



Black yeasts in the Culture Collection of Fungi from Extreme Environments (CCFEE), phylogeny and ecology

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XXXVI Annual Meeting of the European Culture Collections' Organisation (ECCO 2017)

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- 1981 Italy subscribed the Antarctic treaty. In 1985 started the activities of the Italian National Program for Antarctic researches (PNRA).
- 1991 Italian Antarctic National Museum has born.
- 1996 started activities.
- 3 Main sections: Genova, Siena e Trieste,
- 6 thematic sections



- Active participation of our group since 1986, first nucleus of the fungal collection
- In 2000 the CCFFEE has born: Friedmann donated his own collection,

McMurdo Dry Valleys (about 4800 km²)

Terrestrial analogue for Mars

- Aridity less than 50 mm WE precipitation per year
- UV irradiation
- Annual mean T always below 0 °C; min T below – 50°C
- Oligotrophy
- Winds up to 250 km/h

Too harsh for life



- Active participation of our group since 1986, first nucleus of the fungal collection
- In 2000 the CCFFEE has born: Friedmann donated his own collection,
- The collection has constantly improved (Antarctic expeditions, and worldwide sampling in extreme environments)
- In 2006 has officially born the thematic section of Mycology and the CCFFEE collection as part of the Italian National Antarctic Museum (MNA)



Museo Nazionale dell'Antartide

Felice Ippolito

MUSEO

SCOPRI L'ANTARTIDE

SCUOLE

DIDATTICA E DIVULGAZIONE

COLLEZIONI

BIBLIOTECA

CO



Sedi

Il Museo Nazionale dell'Antartide è articolato su tre sedi:

- La sede di **Genova** ha il compito di curare la conservazione del materiale biologico (e d'acqua).
- La sede di **Siena** ha il compito di curare la conservazione del materiale mineralogico (e extraterrestre) e glaciologico.
- La sede di **Trieste** ha il compito di curare la conservazione della documentazione dell'esplorazione in Antartide e del materiale sedimentologico marino.

Per la cura di reperti che necessitano di particolari condizioni per la loro conservazione associate presso le Università di Messina, Trieste, Genova, **Tuscia**, Milano Bicocca, CNR

Active since
1996



Permanent exhibition in the University Museum System (SMA), University of Tuscia, Viterbo (I)



Glossopteris sp.





2006 - University of Tuscia – Mycological

Section

Antarctic National Museum

Culture
Collection of
Fungi from
Extreme
Environments



CCFEE (Culture Collection of Fungi from Extreme Environments)

1350 fungal strains from different extreme environments

851 black yeasts

606 rock inhabiting (RIF)

245 contaminated sites, saltpans, acidic

Locations for Black Fungi

Salt pans

Atacama desert, Chile

Human opportunists

Himalaya, K2

McMurdo Dry
Valleys Antarctica

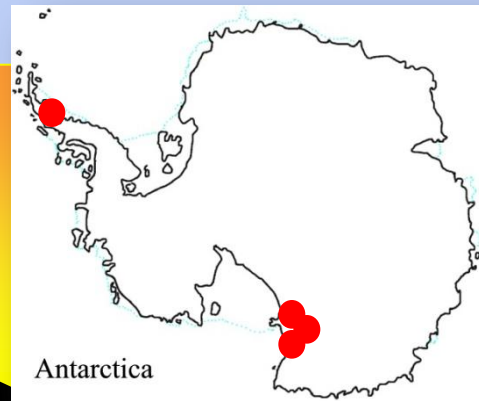
Polluted

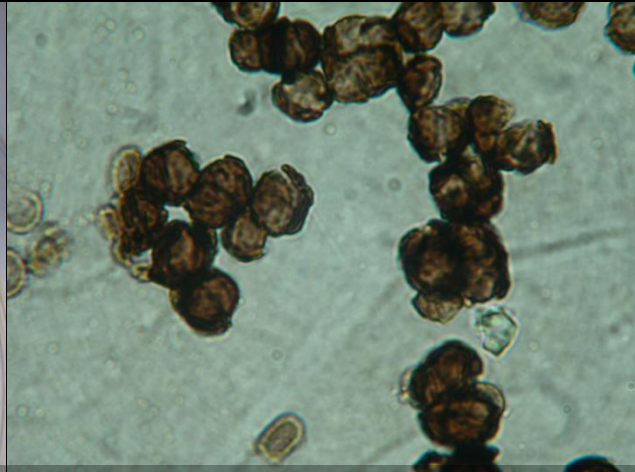
Acidic sites

Monuments



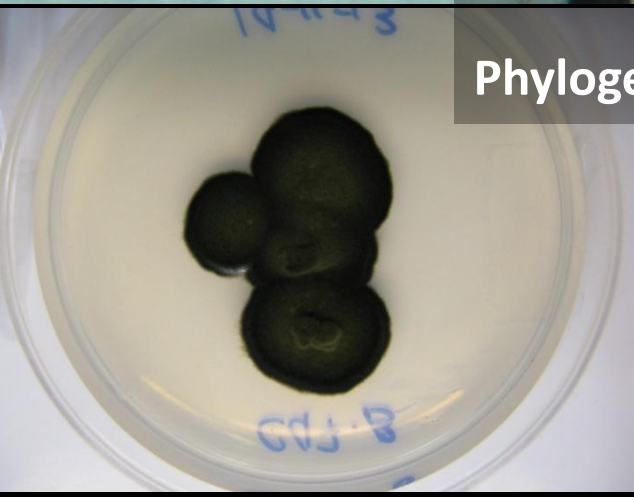
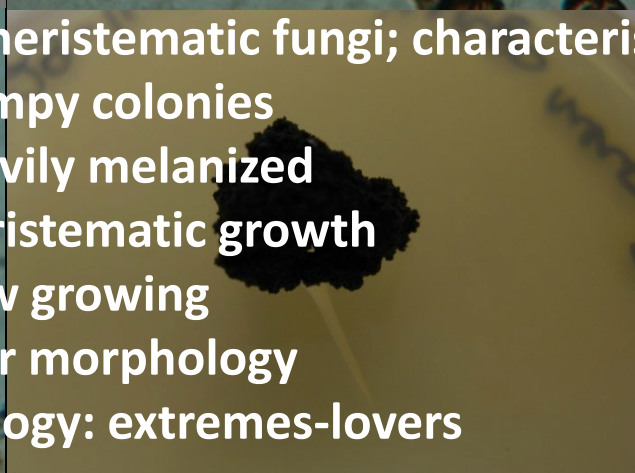
Black fungi: sampling amplitude





Black meristematic fungi; characteristics:

- Clumpy colonies
- Heavily melanized
- Meristematic growth
- Slow growing
- Poor morphology
- Ecology: extremes-lovers



Phylogenetically very diversified



Why Black fungi?





Curr Genet
DOI 10.1007/s00294-014-0457-7

RESEARCH ARTICLE

Rock black fungi: excellence in the extremes, from the Antarctic to space

Laura Selbmann · Laura Zucconi · Daniela Isola ·
Silvano Onofri

Received: 28 August 2014 / Revised: 15 October 2014 / Accepted: 17 October 2014
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EXCELLENCE IN THE
EXTREMES



Cryomyces antarcticus lives in the closest Mars ambient on Earth

Selected as best model for astrobiological studies and Space experiments

ESA Space Experiments

LIFE

Lichens and Fungi Experiment
(Lithopanspermia)

BIOMEX

Biology and Mars Experimentsù
(Biosignatures)

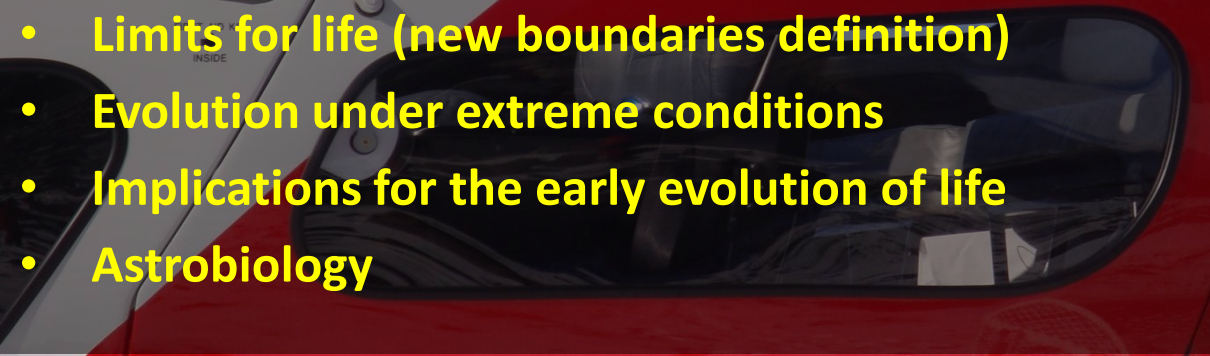
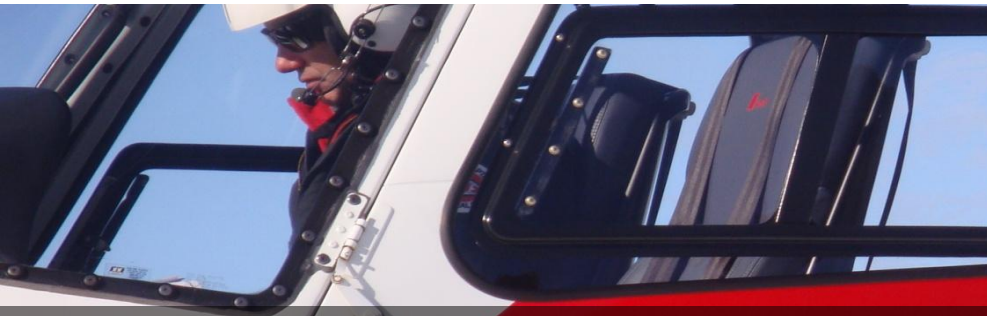
Tests for stress resistance

- Desiccation
- Extreme of T
- Vacuum
- ...
- **UV-R and Ionizing-R**

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EXCELLENCE IN THE
EXTREMES

- Limits for life (new boundaries definition)
- Evolution under extreme conditions
- Implications for the early evolution of life
- Astrobiology

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Black fungi

EXCELLENCE IN THE
EXTREMES

- Limits for life (new boundaries definition)
- Evolution under extreme conditions
- Implications for the early evolution of life
- Astrobiology
- **Description of new taxa**



Environmental Pressure, Isolation

Adaptive radiation

Friedmanniomyces endolithicus

Friedmanniomyces simplex

Cryomyces minteri

Cryomyces antarcticus

Cryomyces funiculosus

Meristemomyces frigidum

Recurvomyces mirabilis

Oleoguttula mirabilis

Saxomyces alpinus

Elasticomyces elasticus



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Silvano Onofri

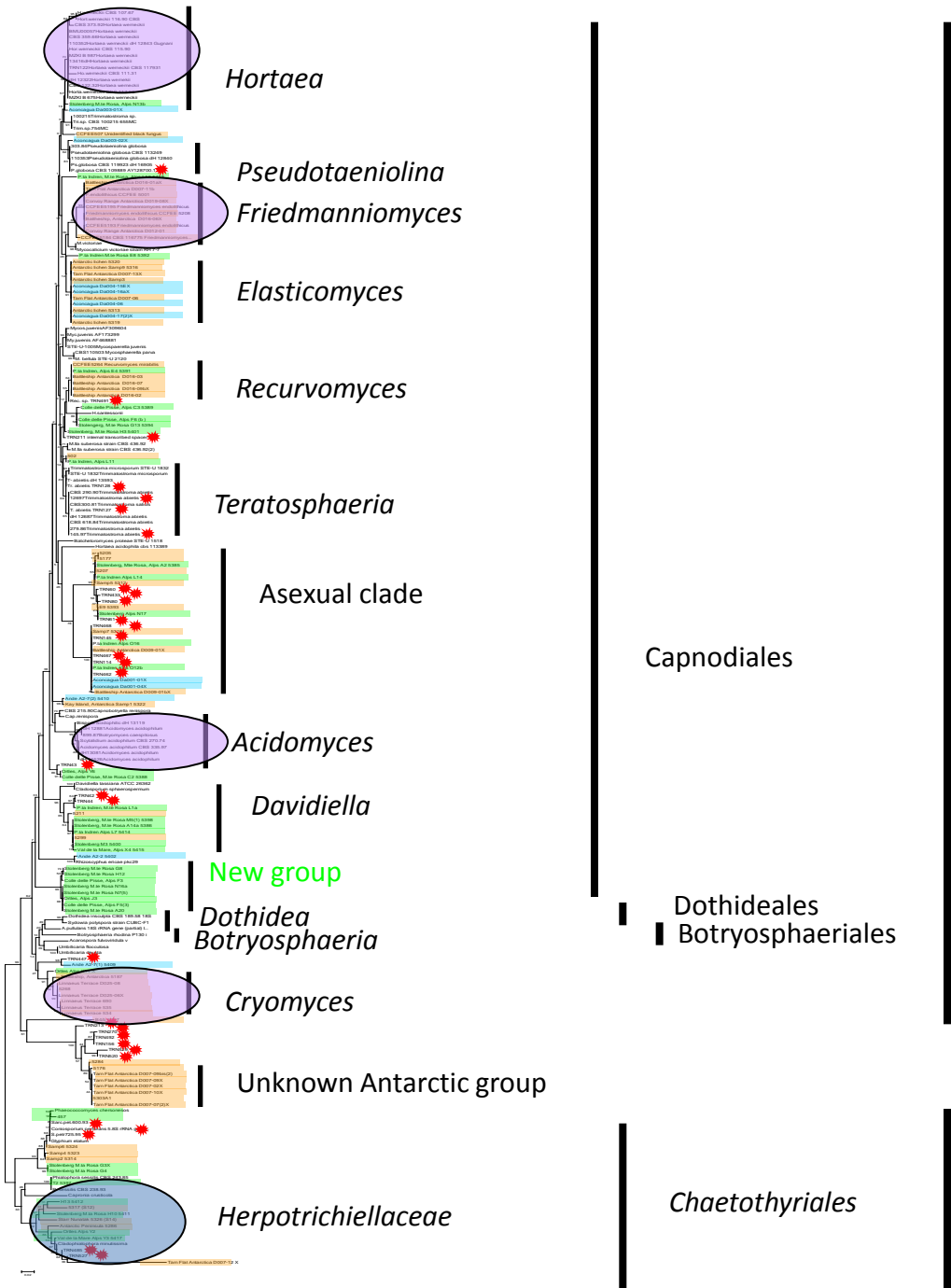
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Black fungi



- Limits for life (new boundaries definition)
- Evolution under extreme conditions
- Implications for the early evolution of life
- Astrobiology
- Description of new taxa
- Evolution of pathogenicity
- Extremophiles and possible applications (extremozymes, biodeterioration, bioremediation...)

