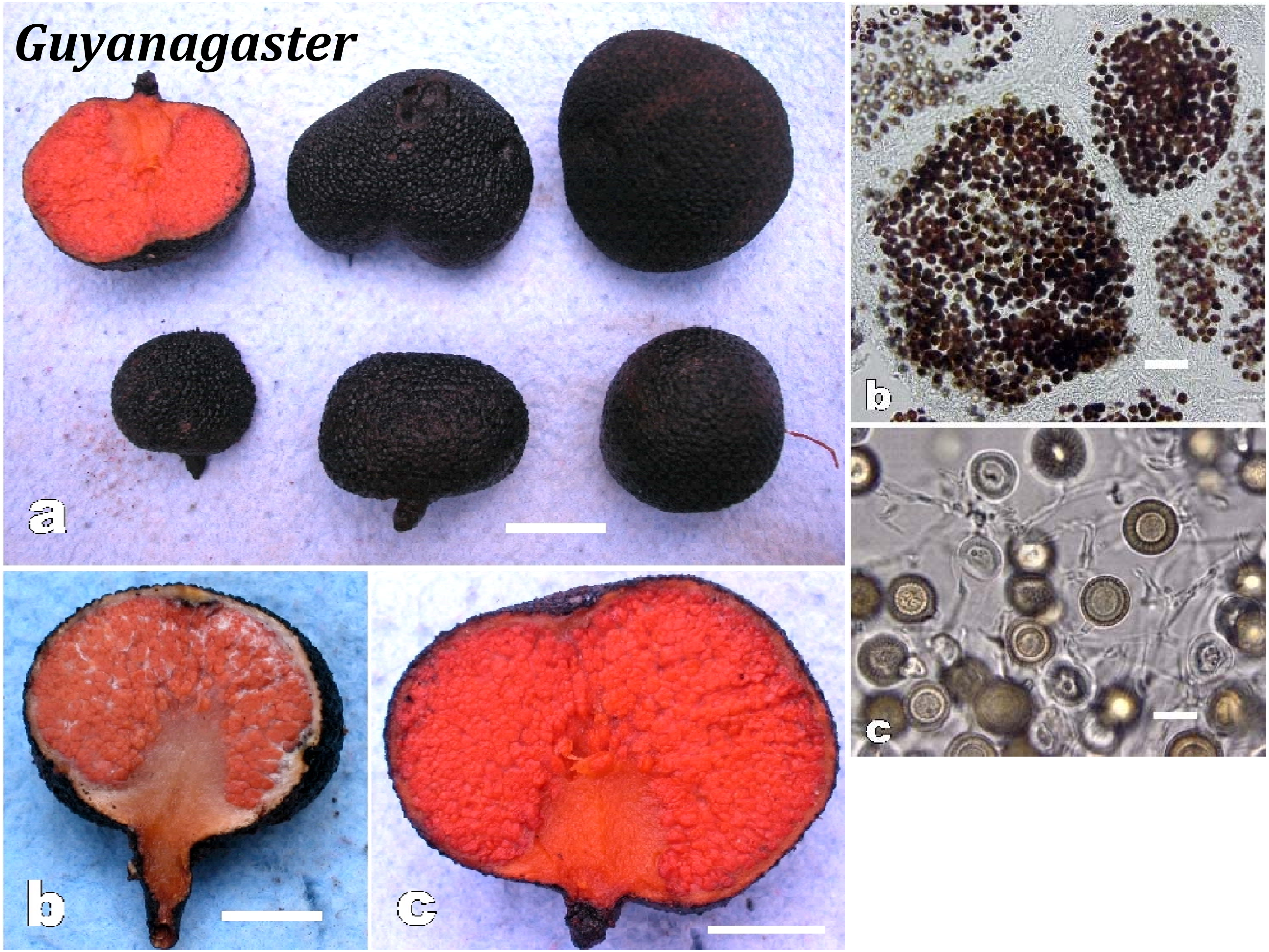
3. Evidence of antiquity of some lineages



Inocybe

6 new species
Basal clade

4. New higher-level lineages


Guyanagaster
a
b
c
b
c

PSEUDOTULOSTOMA: THE FIND OF THE CENTURY?

So commented one of the reviewer's of the paper by Miller *et al.* (2001) included in this issue which describes one of the most unusual fungi to be found at least in recent years. The new genus and species, *Pseudotulostoma volvata*, is an ascomycete which is a sister taxon to *Elaphomyces*, and comes from one of the most inaccessible forests so far surveyed for fungi in Guyana. However, unlike its hypogeous, truffle-like *Elaphomyces* relative, *Pseudotulostoma* produces stalked and volvate ascomata resembling the basidiomycete genera *Chlamydopus* and *Tulostoma*. The uncanny similarity, a result of evolutionary convergence, combined with the absence of either basidia or asci from very early stages of maturation, as also occurs in *Elaphomyces*, so fooled the authors, referees, and editors that it was almost described as a new genus of basidiomycetes. Initial molecular work suggested that it was an ascomycete close to the *Eurotiales*. This was so surprising that the DNA was presumed to have come from a contaminant; contamination by moulds such as *Penicillium* which belongs to the *Eurotiales* is a common phenomenon in the tropics.

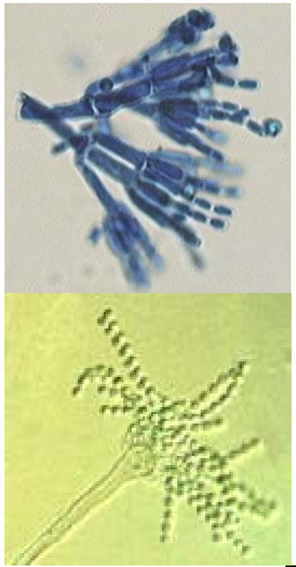
The collection sites are in the remote Pakaraima Mountains