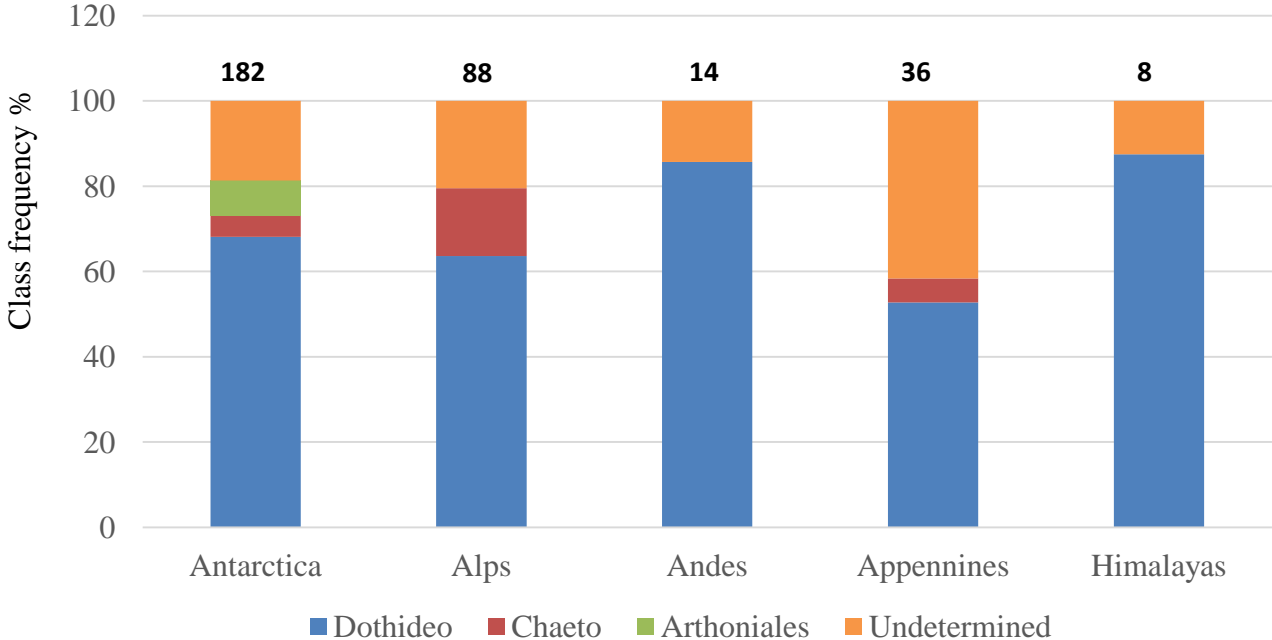


Dothideomycetes

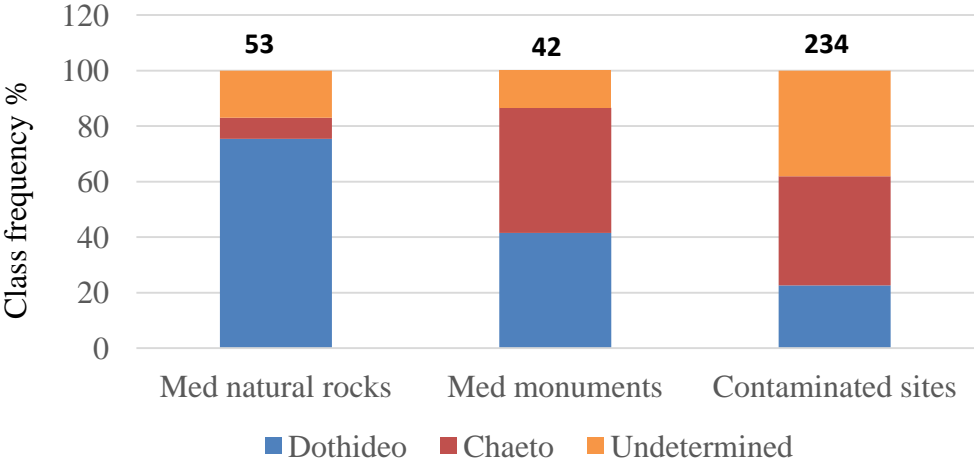
Eurotiomycetes

Occurrence of RIF in the CCFEE

Cold environments



Warm/hot environments



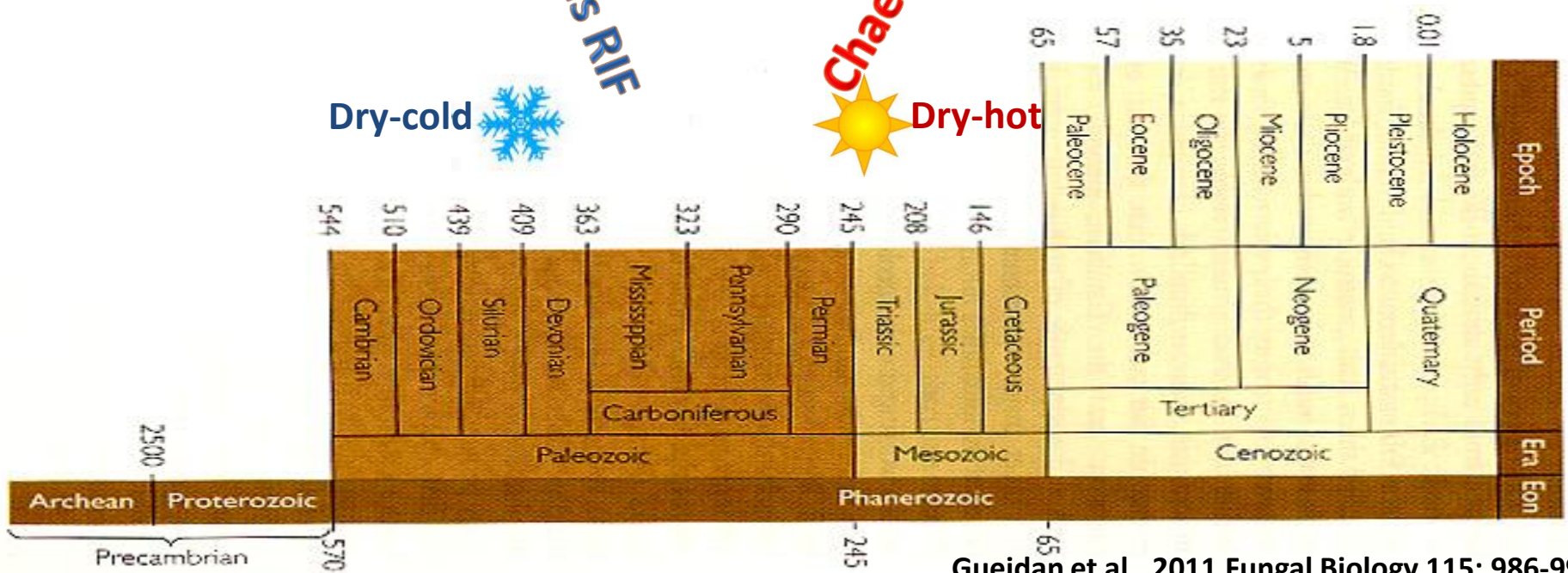


Dothideomycetous RIF

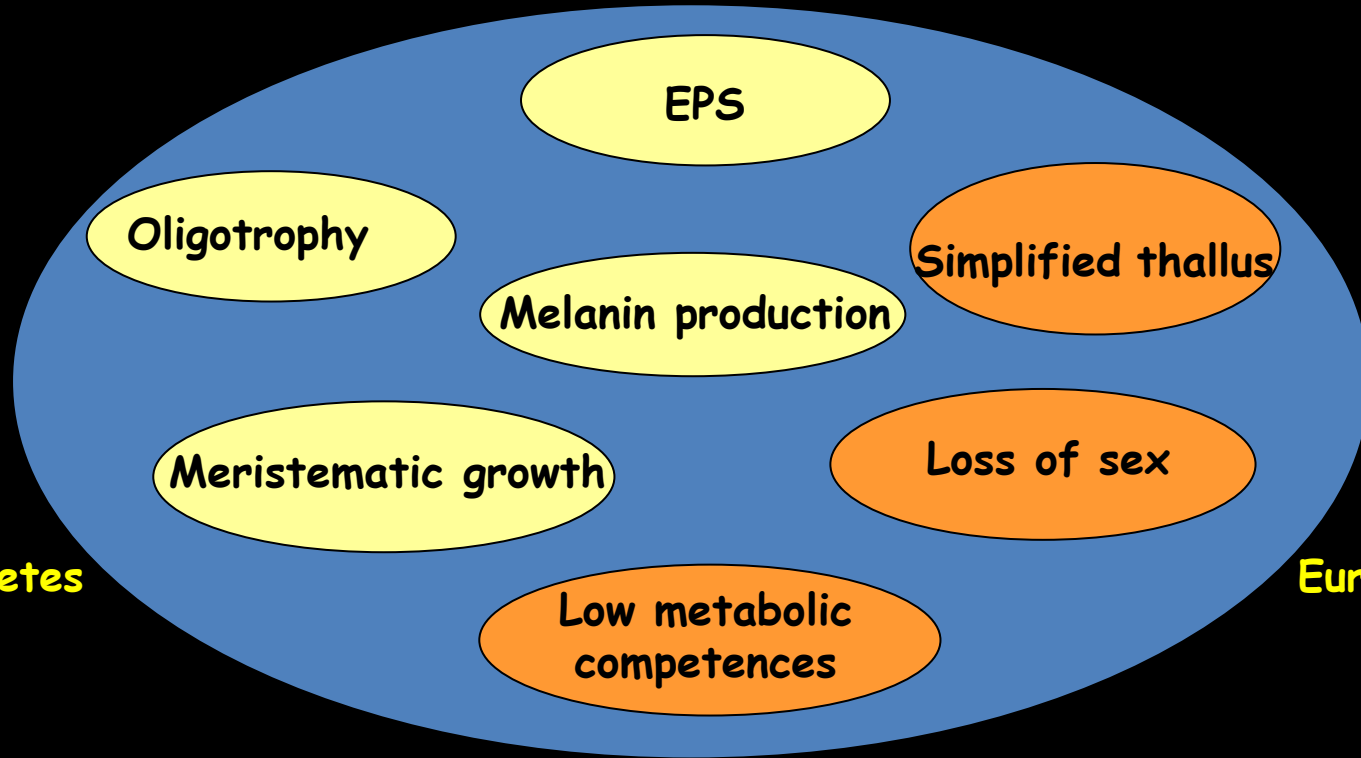
Chaetothyrialean RIF

Dry-cold ❄️

☀️ **Dry-hot**



Morpho-physiological characters



Dothideomycetes

Eurotiomycetes

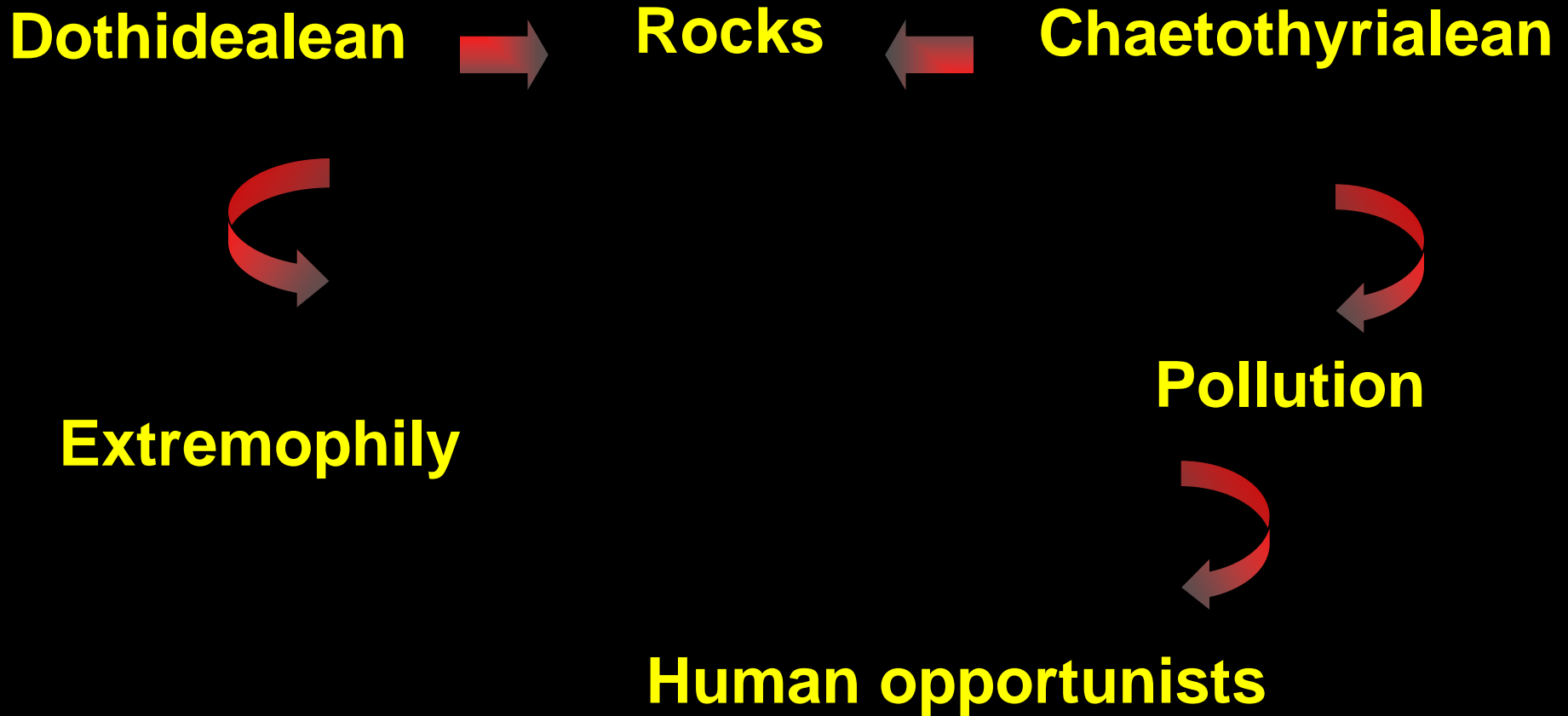
High tolerance low competition

High tolerance, competition

Edge of life

**Degradative
Pathogenicity**

OUTCOMES



Pollution

Natural conditions



Driving force for spreading

OUTPUTS

- T is not apparently *per se* discriminant at Class level
- By chance very cold sites for RIF are clean (Antarctic, Mountain tops...)
- Hot sites for RIF may be polluted (monuments in urban environments)

Cold sites for Rock-inhabiting black fungi

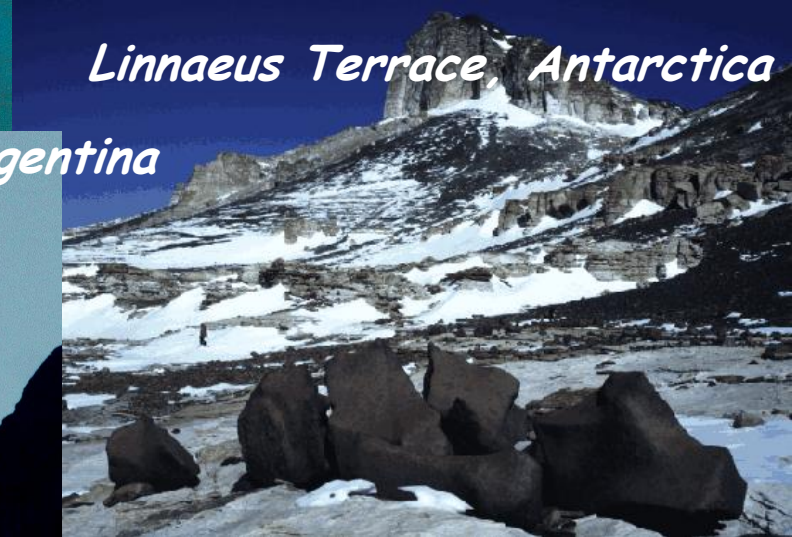
K2



Greenland



Battleship Promontory, Antarctica



Linnaeus Terrace, Antarctica



Monte Rosa, Italy



Mount Aconcagua, Argentina

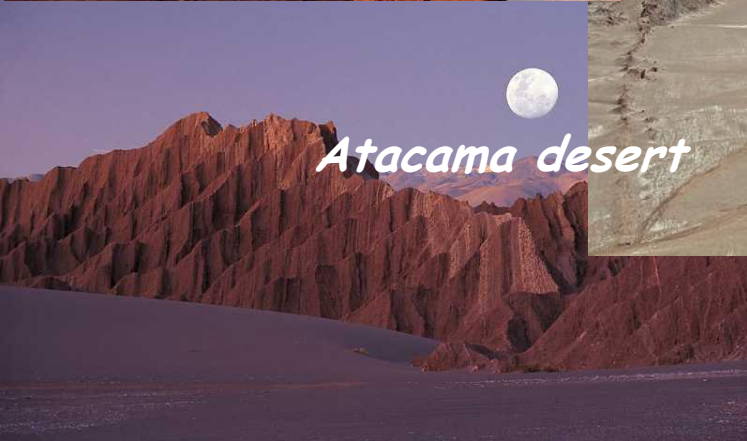
Hot sites for Rock-inhabiting black fungi



Utah Parks



Atacama desert



Cliff, Sardinia, Italy



La Cabrera



Monuments



Algerian desert

OUTPUTS

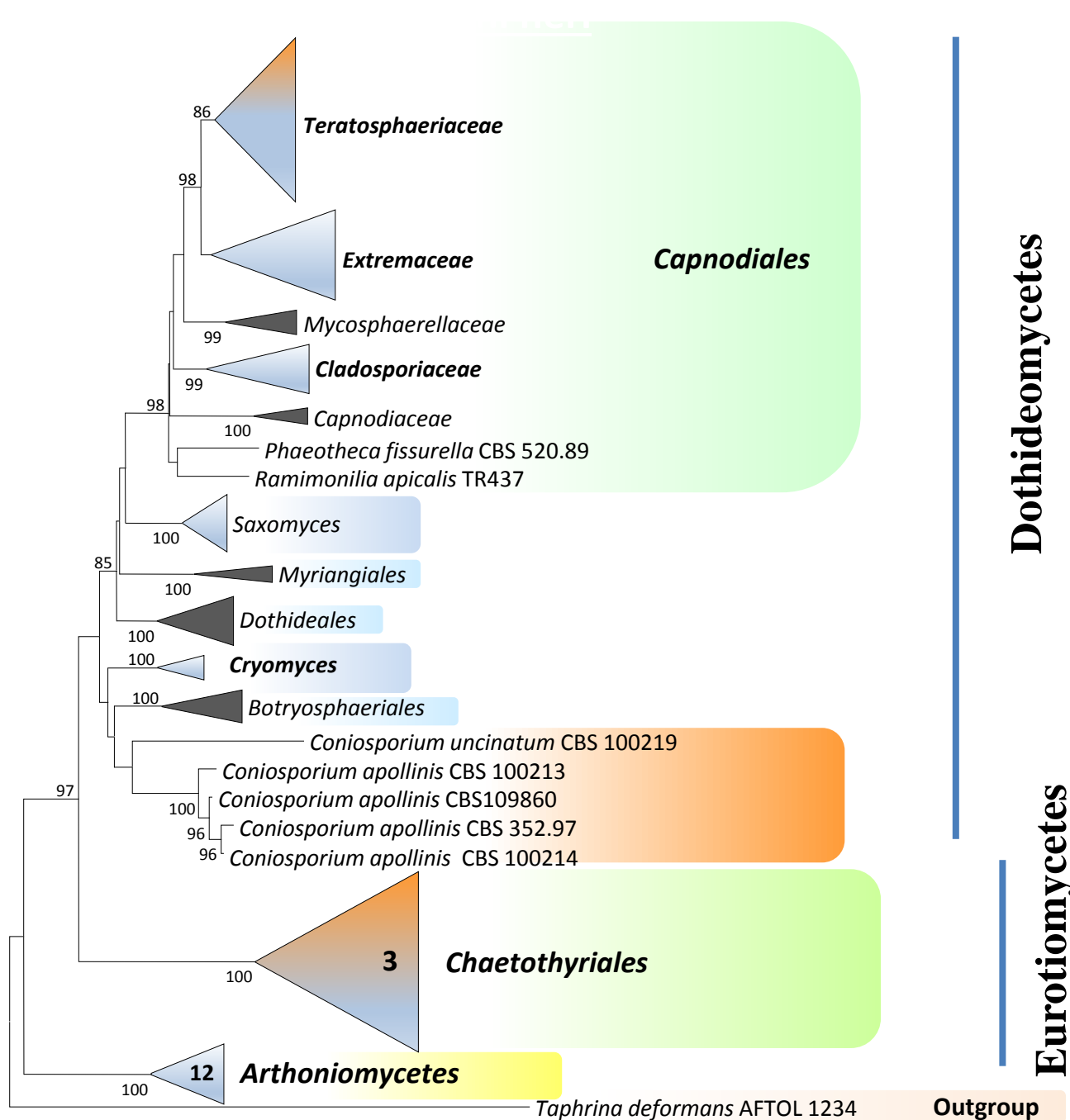
- T is not apparently *per se* discriminant at Class level
- By chance very cold sites for RIF are clean (Antarctic, Mountain tops...)
- Hot sites for RIF may be polluted (monuments in urban environments)
- RIF are normally extremely simplified: no spores, no sexuality

OUTPUTS

- T is apparently *per se* discriminant at Class level
- By chance very cold sites are clean (Antarctic, Mountain tops...)
- Hot sites may be polluted (monuments in urban environments)
- RIF are extremely simplified: no spores, no sexuality

QUESTIONS

- **Is there a T-relation at lower taxonomic rank?**
- **What is the amplitude of the spreading for RIF?**
- **Have they sufficient genetic variability?**

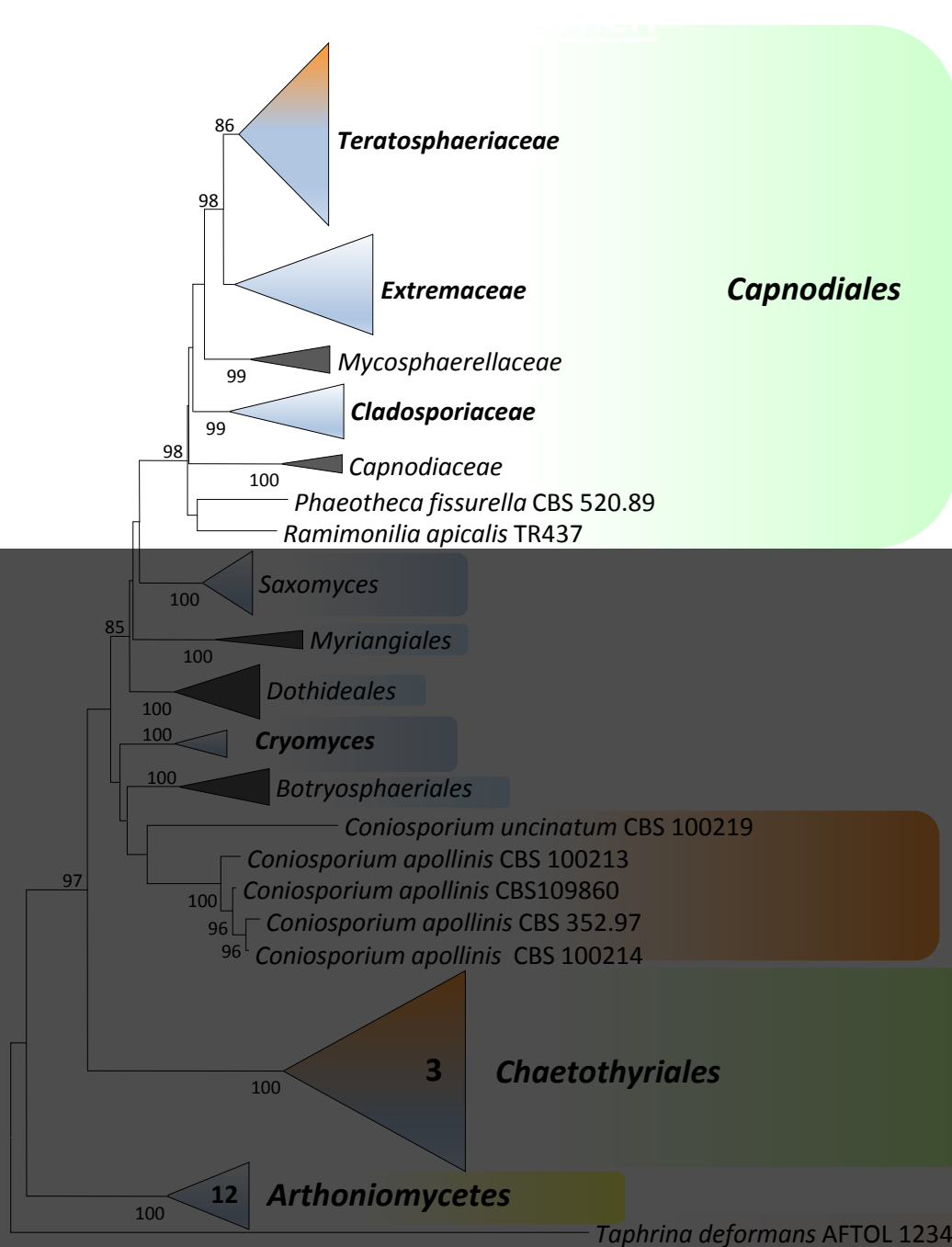


Occurrence of
 cold/
 hot-loving RIF

Dothideomycetes

Eurotiomycetes

Outgroup



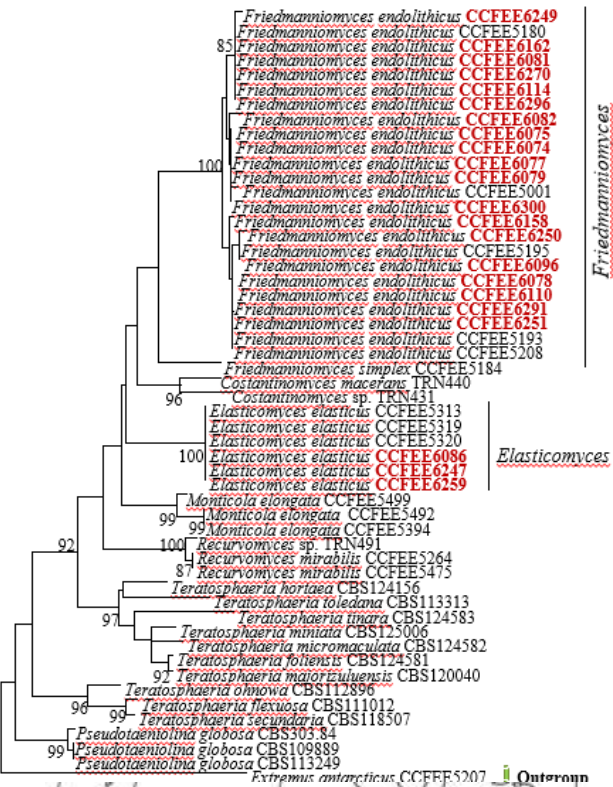
Occurrence of
 cold/
 hot-loving RIF

Dothideomycetes

Eurotiomycetes

Outgroup

NJ Multilocus SSU-LSU tree



Genus *Friedmanniomyces*

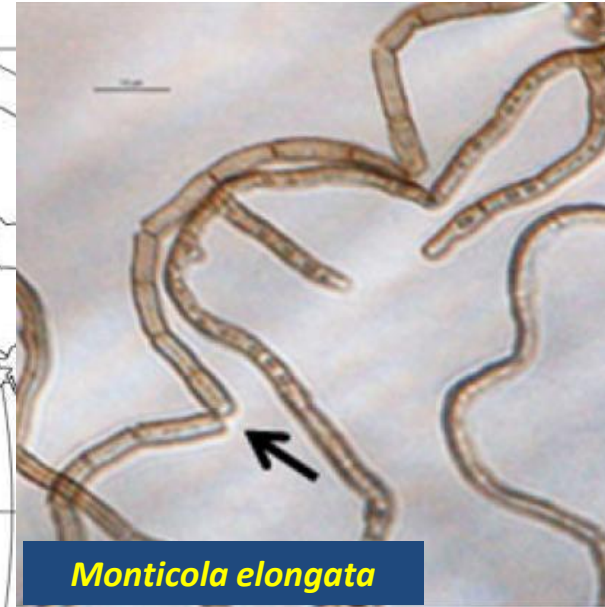
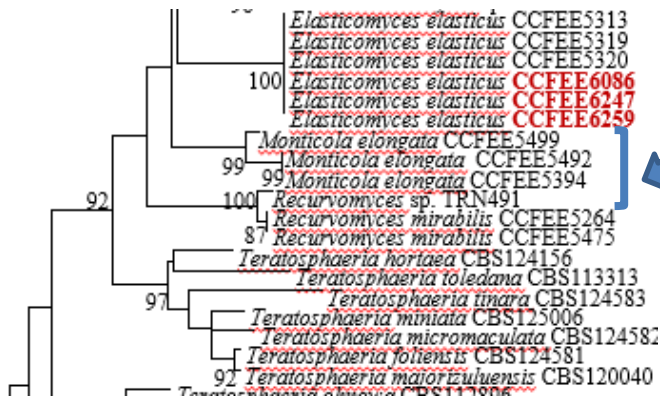
- 2 species (over 50 isolates). Very restricted distribution; Antarctic only (Victoria Land)
- Genetic variability (4.5%)

Friedmanniomyces endolithicus

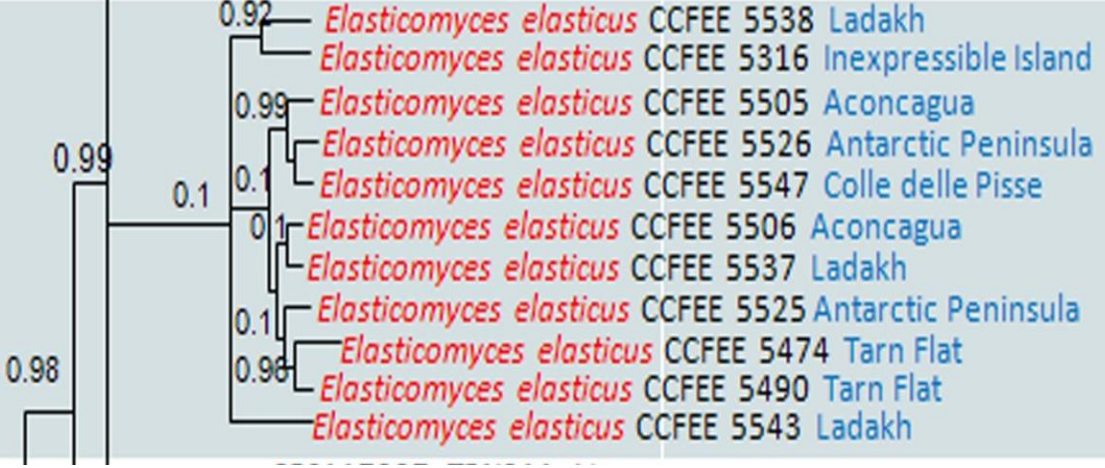


● Genus *Monticola* (1 species)

- 5 isolates. Very restricted distribution; Alps

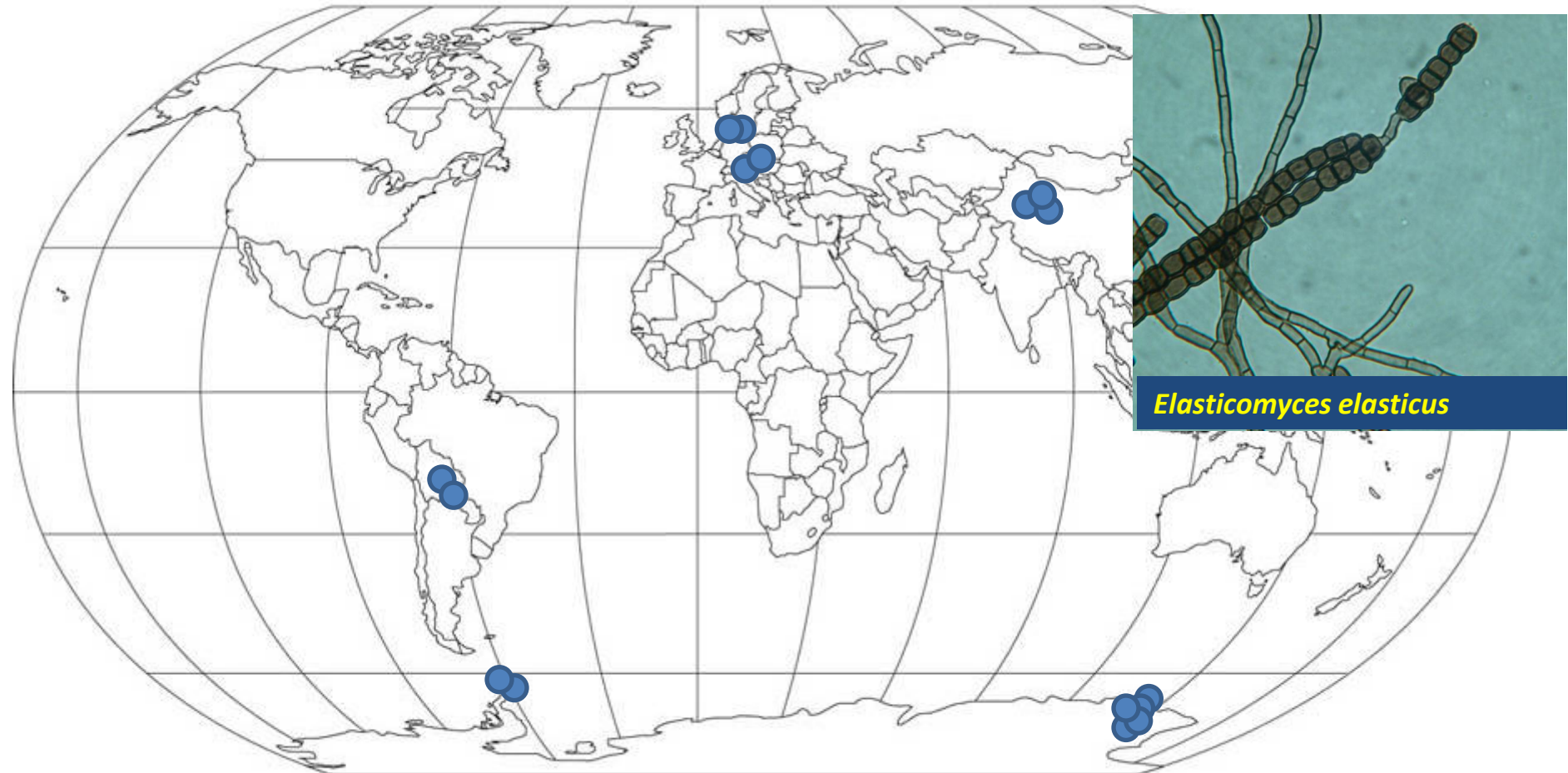


Monticola elongata



Genus *Elasticomyces* (1 species)

- 24 isolates in CCFEE
- disperse distribution
- cold locations
- high intraspecific variability (4% ITS)



Elasticomyces elasticus

100

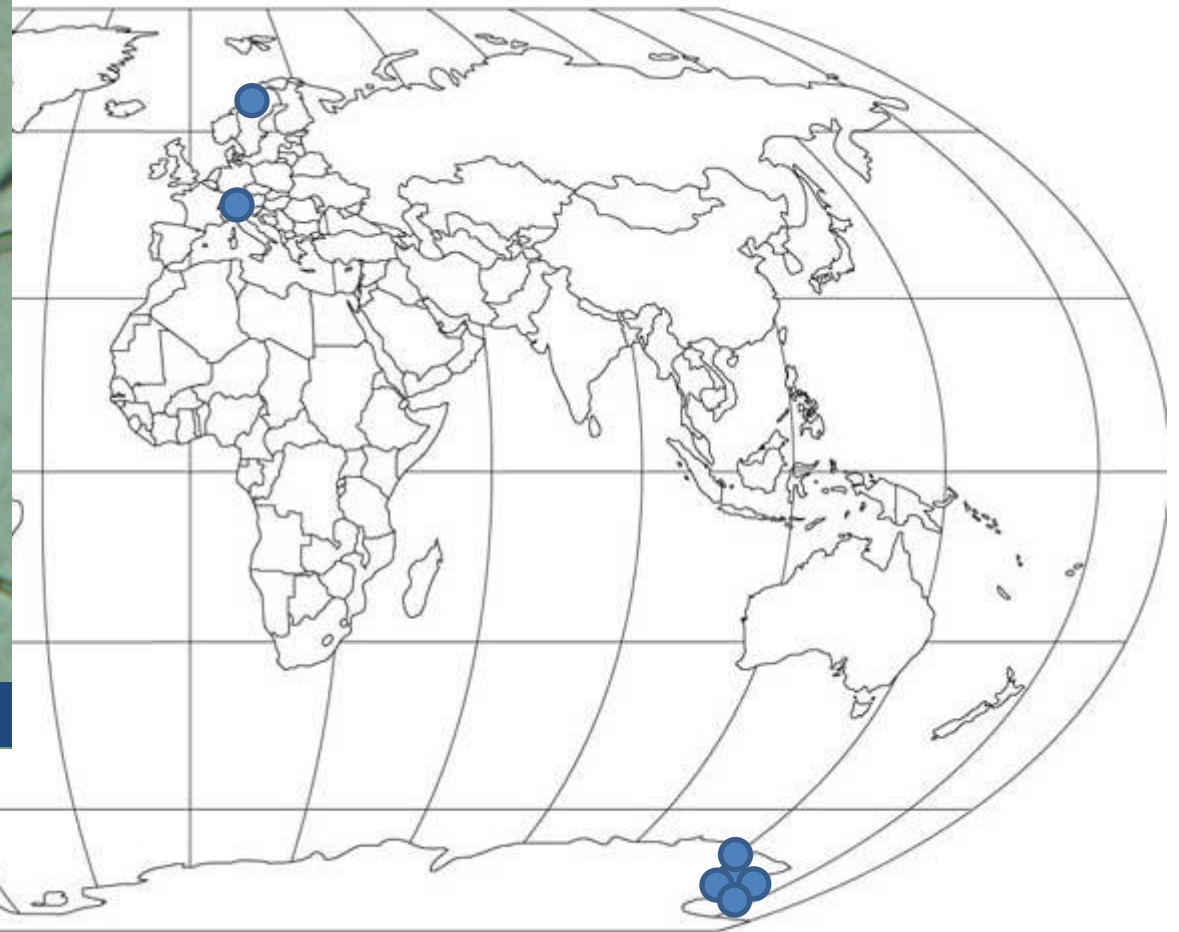
Recurvomyces mirabilis CCFEE 5480
Recurvomyces mirabilis CBS 119434
Recurvomyces mirabilis CCFEE 5391
Recurvomyces sp. CBS 117957

● Genus *Recurvomyces*
(1 species)

- 7 isolates in CCFEE
- Disperse distribution
- Cold locations

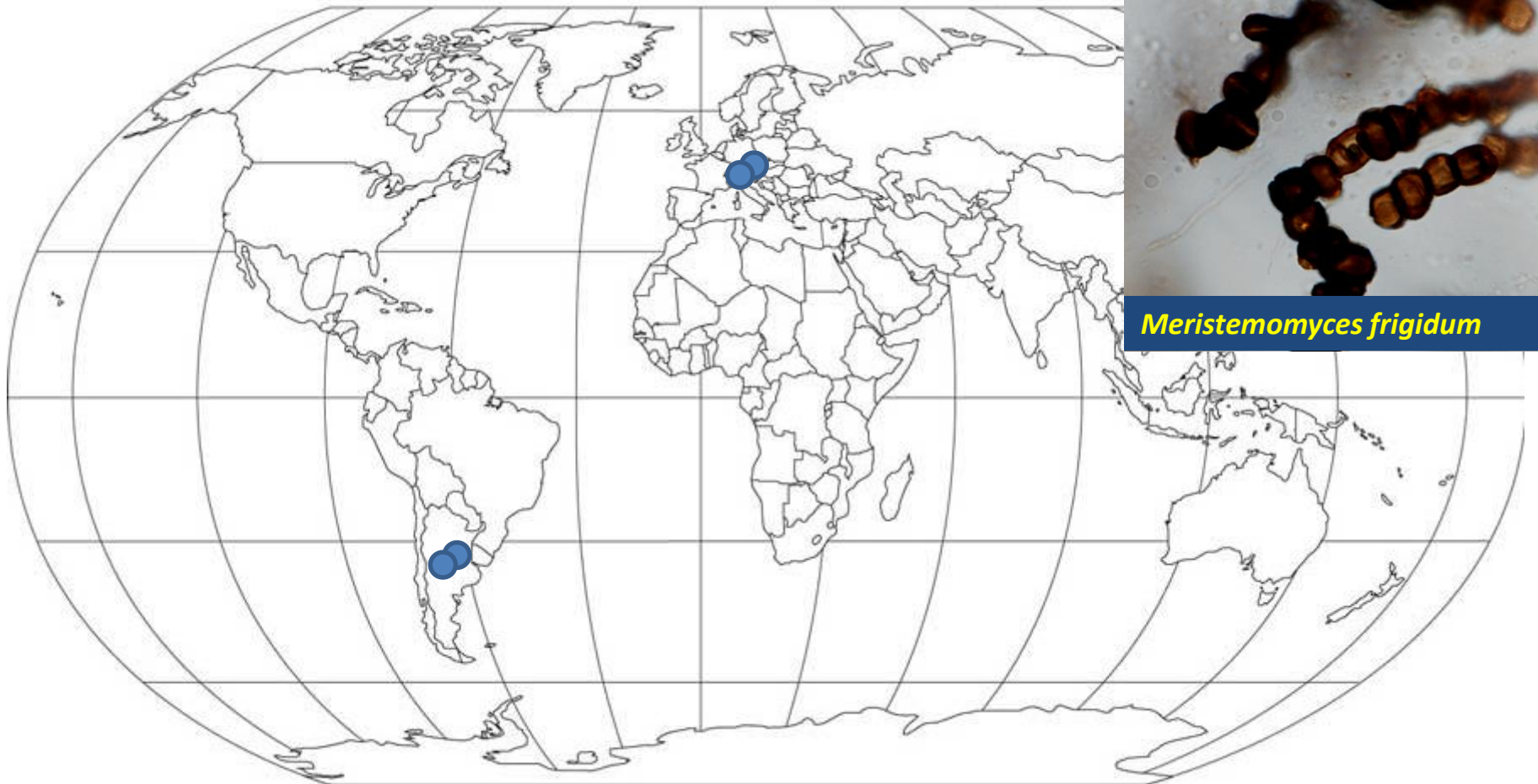


Recurvomyces mirabilis



Genus *Meristemomyces* (1 species)