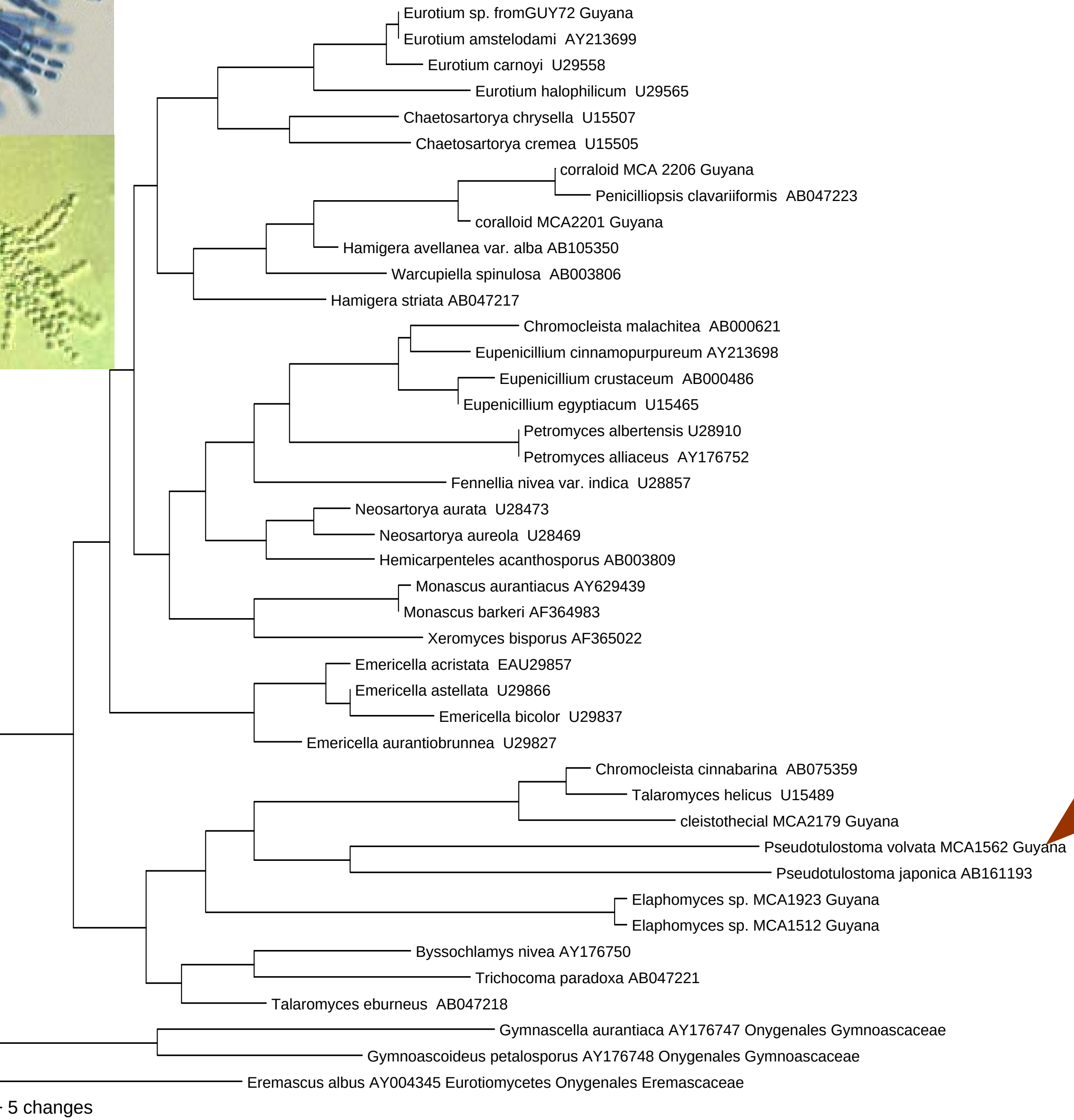
with the most hi
of the *Eurotiales*
persistence unde

The existence
remote habitat
ectomycorrhizal
second coup fo
pleurotoid *Lactar*
their unusual biol
2000). Those fu
trunks in which r
Lactarius fruit b
pleurotoid *Lacta*
ceedingly wet tr

Henkel, T., Aime, M
Russulaceae from G
status. *Mycologia* 9
Miller, O. K. jr, Henke

Eurotiales



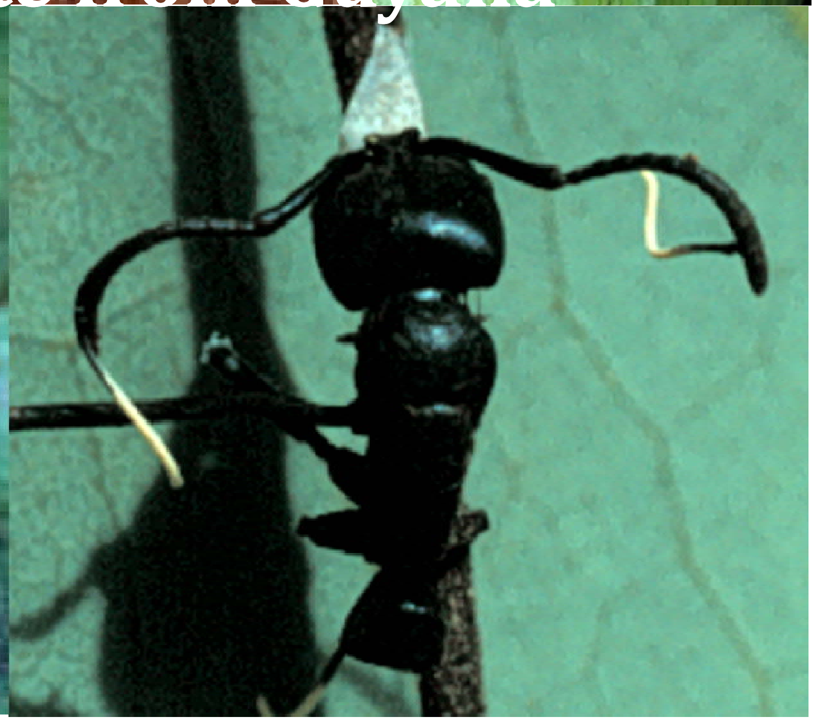


Eurotium sp. fromGUY72 Guyana
Eurotium amstelodami AY213699
Eurotium carnoyi U29558
Eurotium halophilicum U29565
Chaetosartorya chrysella U15507
Chaetosartorya cremea U15505
corraloid MCA 2206 Guyana
Penicilliopsis clavariiformis AB047223
coralloid MCA2201 Guyana
Hamigera avellanea var. alba AB105350
Warcupiella spinulosa AB003806
Hamigera striata AB047217
Chromocleista malachitea AB000621
Eupenicillium cinnamopurpureum AY213698
Eupenicillium crustaceum AB000486
Eupenicillium egyptiacum U15465
Petromyces albertensis U28910
Petromyces alliaceus AY176752
Fennellia nivea var. indica U28857
Neosartorya aurata U28473
Neosartorya aureola U28469
Hemicarpenteles acanthosporus AB003809
Monascus aurantiacus AY629439
Monascus barkeri AF364983
Xeromyces bisporus AF365022
Emericella acristata EAU29857
Emericella astellata U29866
Emericella bicolor U29837
Emericella aurantiobrunnea U29827
Chromocleista cinnabarina AB075359
Talaromyces helicus U15489
cleistothecial MCA2179 Guyana
Pseudotulostoma volvata MCA1562 Guyana
Pseudotulostoma japonica AB161193
Elaphomyces sp. MCA1923 Guyana
Elaphomyces sp. MCA1512 Guyana
Byssochlamys nivea AY176750
Trichocoma paradoxa AB047221
Talaromyces eburneus AB047218
Gymnascella aurantiaca AY176747 Onygenales Gymnoascaceae
Gymnoascoideus petalosporus AY176748 Onygenales Gymnoascaceae
Eremascus albus AY004345 Eurotiomycetes Onygenales Eremascaceae
5 changes

5. Diversity

Cordyceps & anamorphs: insect pathogens

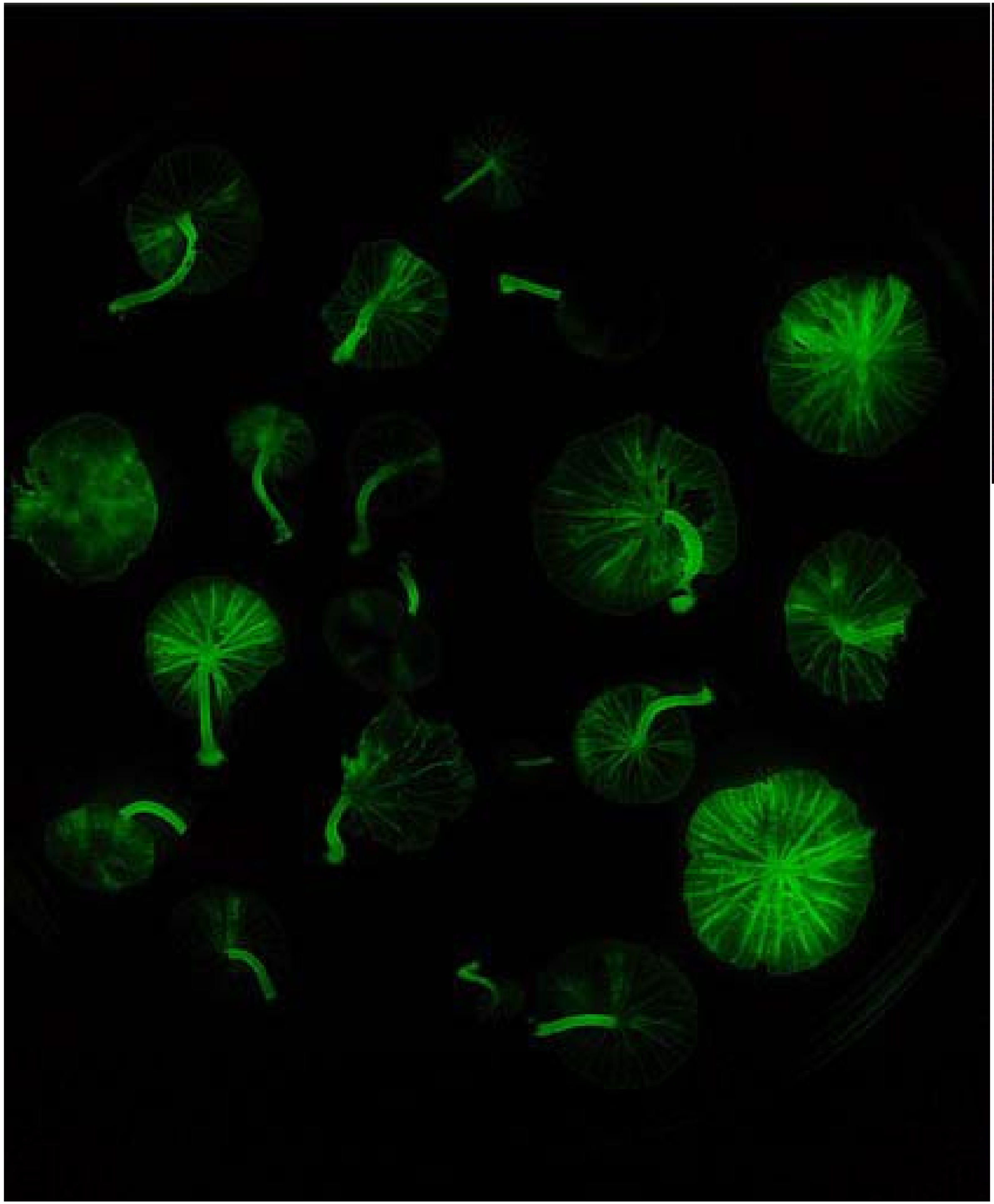
50 spp collected to date from Guyana

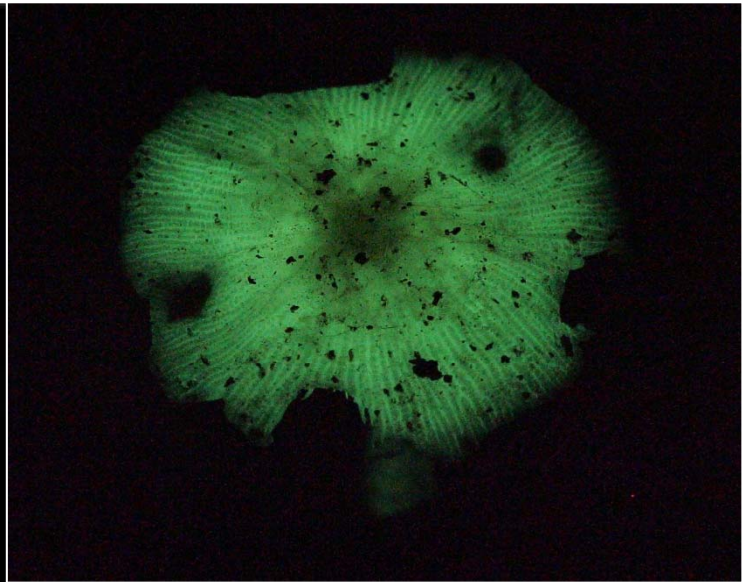


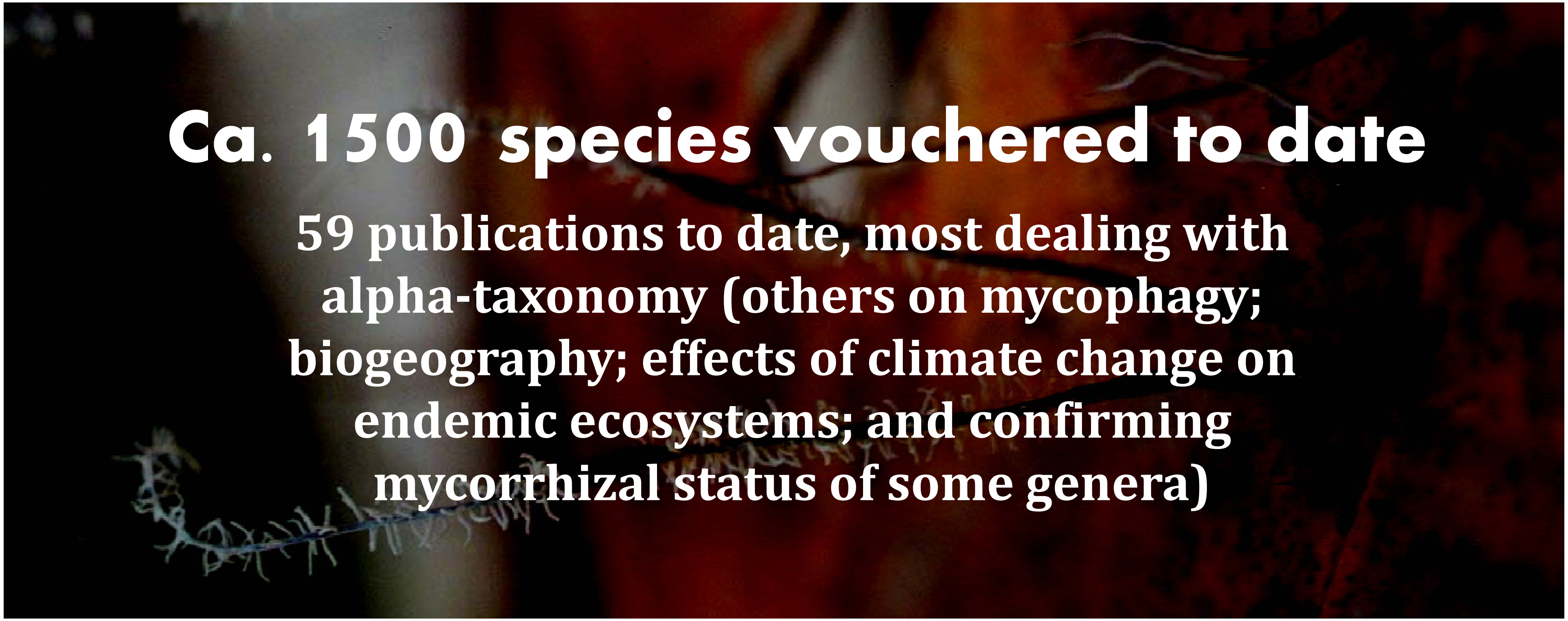

Marasmius


Mycena


Hemimycena



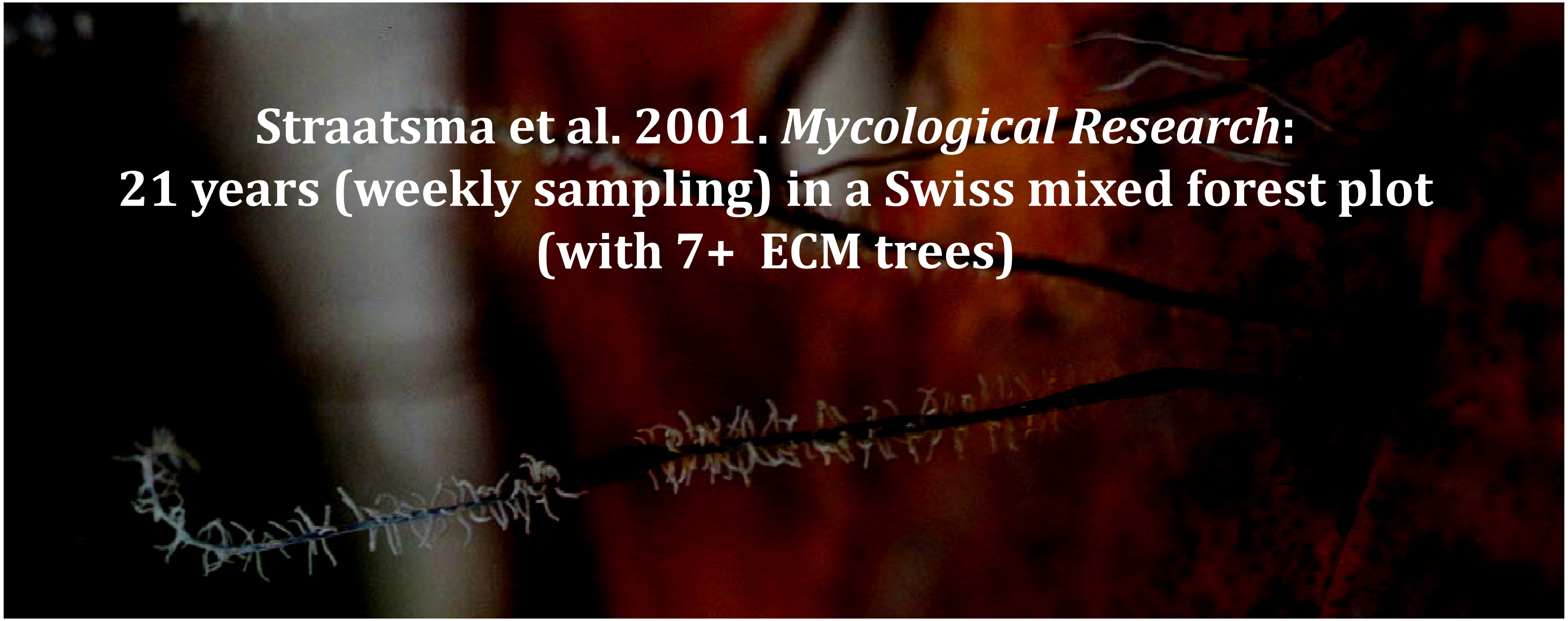




guild		total spp	spp nov	not examined	described	% spp nov	% spp nov
Mycorrizal	Russulaceae	31	29	0	9	93.5%	78.5%
	Boletaceae	23	11	9	11	64.3%	
	Amanita	22	5	15	5	71.4%	
	Cortinarius	[illegible]	n/d	n/d	n/d	n/d	
	Inocybe	11	[illegible]	0	9	77.8%	
	Oth. ECM	59	[illegible]	[illegible]	[illegible]	85.3%	
Decomposers	Polypores	91	9	0	9	9.9%	68.6%
	Thamnomyces	3	2	0	0	66.7%	
	[illegible]collybia	4	3	0	1	75.0%	
	Entolomataceae	46	42	0	12	91.3%	
	Oth. Sap.	748	3	745	3	100%	

73% spp. nov.

Ca. 1.5 sp. nov. ea. subplot



Straatsma et al. 2001. *Mycological Research*: 21 years (weekly sampling) in a Swiss mixed forest plot (with 7+ ECM trees)

	Total counts	# taxa	years	# new taxa	% new taxa
Straatsma et al	71, 222 FB	408 spp.	21 yrs.	82 only IDd to genus	(<20%)
Guyana	~38,318 FB	~1500 spp.	8 yrs	80 publ. to date	~73%

How many fungi?