- 5 isolates in CCFEE Aconcagua, Mt. Rosa

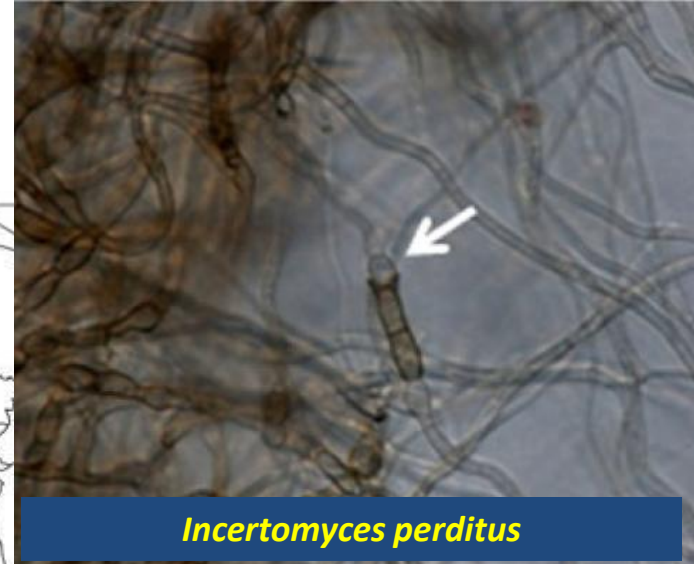
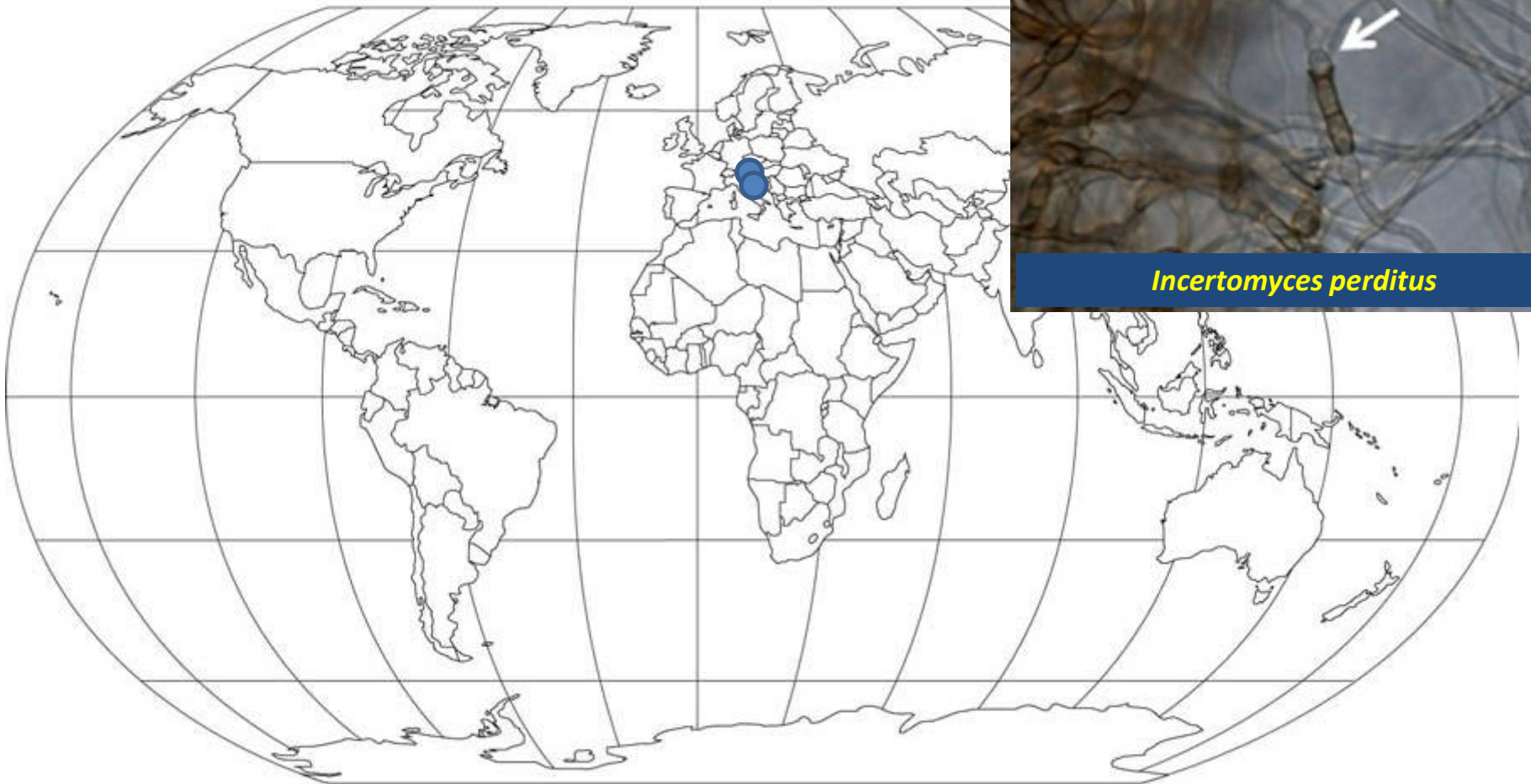


0.1 *Incertomyces perditus* CCFEE 5385 Monte Rosa

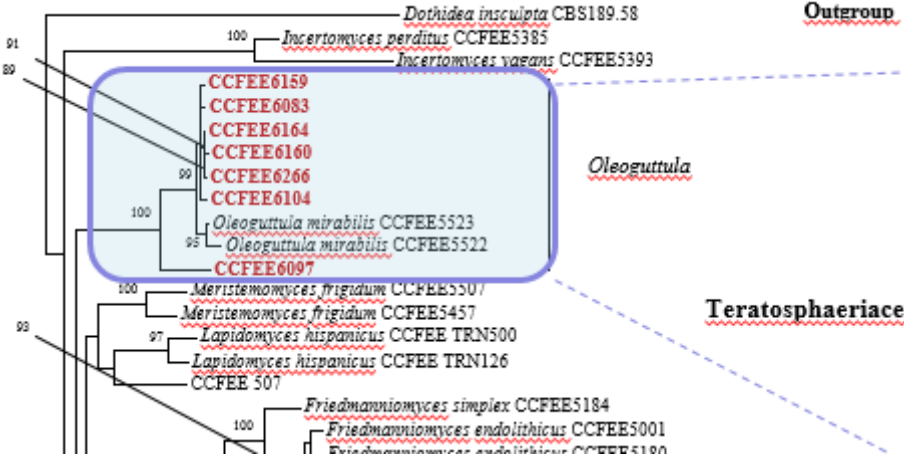
Incertomyces vagans CCFEE 5393 Monte Rosa

● Genus *Incertomyces* (2 species)

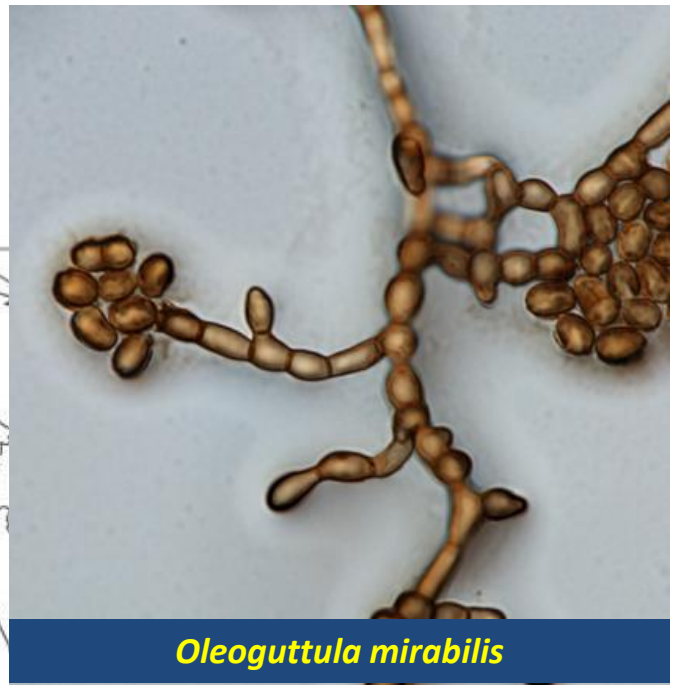
- Alps, Monte Rosa
- Cold only

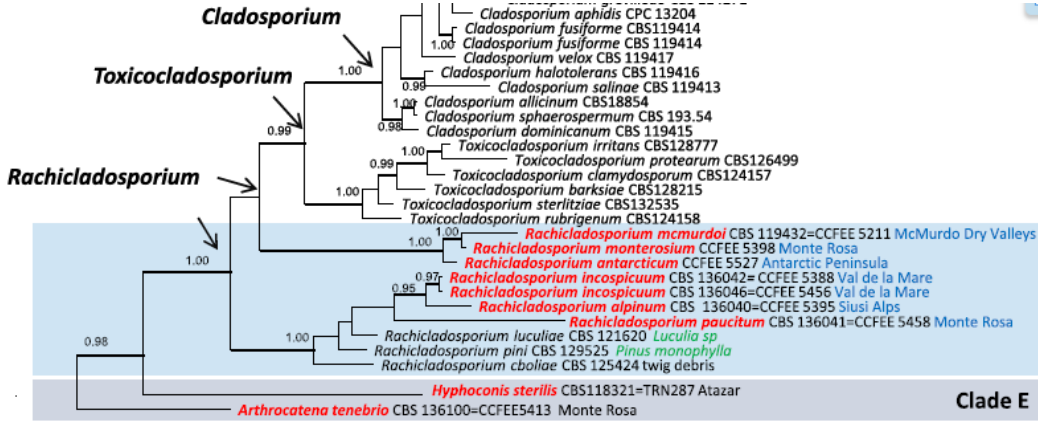


Incertomyces perditus



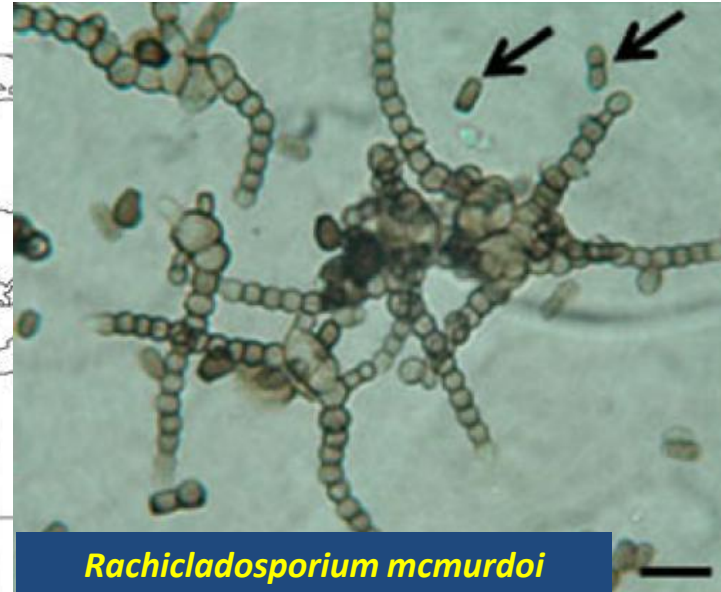
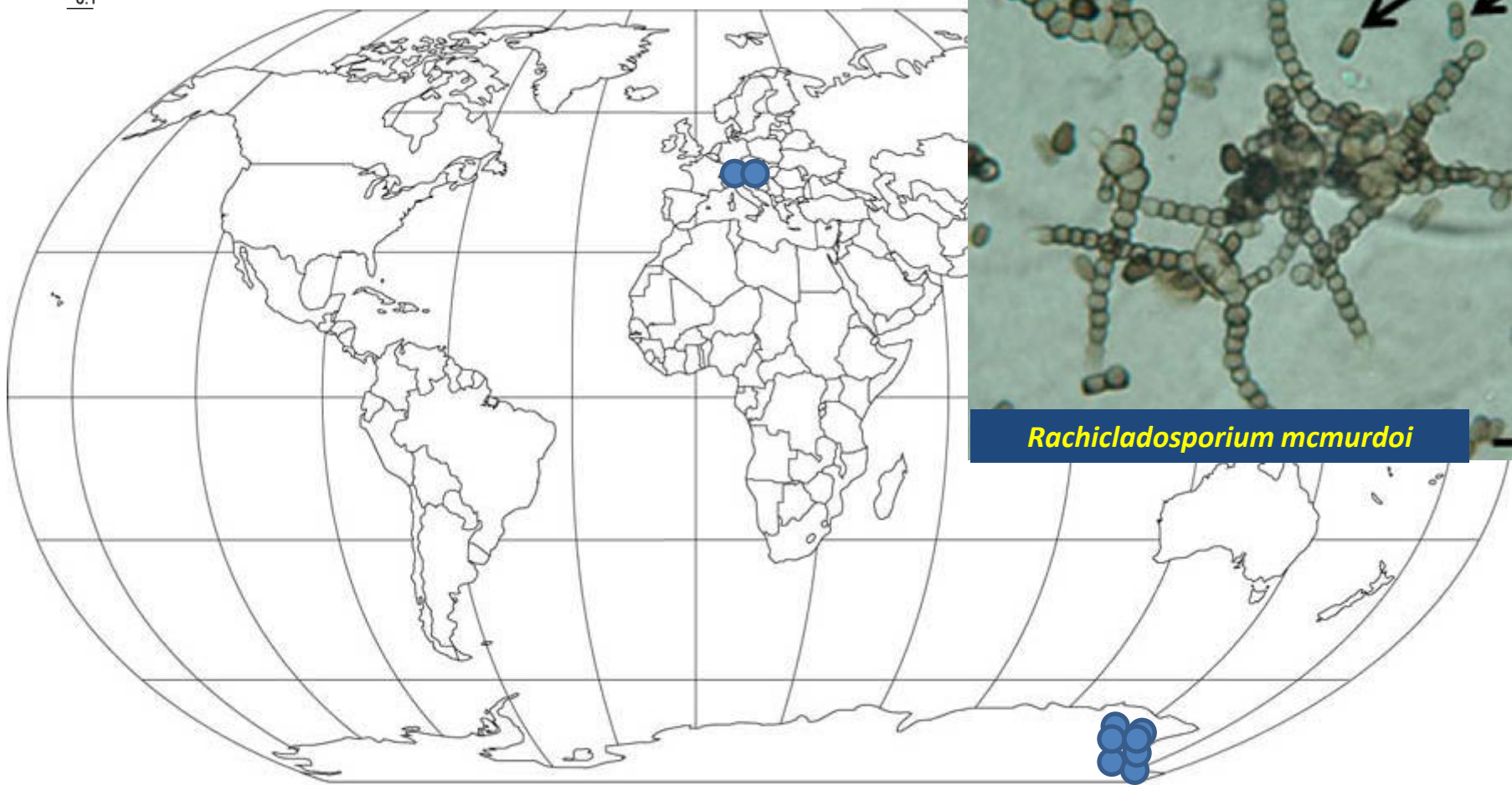
● **Genus *Oleoguttula*** (3 species, 2 undescribed) 8 isolates. Antarctica



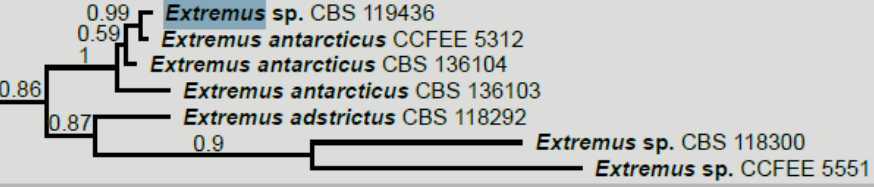


● Genus *Rachicladosporium* (6 RIF species) 7 isolates. Antarctica, Alps

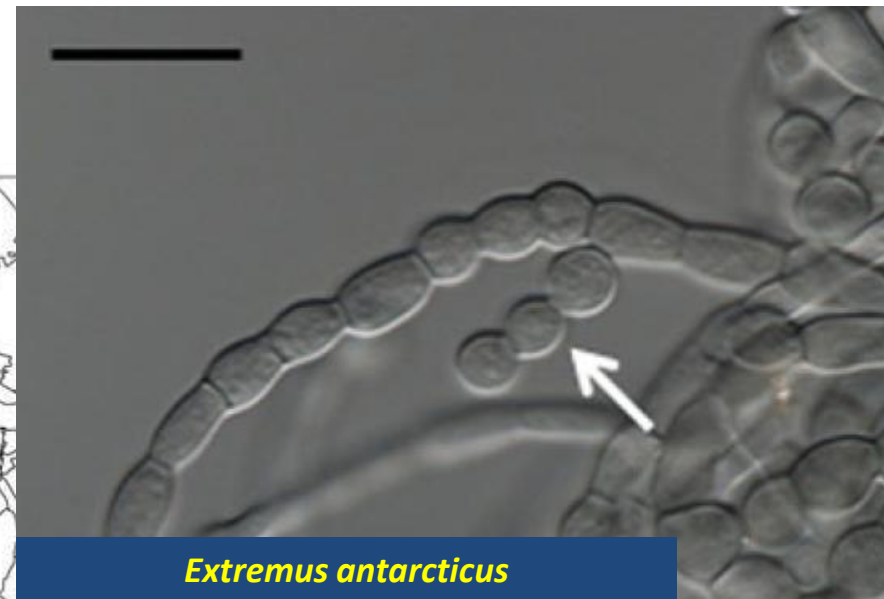
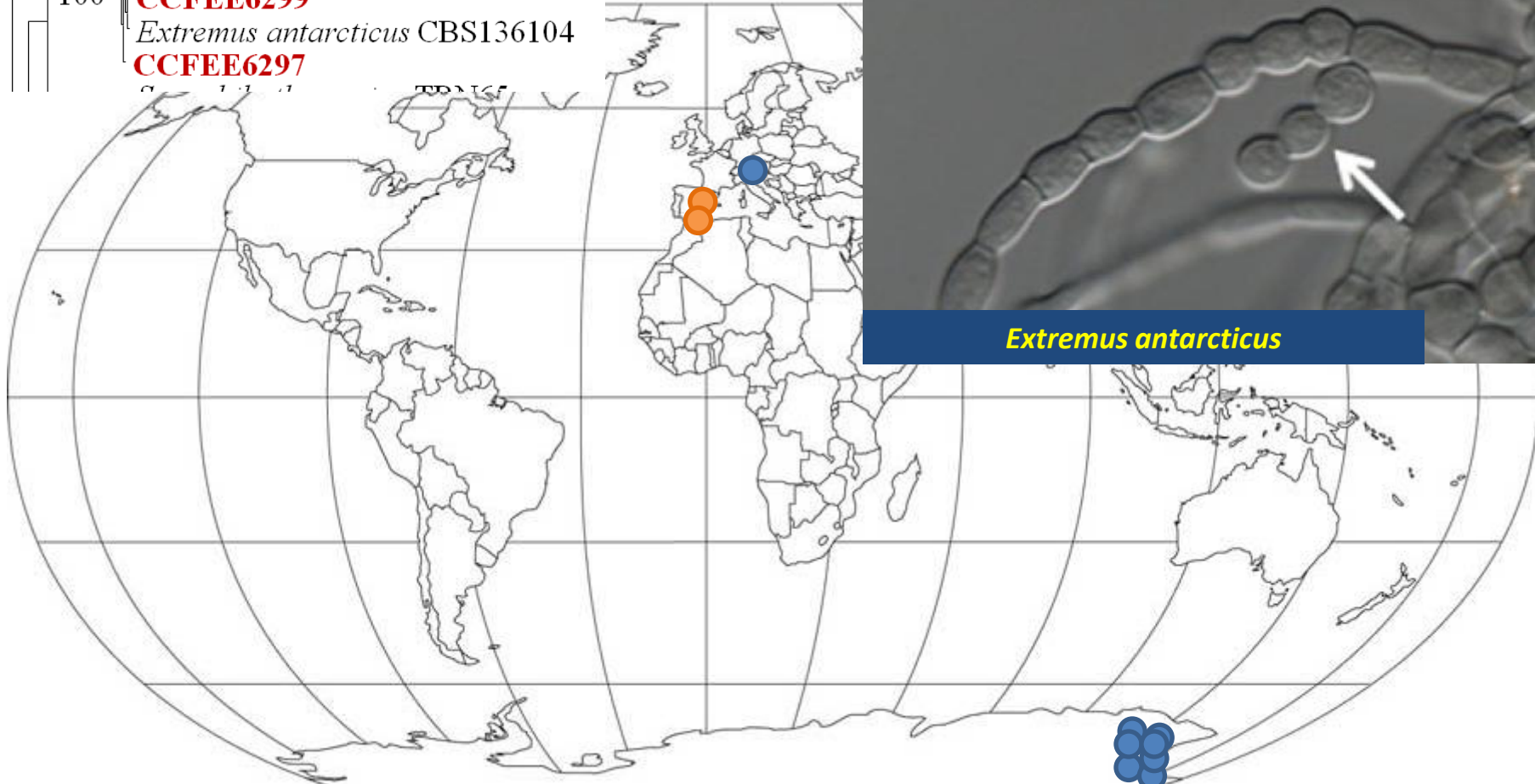
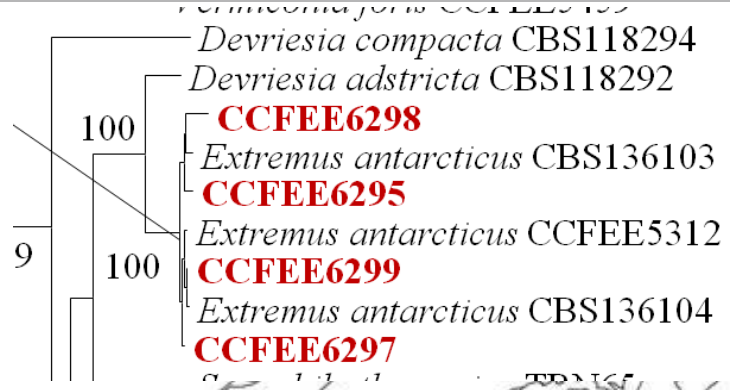
Rachicladosporium from plants distantly related