Macrofungi associated with *Dicymbe corymbosa:*

~260 spp. only with *Dicymbe* (~90% of mycorrhizal and ~15% of saprobic)

~65,000,000 fungi ?!

- **Doesn’t take into account temperate zones**
- **Doesn’t take into account microfungi**

Some conclusions

•Fungal concepts (eg, taxonomic, evolutionary) based on temperate taxa are incomplete. The same is most likely true for diversity estimates.

•Perhaps less than 5% of fungal species have been discovered and described. Tropical regions are understudied in mycology and may still harbor tremendous undocumented diversity.


Acknowledgements:
National Geographic Society
National Science Foundation
Explorer's Club, Washington Group
Linnaean Society of London
University of Guyana

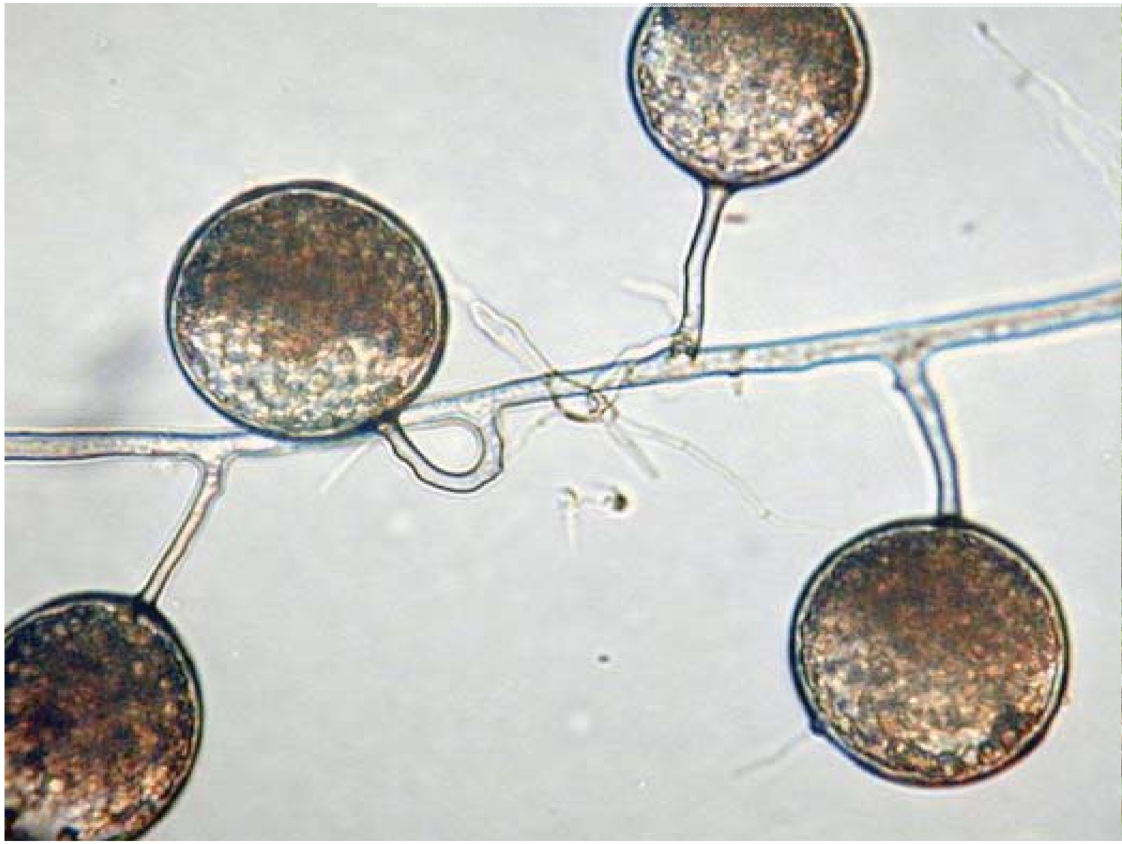
1. Saprobes: Essential decomposers

- Fungi are extremely important primary and secondary decomposers of organic materials.
- A handful of Fungi are the only organisms that can effectively and completely degrade lignin. Lignin is a complex, three-dimensional non-stereopolymer that protects plant cellulose from attack. Probably the most recalcitrant of all natural products.

2. Symbionts: Essential partners for plants and animals

•**Mycorrhizae**: 90% of the world's plants have a beneficial fungal mycorrhizal partner colonizing the roots. The fungus helps the plant absorb water, nutrients and minerals, especially phosphorus.

•**Lichens**: Mutualism between a fungus and an alga; allows colonization of harsh environments. Also animal gut mutualists.



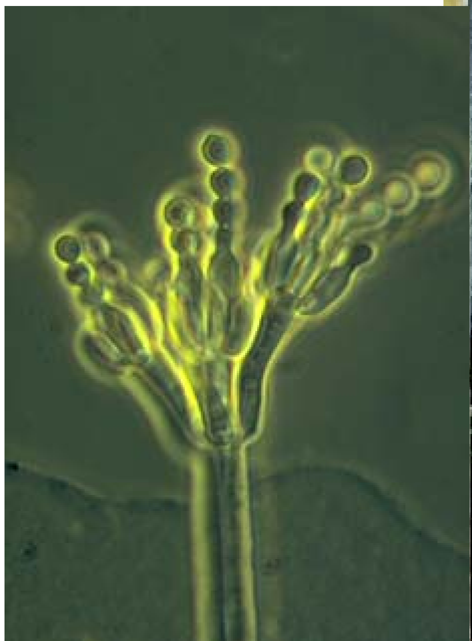
3.

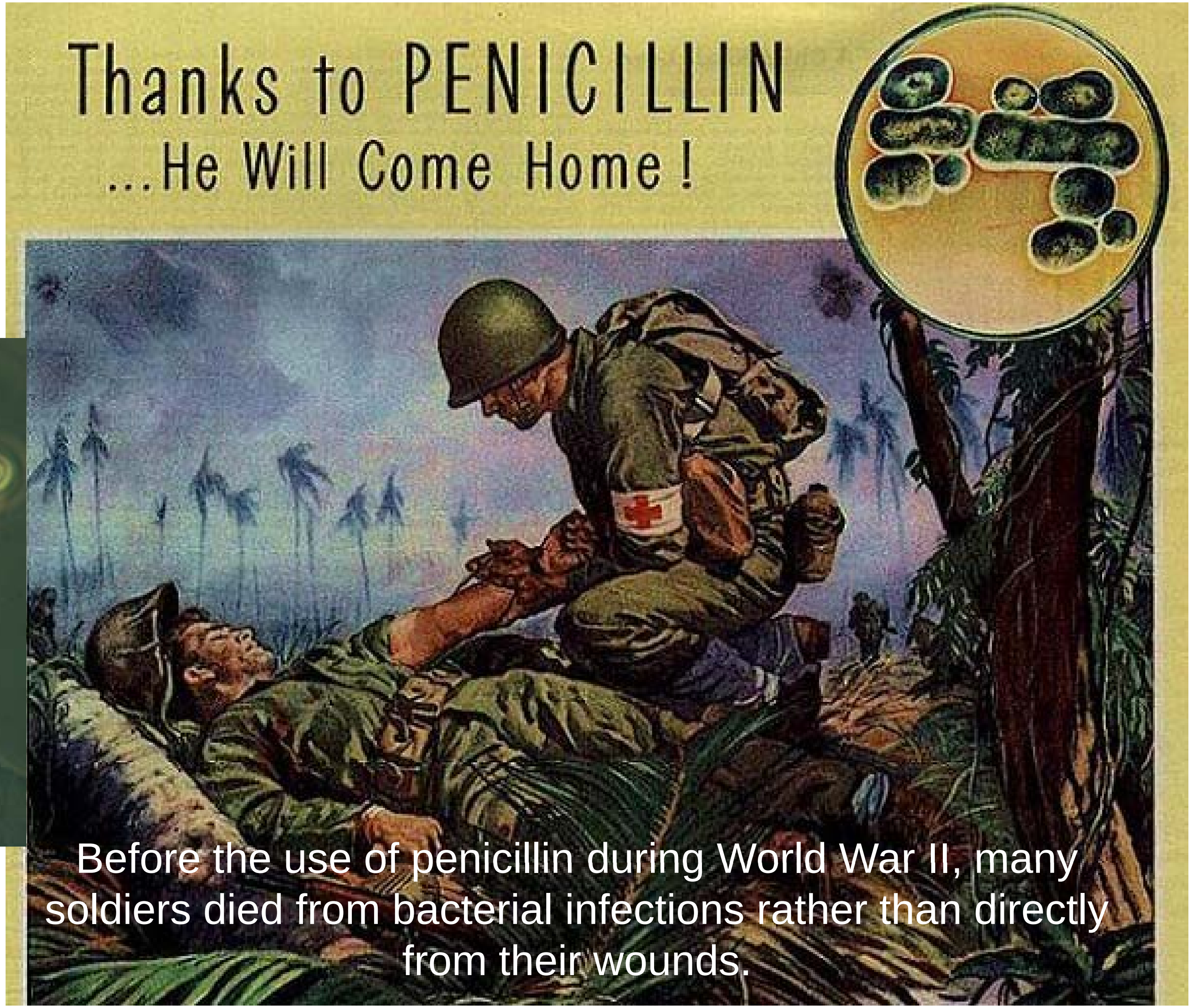
Pathogens: Causal agents of emerging global epidemics

e.g., chytridiomycosis, “the worst infectious disease ever recorded among vertebrates” in terms of the number of species impacted, and it’s propensity to drive them to extinction (Gascon et al, 2007).

4.

Food, Medicines, Bioremediation…





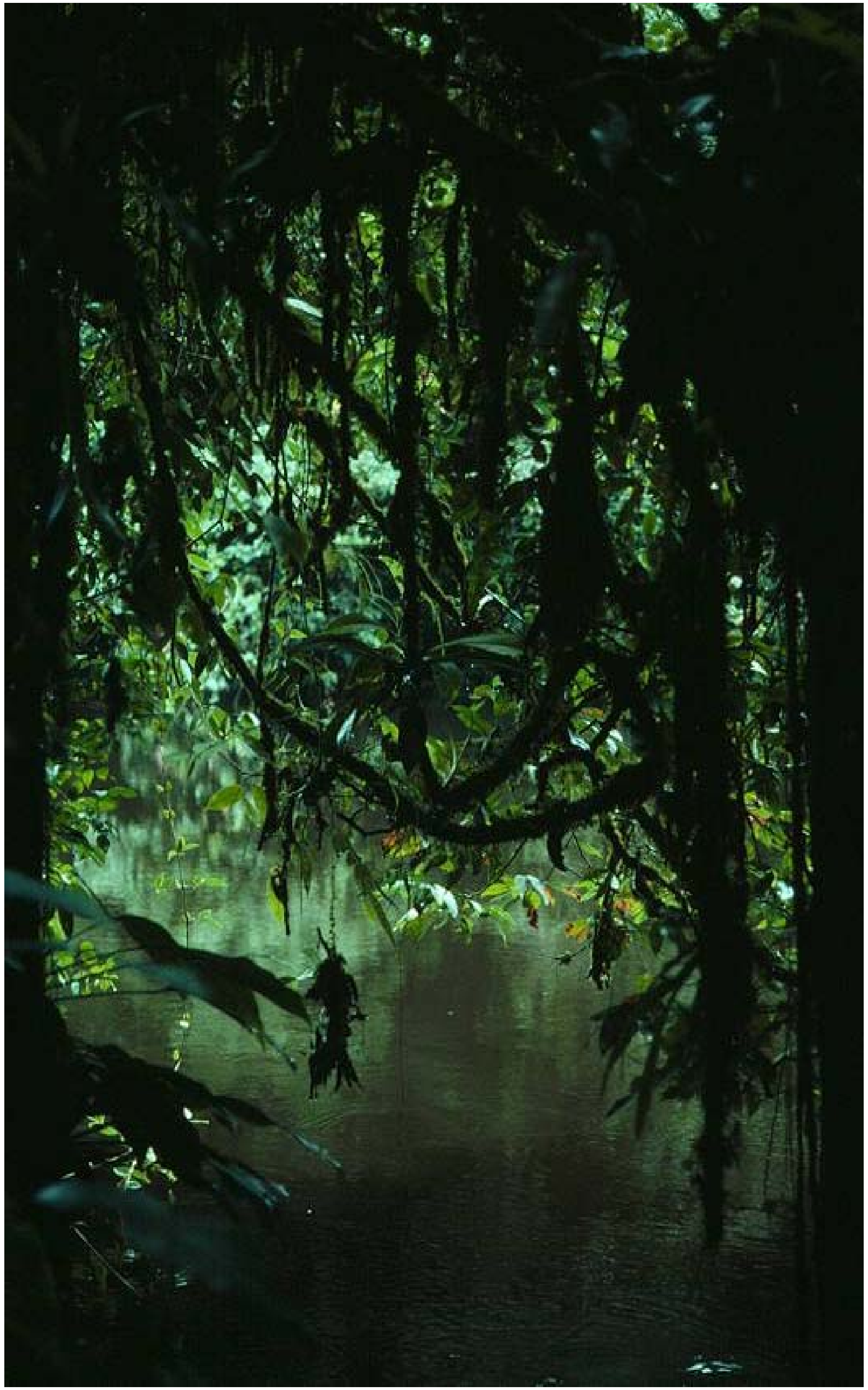
Before the use of penicillin during World War II, many soldiers died from bacterial infections rather than directly from their wounds.