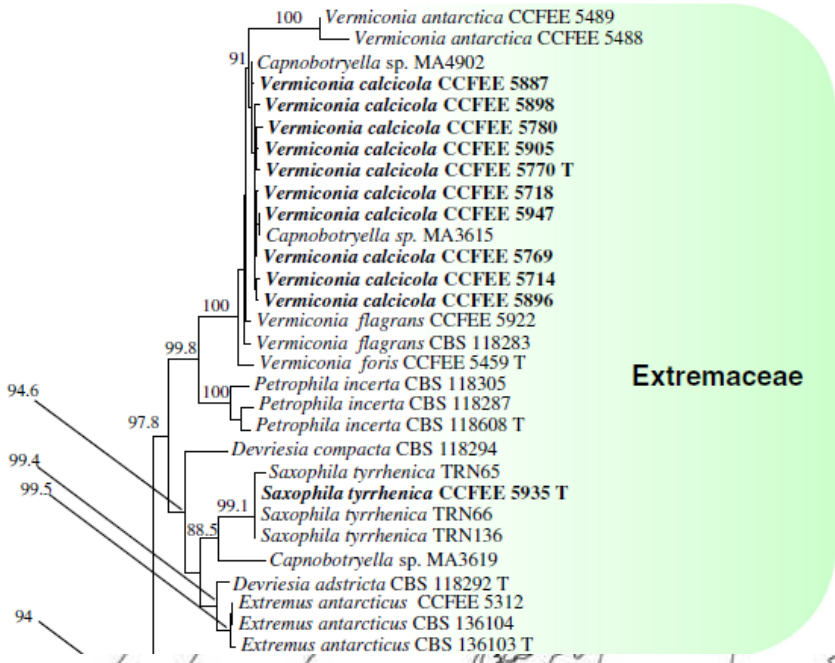


Rachicladosporium mcmurdoi

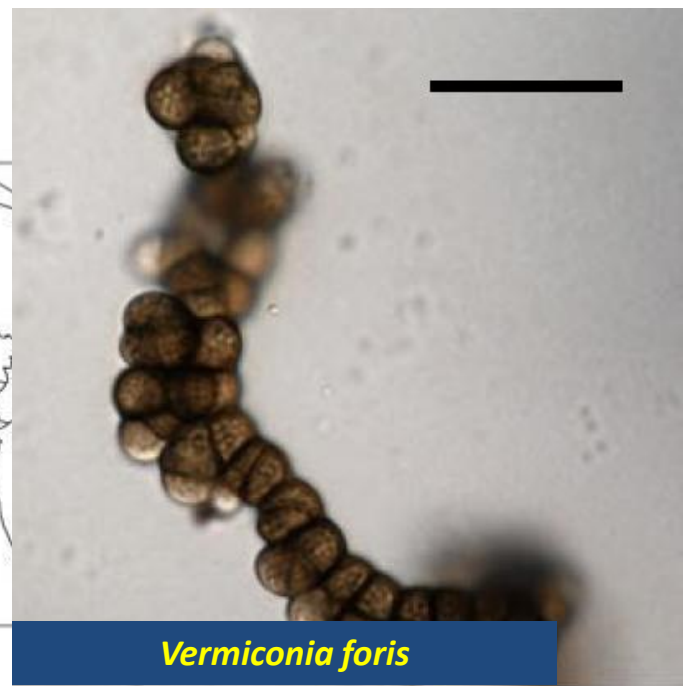
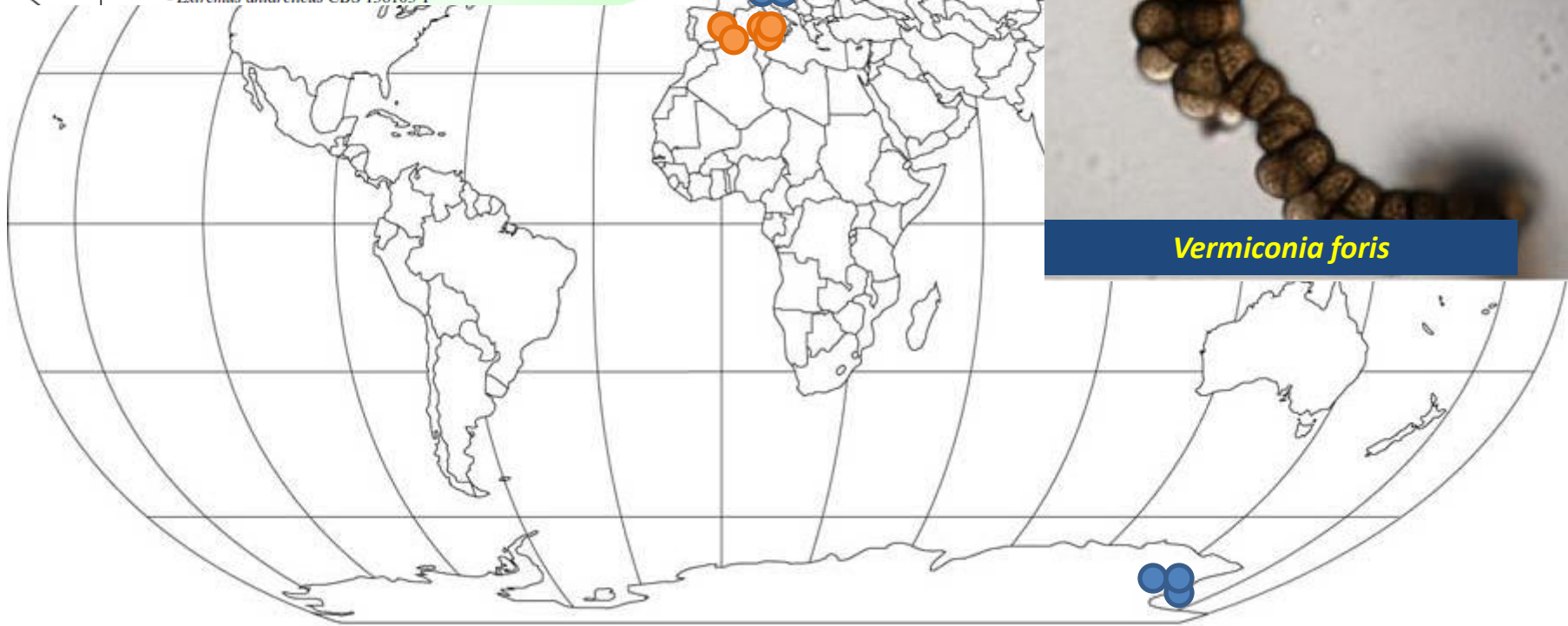


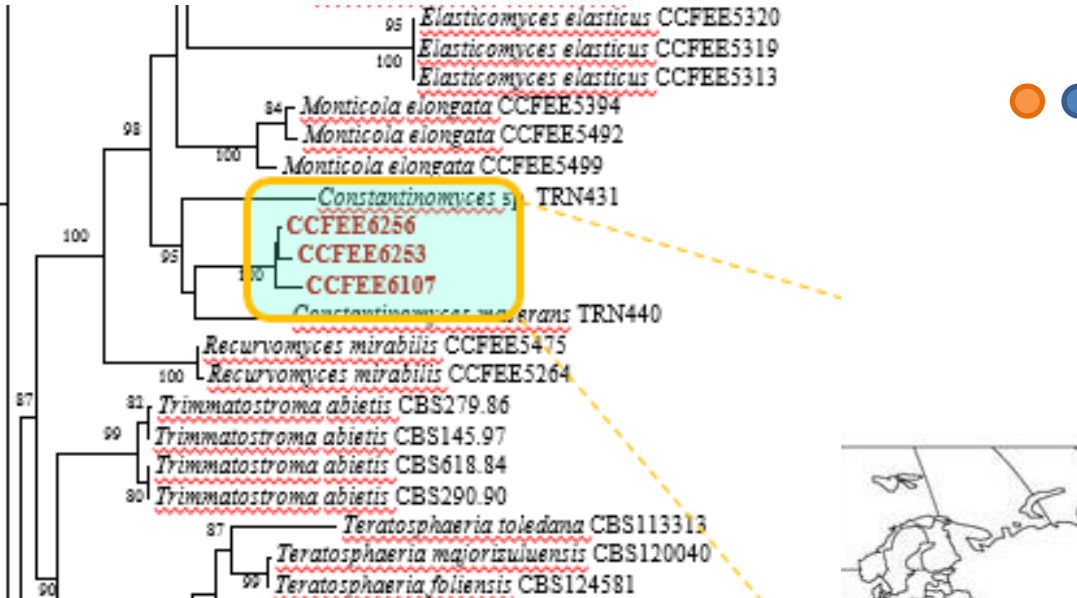
Genus *Extremus* (1 species) 7 isolates; Antarctica and Europe. *E. antarcticus* cold only, wide distribution.



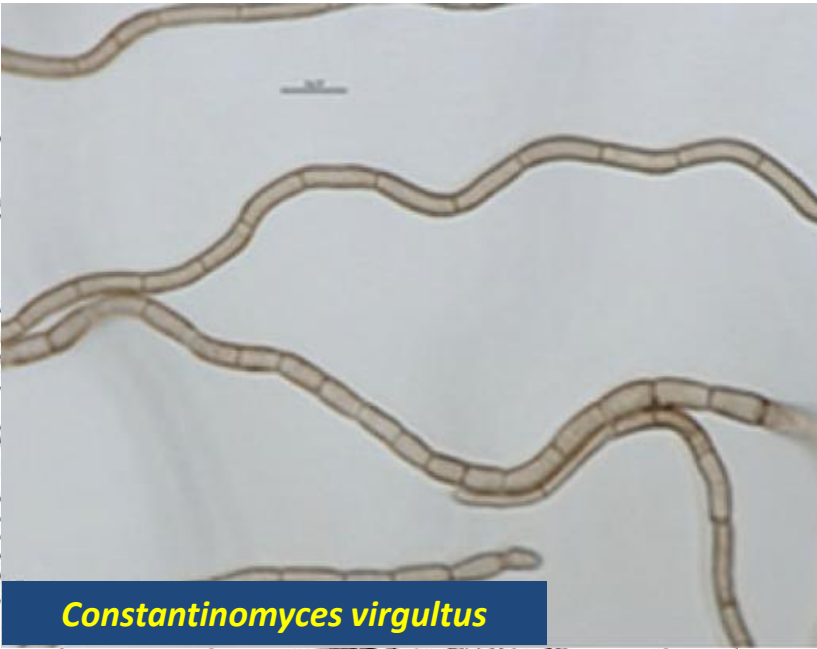


- ● • **Genus *Vermiconia*** (4 species) 15 isolates. Antarctica, Alps, Spain, Sardinia (Italy)
- *V. calcicola* genetic variability 4.2%

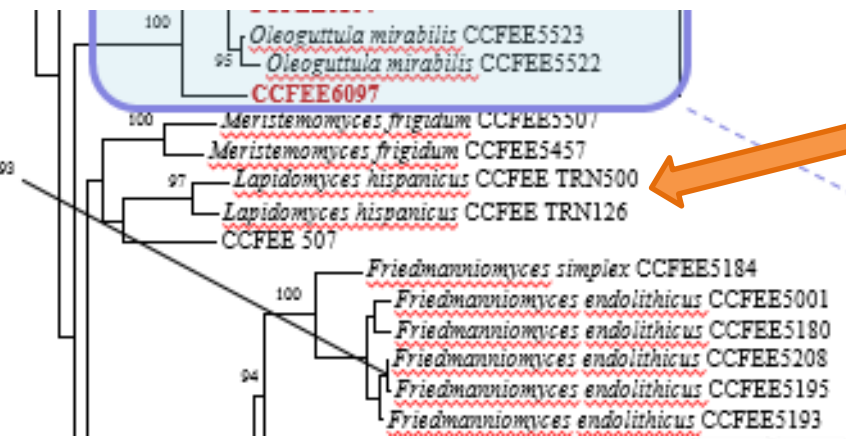




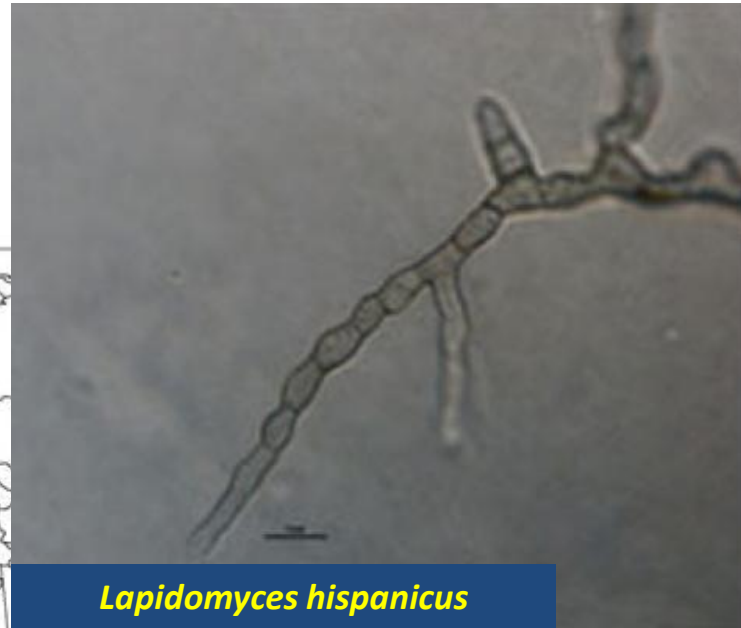
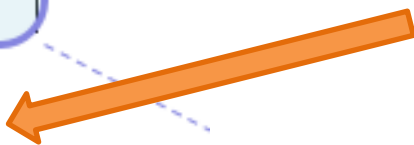
● ● Genus *Constantinomyces* (4 species Spain; 1, undescribed Antarctica)