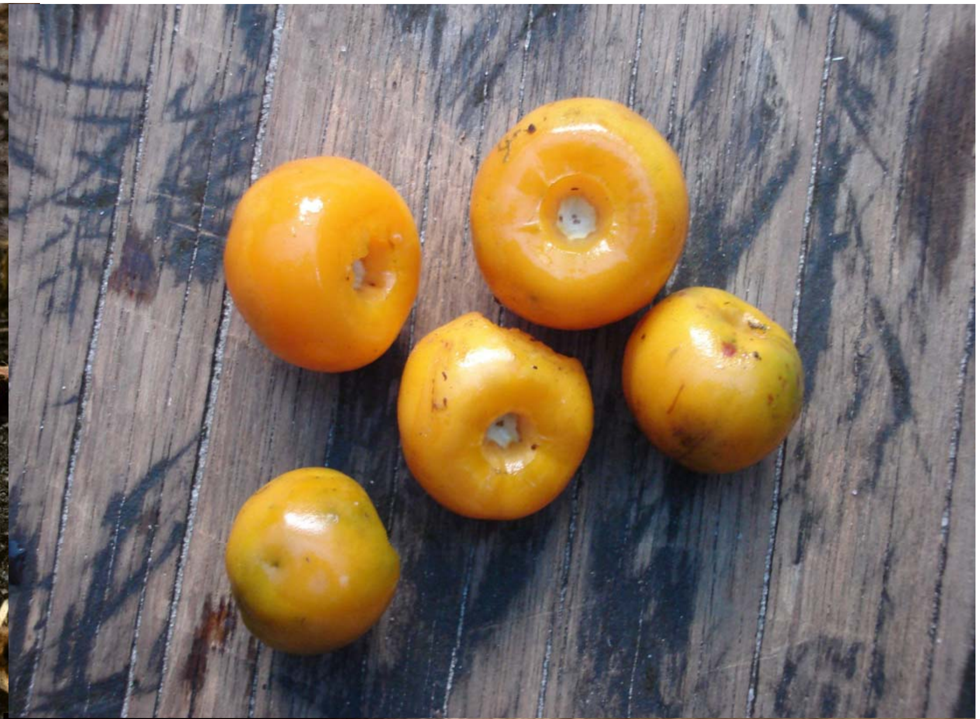
BIODIVERSITY

Part of the science of **systematics**, which:

(a) discovers, describes and provides names for all organisms
(b) preserves collections of them
(c) provides classifications for the organisms, keys for their identification, and data on their distributions
(d) investigates how species are related to each other, their evolution and adaptation

DISCOVERY, DESCRIPTION, DISTRIBUTION



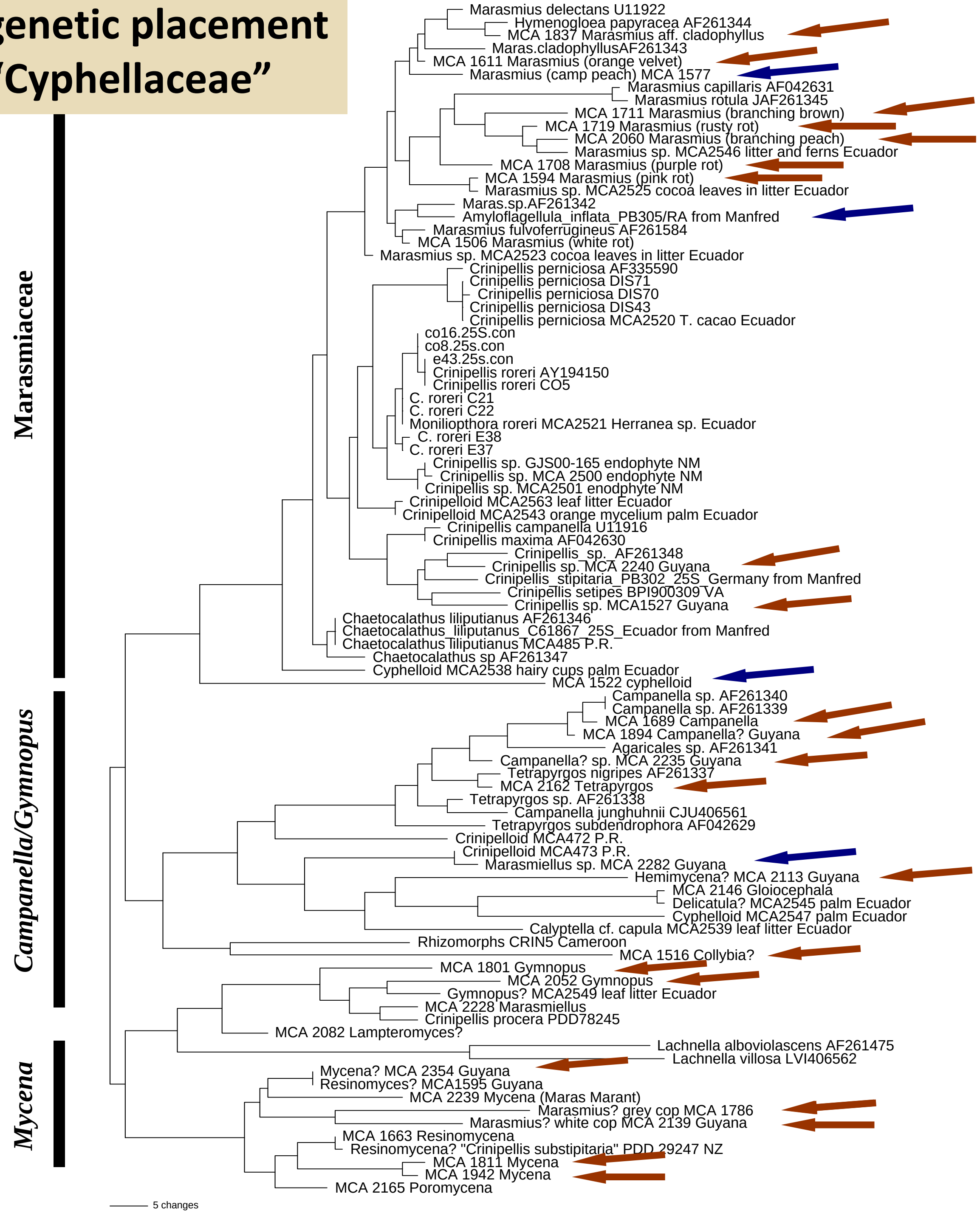



Cookeina sp. nov.