Constantinomyces virgultus

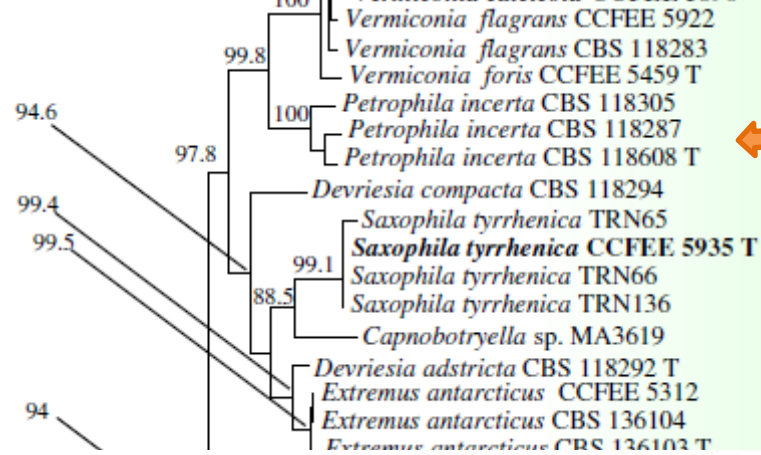


● Genus *Lapidomyces* (2 species)
 Spain



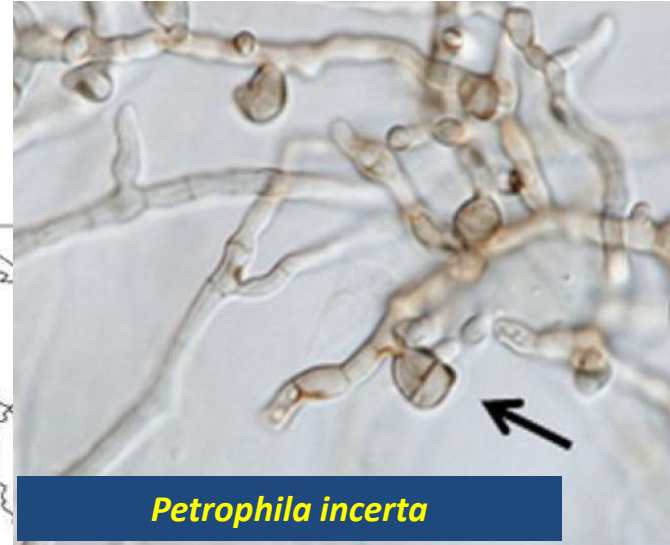
Lapidomyces hispanicus

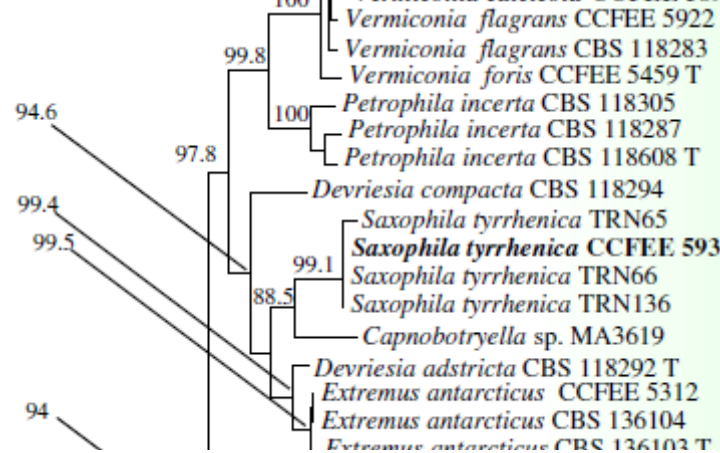




Extremaceae

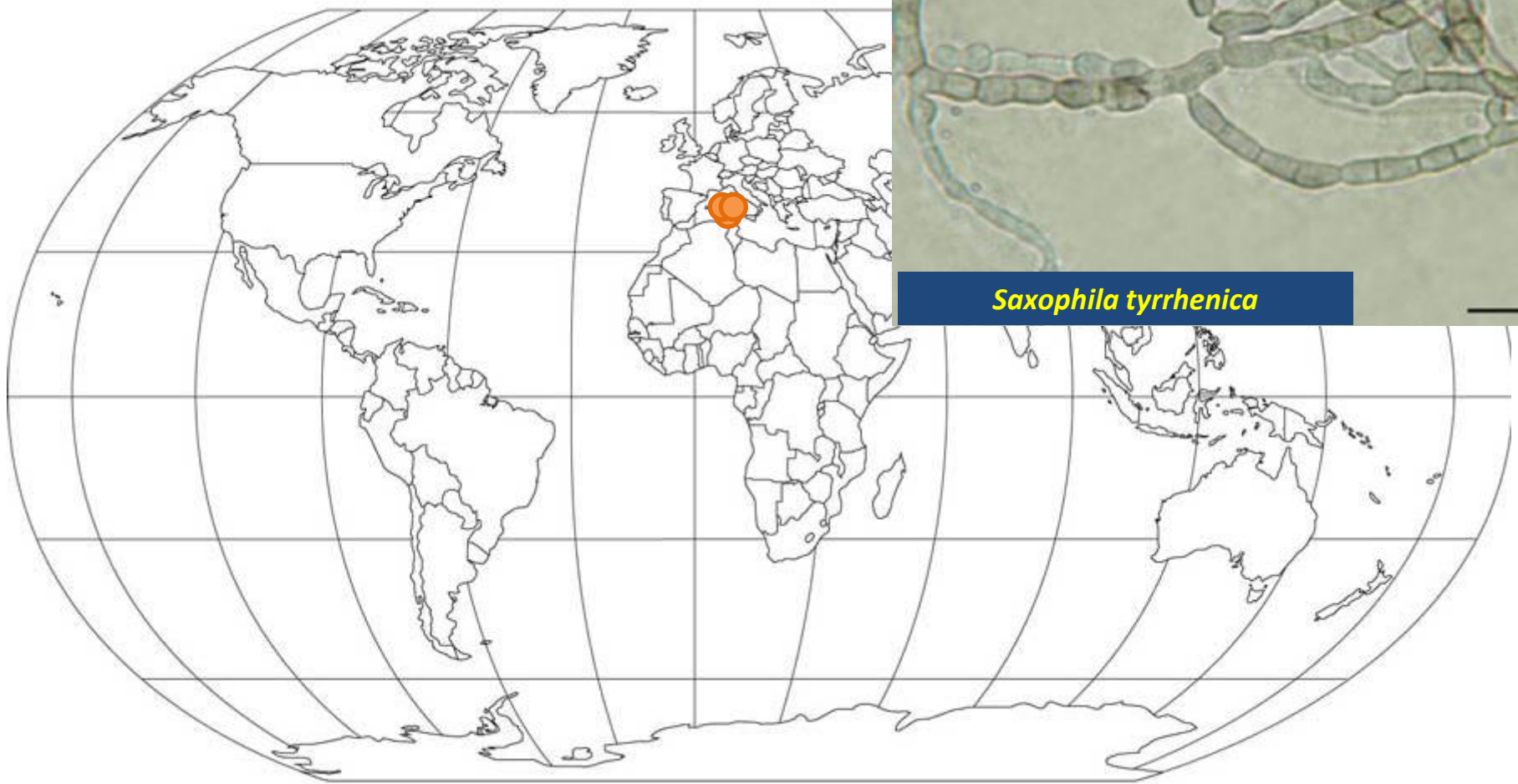
Genus *Petrophila* (1 species)
Spain



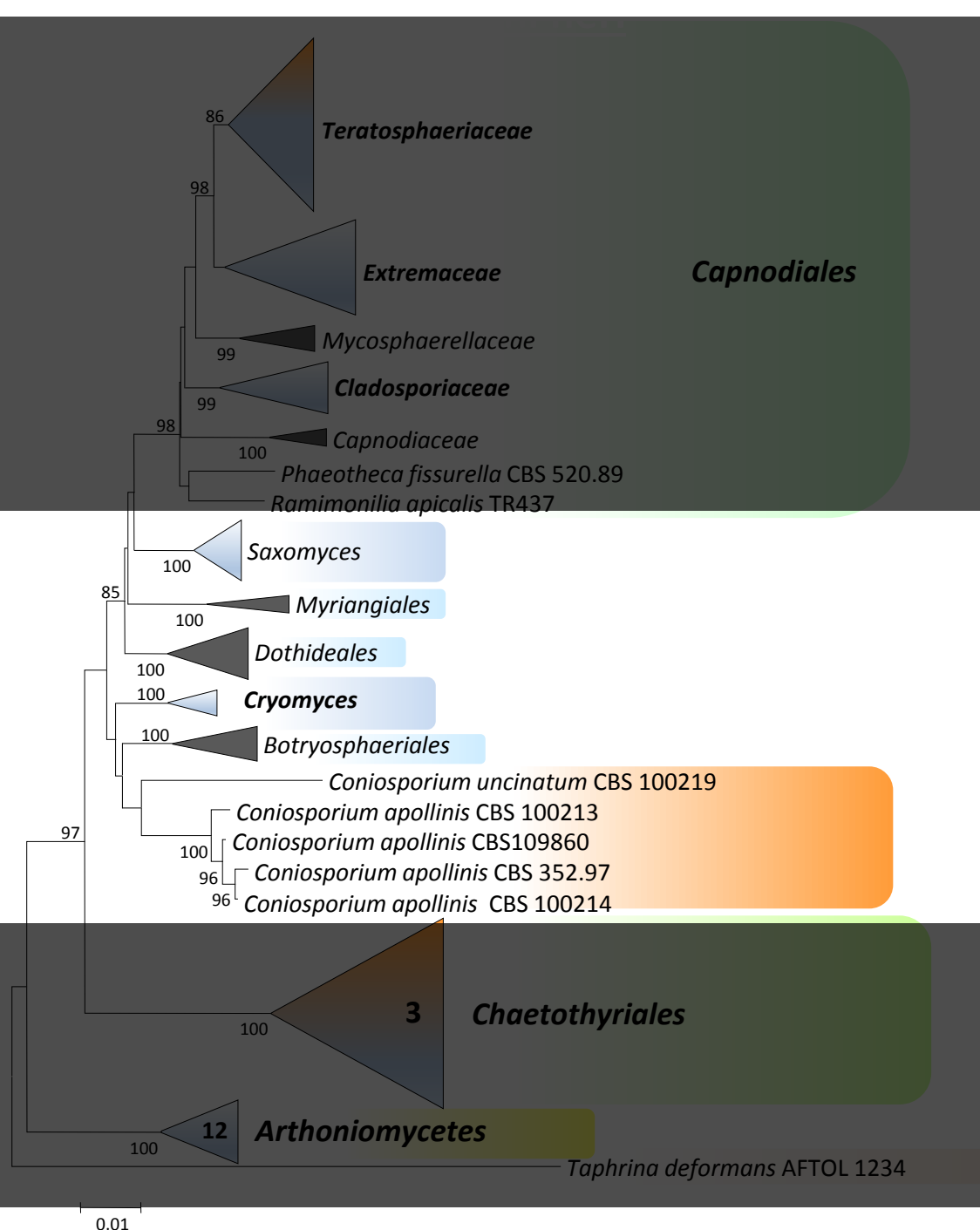


Extremaceae

● Genus *Saxophila* (1 species)
Sardinia (Italy)



Saxophila tyrrhenica



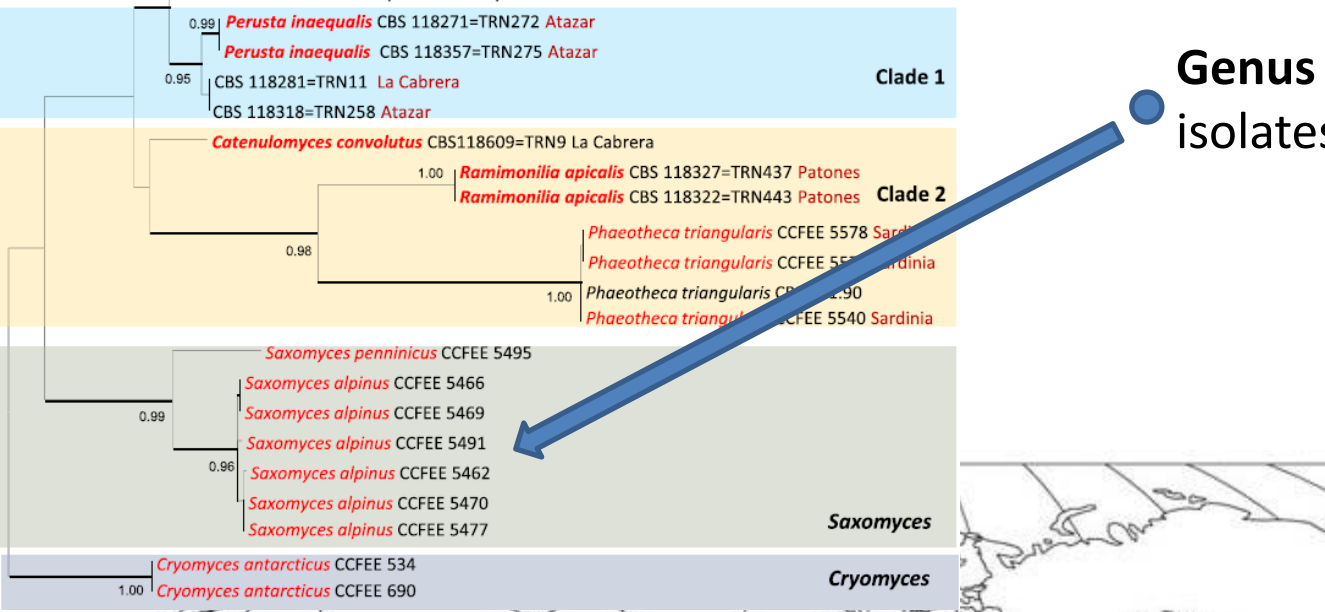
Occurrence of
 cold/
 hot-loving RIF

Dothideomycetes

Eurotiomycetes

Outgroup

Genus *Saxomyces* (2 species), 7 isolates, Alps Italy

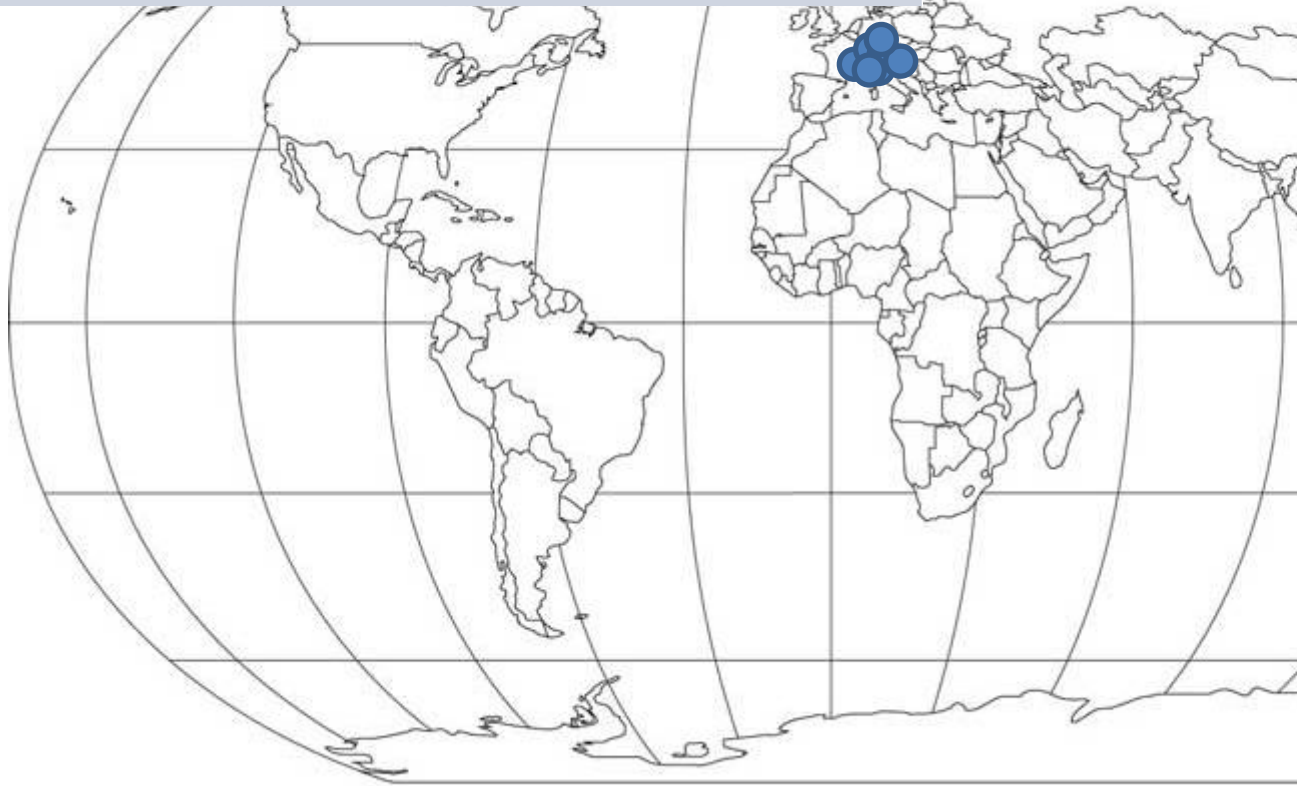


Clade 1

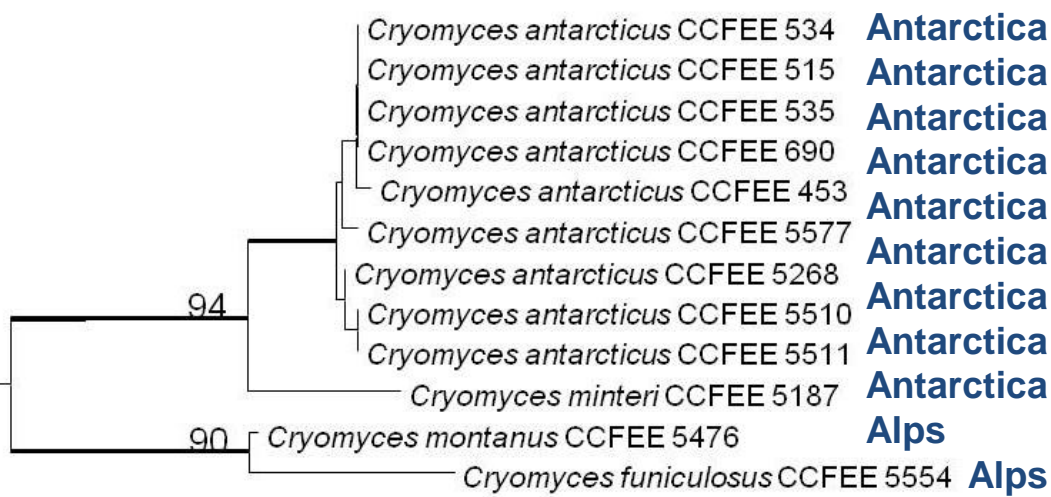
Clade 2

Saxomyces

Cryomyces

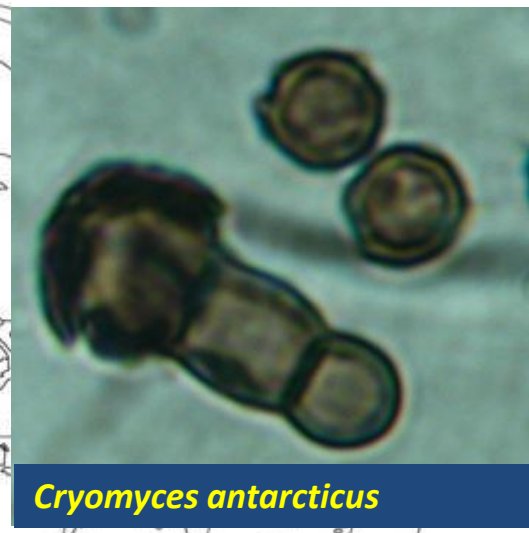
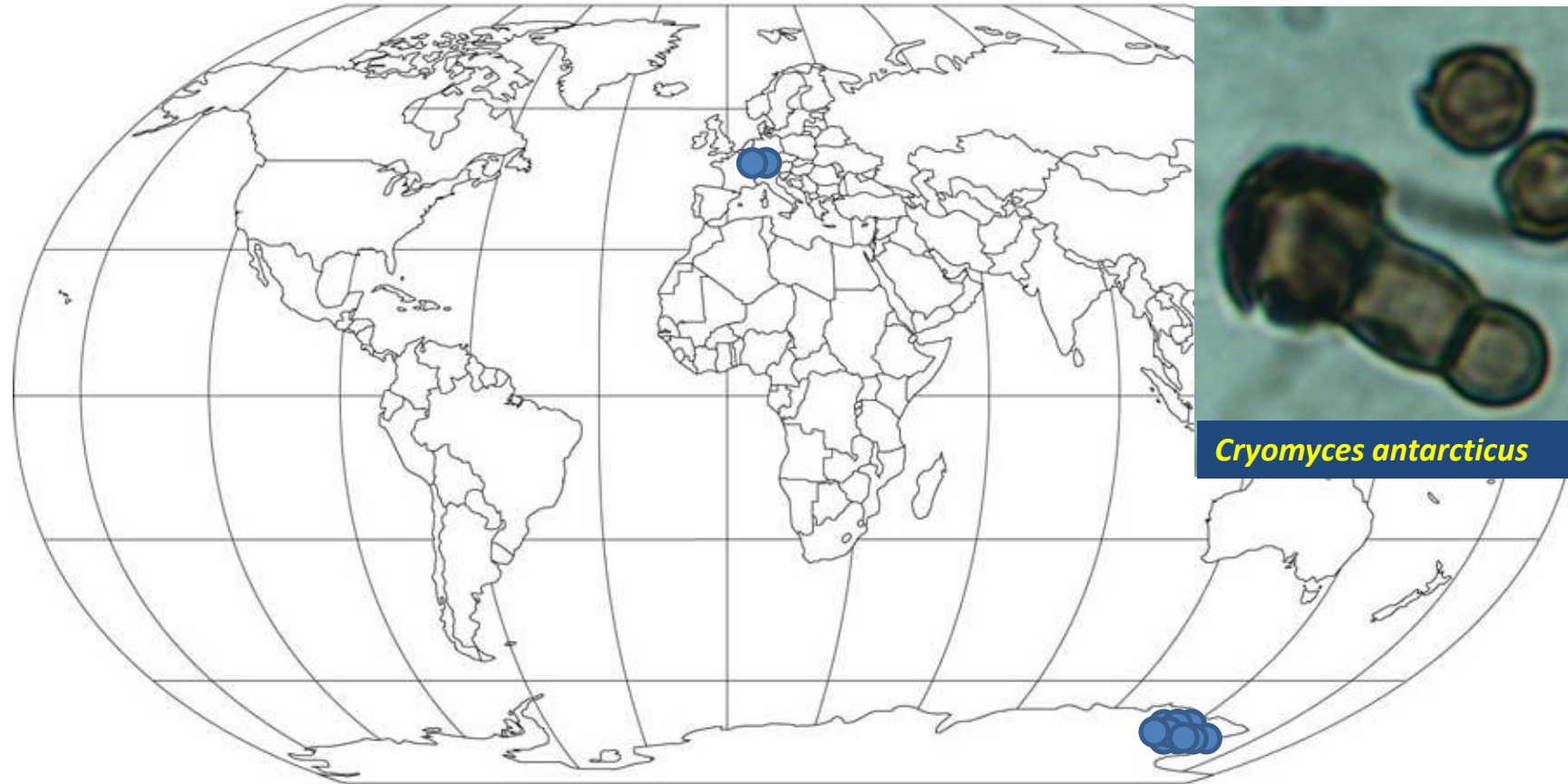


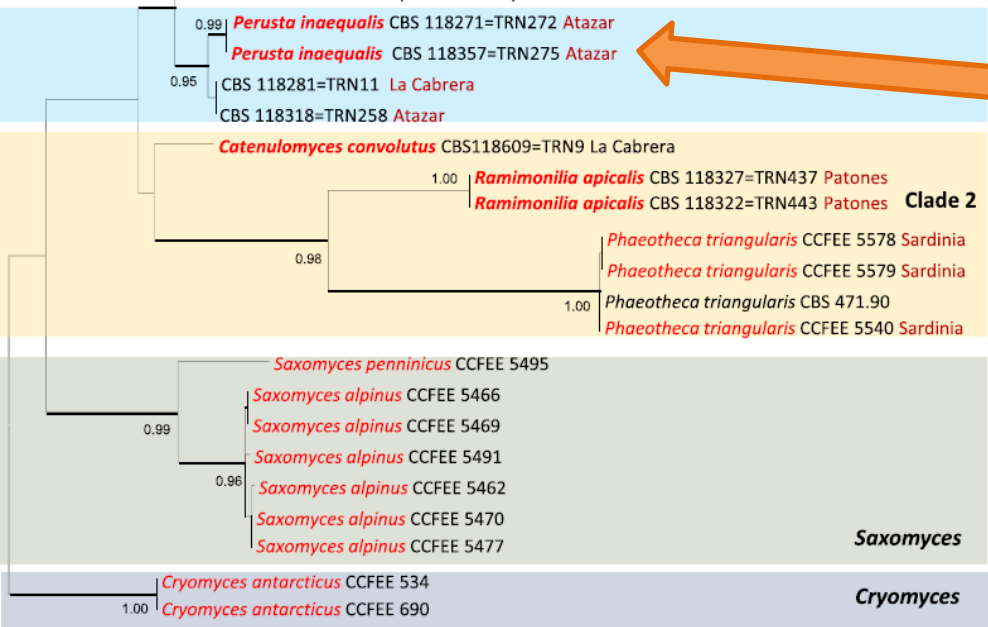
Saxomyces alpinus



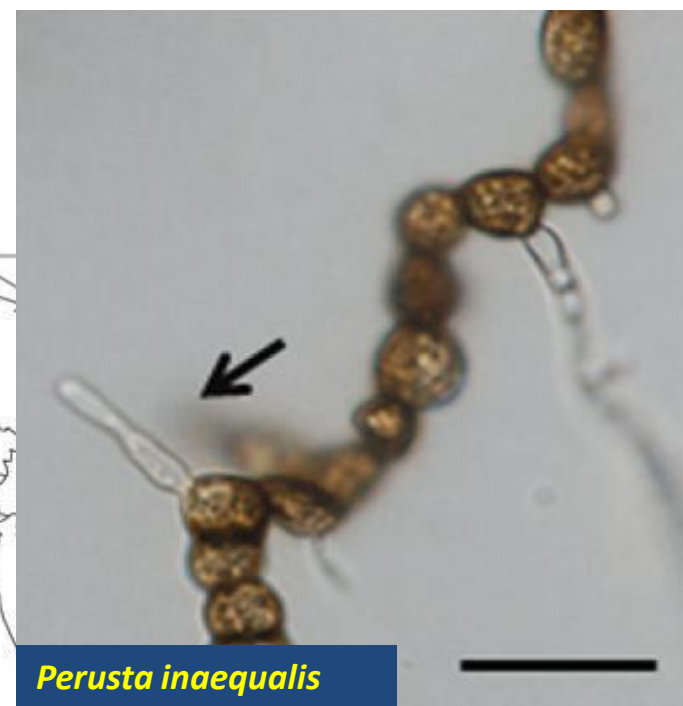
Antarctica
Antarctica
Antarctica
Antarctica
Antarctica
Antarctica
Antarctica
Antarctica
Antarctica
Alps
Alps