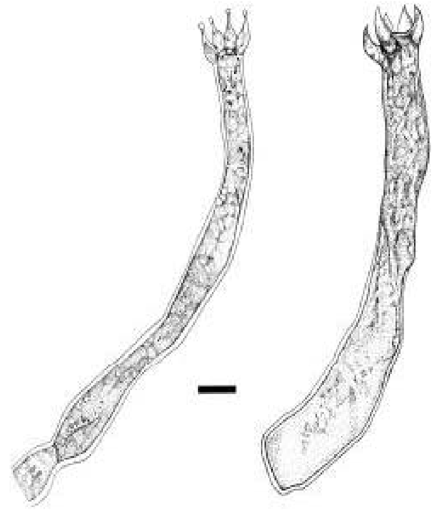
Saprotrophic/lignicolous


Amanita

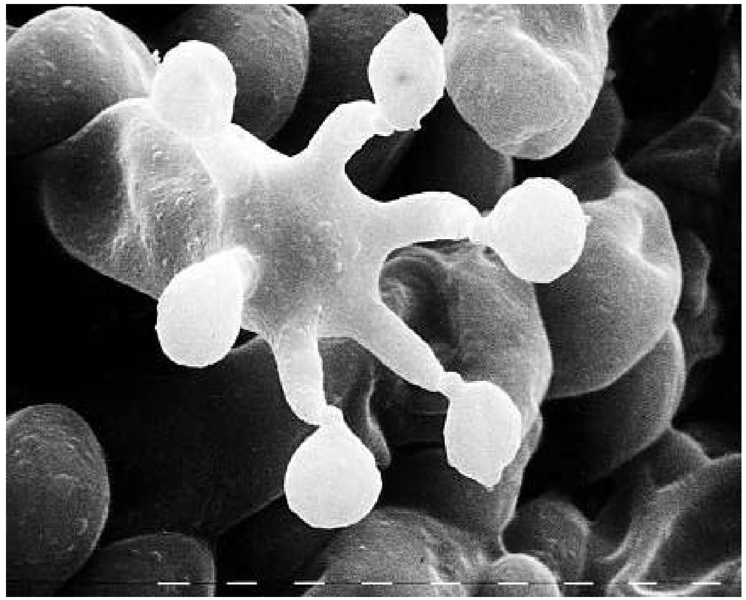
Phylogenetic placement of “Cyphellaceae”



Clavulina nigricans sp. nov.



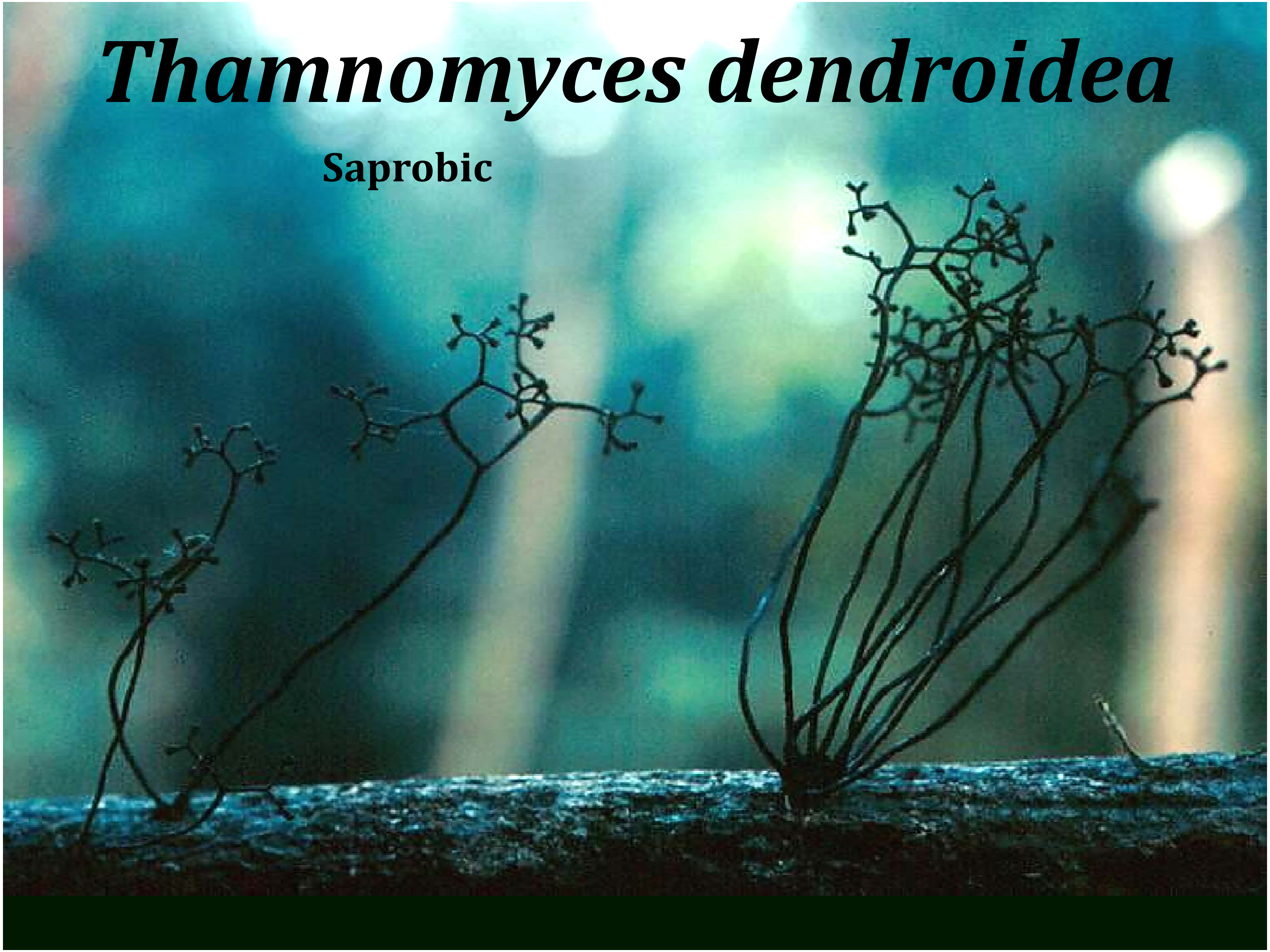
Drawing: Sharon Sinckiewicz



SEM: Jason Thacker

Thamnomyces dendroidea

Saprobic




Saprobic

2. Expanding taxonomic concepts


4 species of pleurotoid Russulaceae