- Cryomyces spp.**
- 14 isolates in CCFEE (7 Antarctica)
 - Alps, McMurdo Dry Valleys Antarctica
 - cold only
 - ITS variability *C. antarcticus* 1.3%

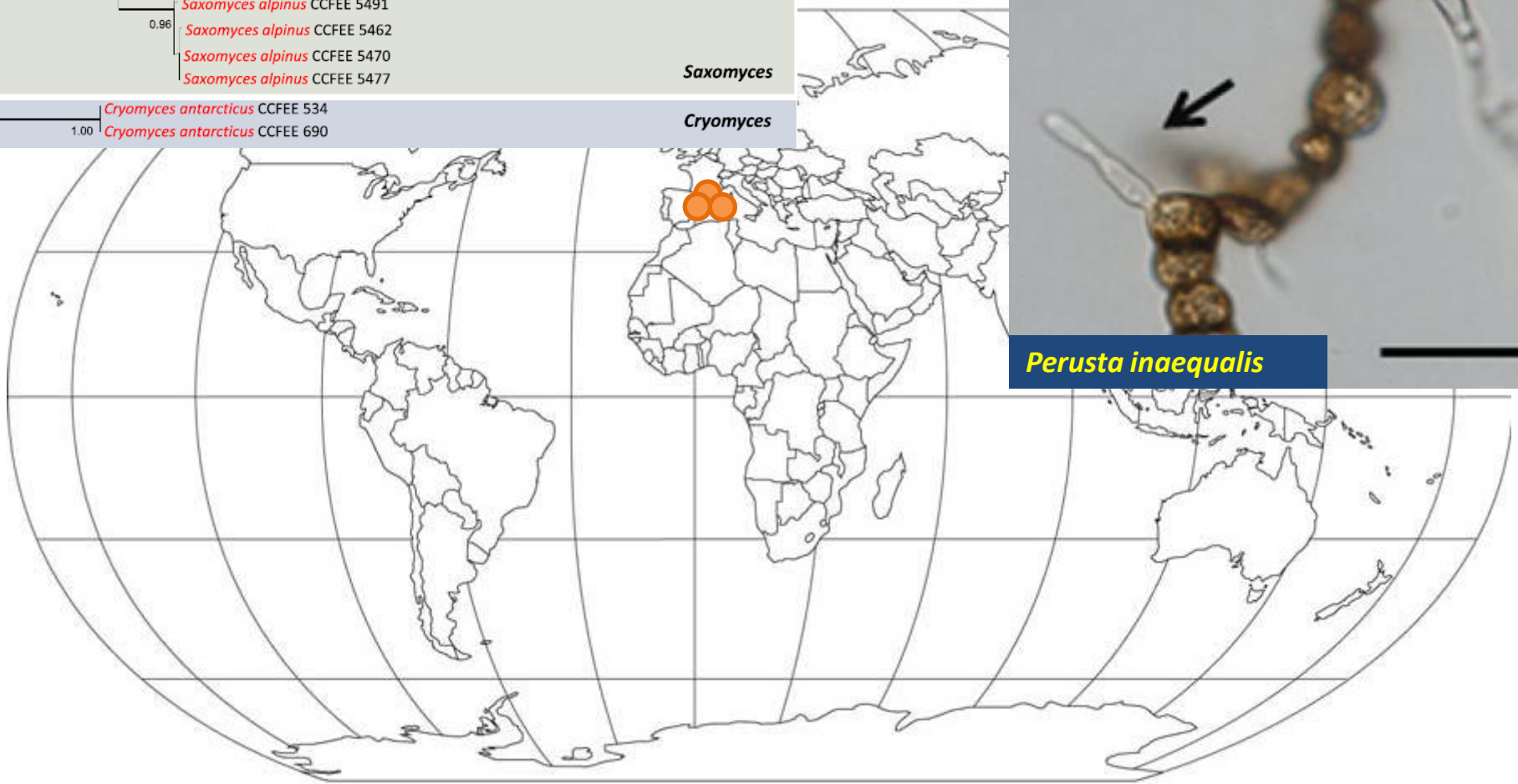


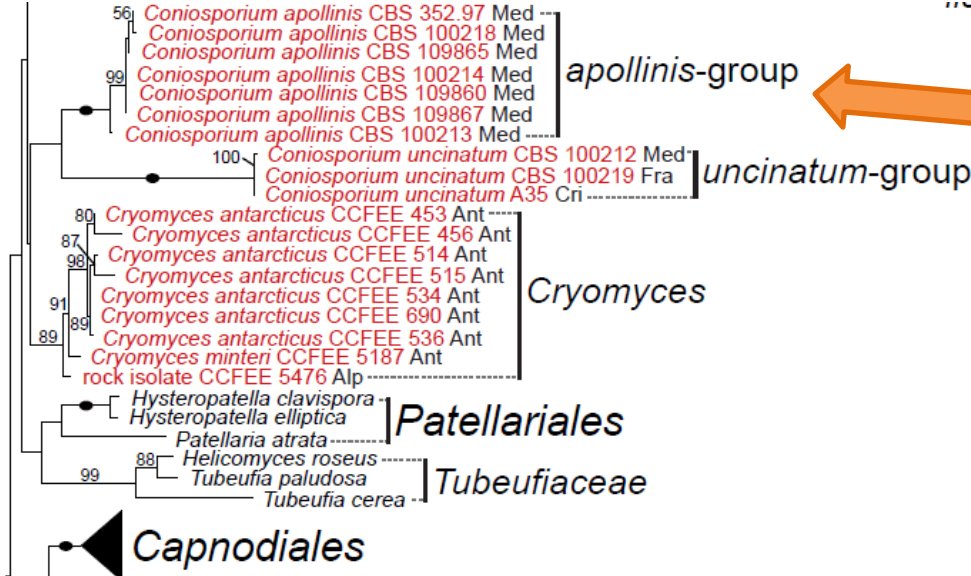


● Genus *Perusta* (2 species) Spain

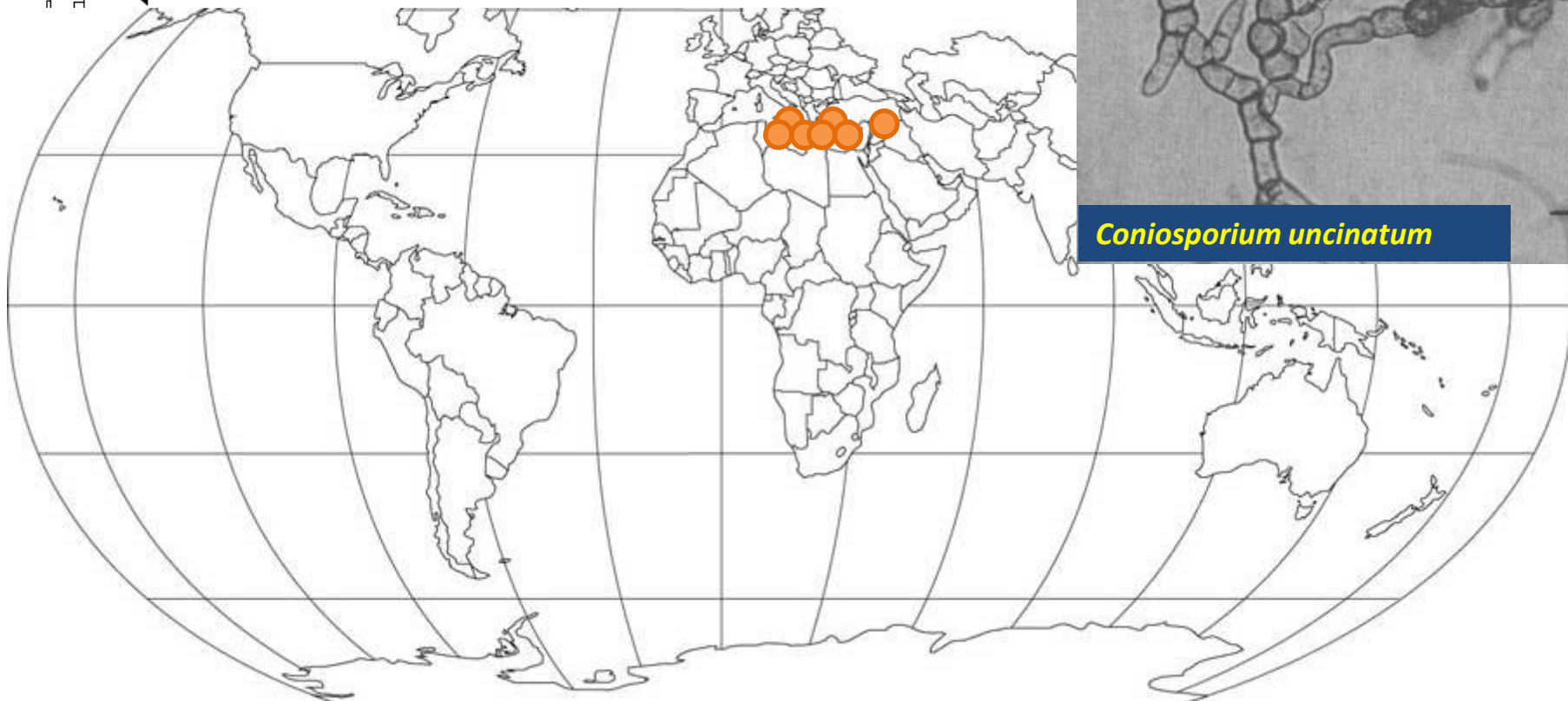
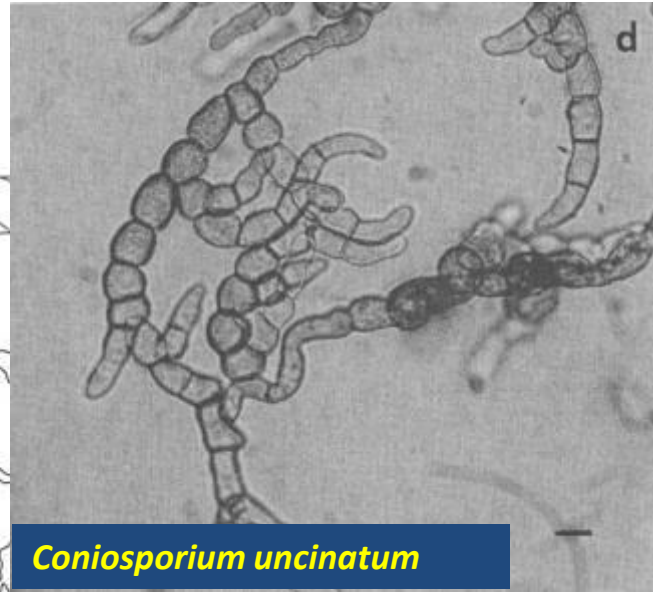


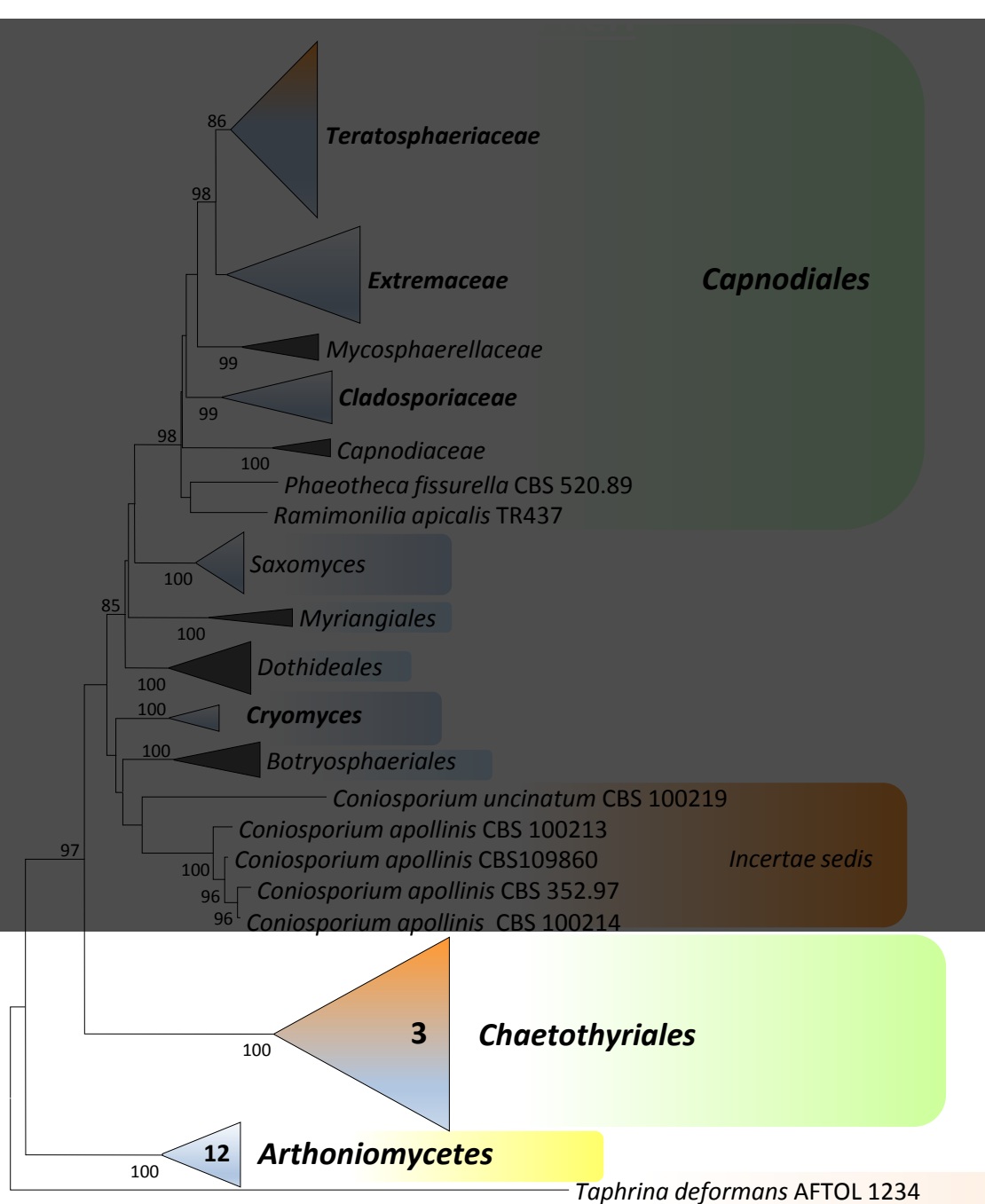
Perusta inaequalis





● **Genus *Coniosporium* (2 species)**
Sicily (IT), Delos (Greece), Crimea





Occurrence of
 cold/
 hot-loving RIF

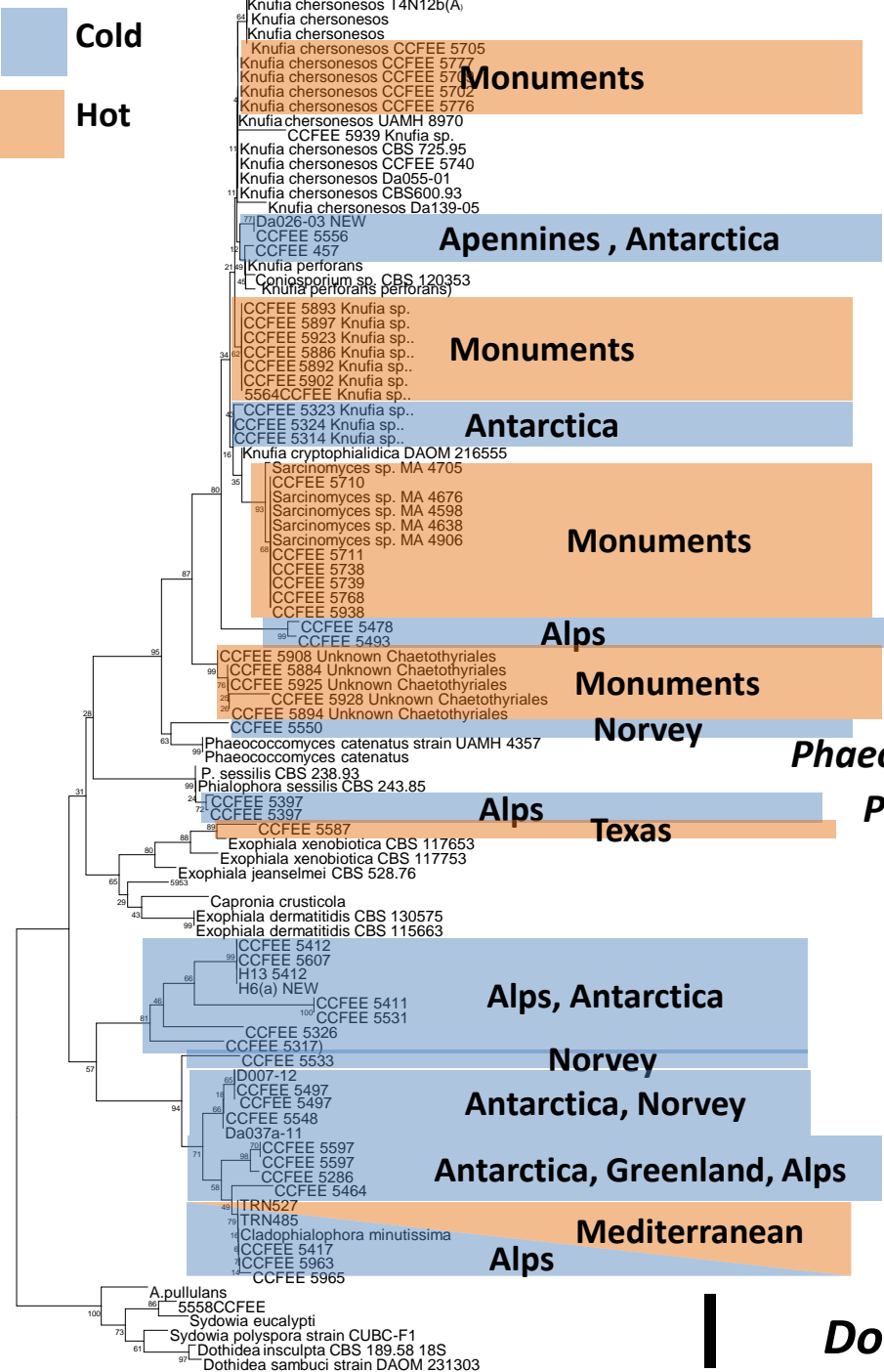
Dothideomycetes

Eurotiomycetes

Outgroup

NJ Multilocus SSU-LSU tree

0.01



Knufia chersonesos

Knufia ??

Knufia ?

Phaeococcomyces nigrigans

Phialophora sessilis

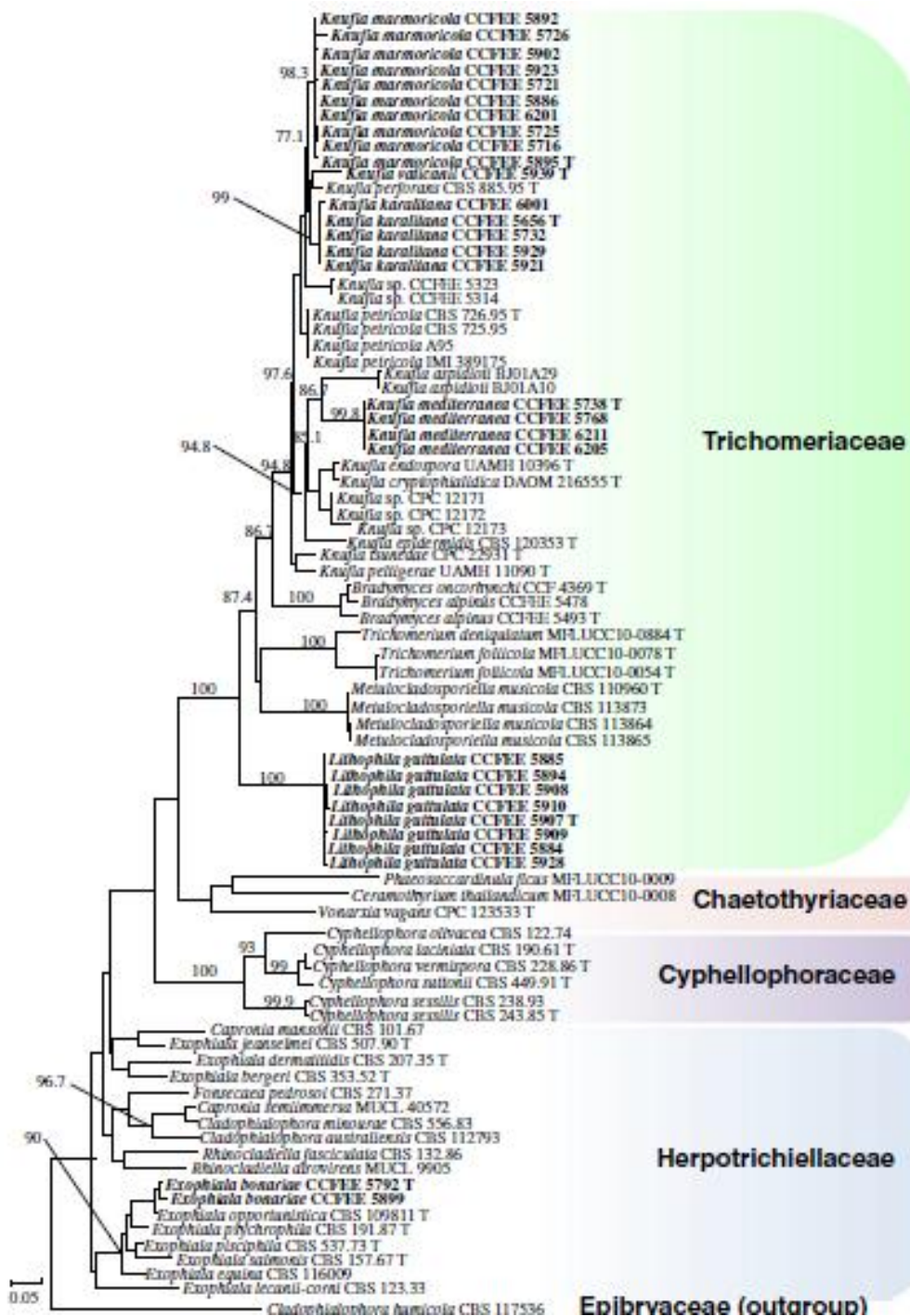
Exophiala

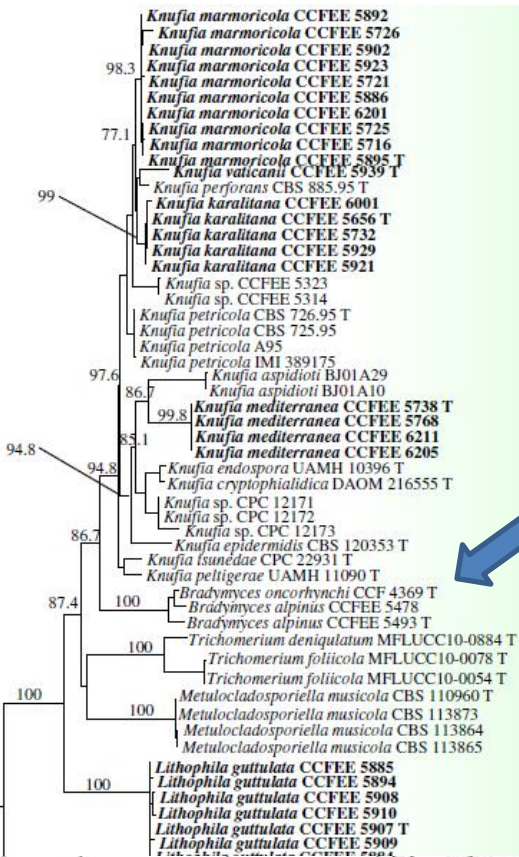
Dothideomycetes (outgroup)

Occurrence of cold-loving RIF in Chaetothyriales

Chaetothyriales

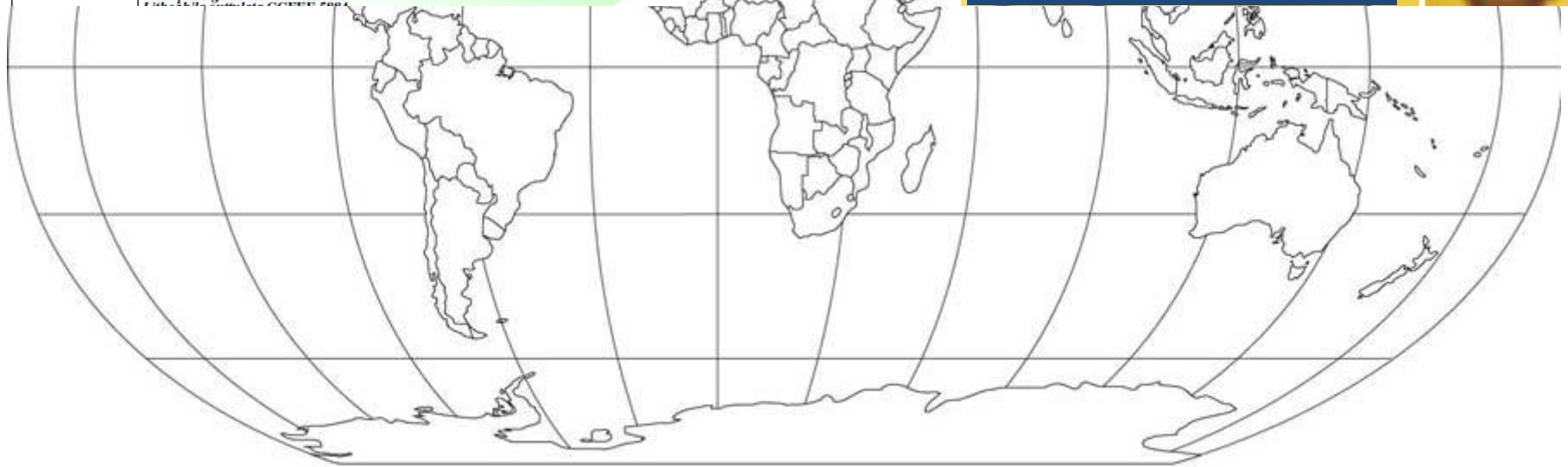
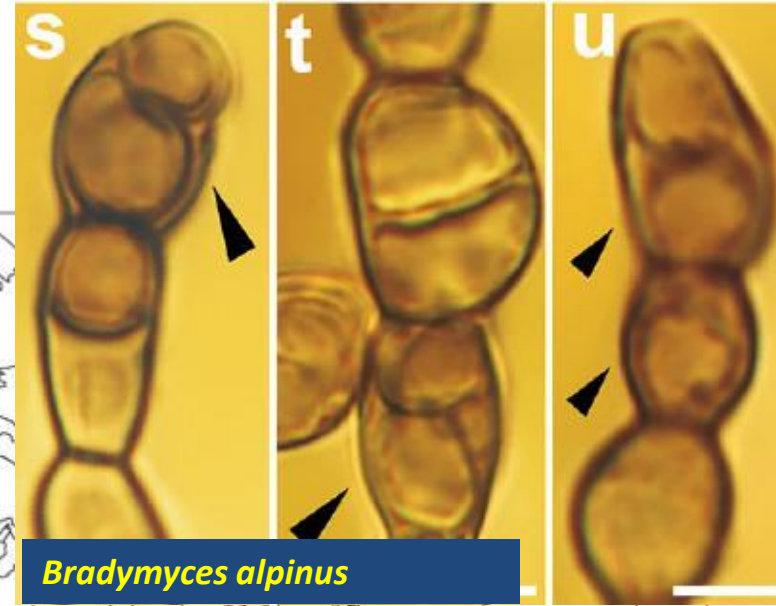
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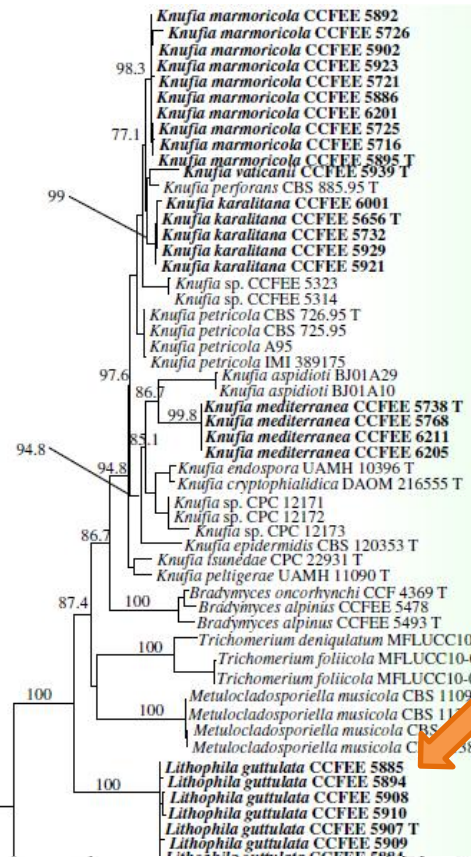




Trichomyces

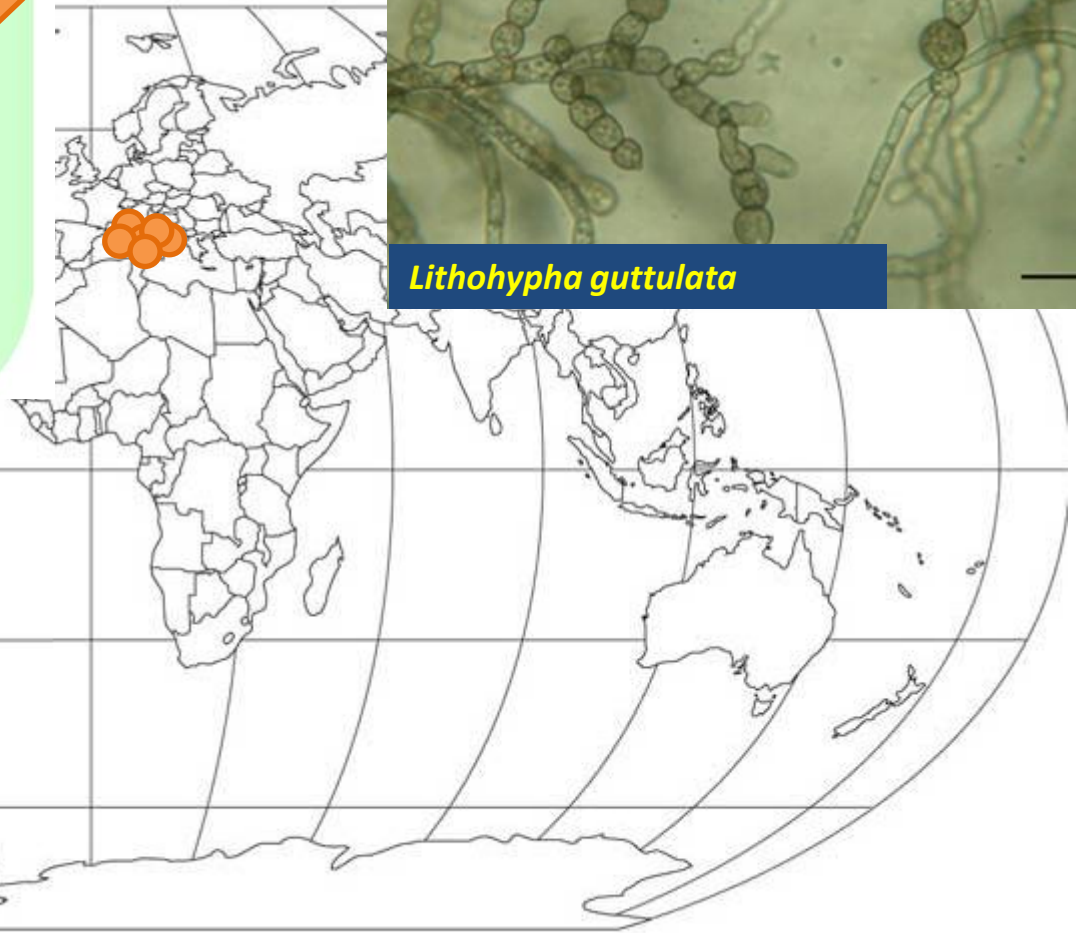
● Genus *Bradymyces* (1 RIF species) 2 isolates, Alps, Italy



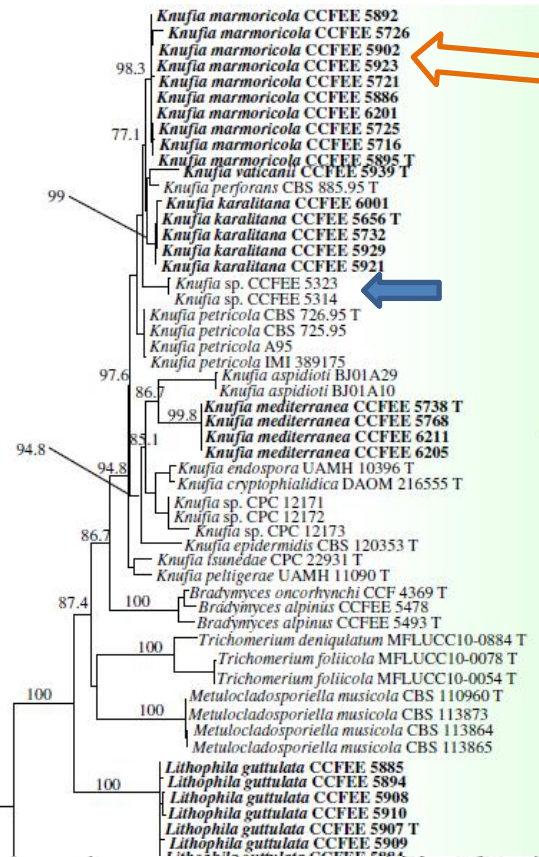


Trichomeriaceae

● Genus *Lithohypha* (1 RIF species)
7 isolates, Vatican marble monuments



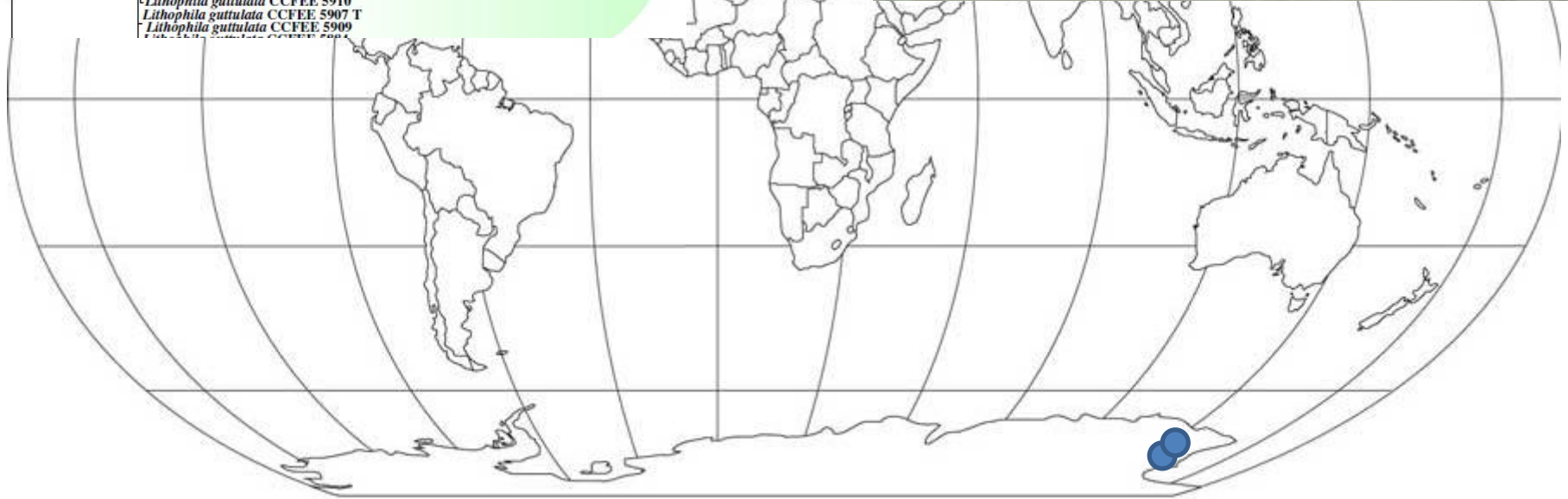
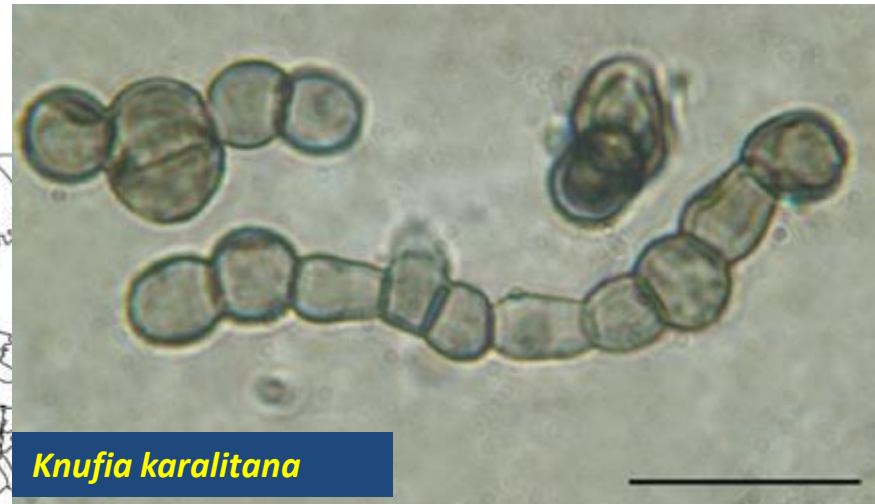
Lithohypha guttulata



Trichomeriaceae

● ● Genus *Knufia* (6 RIF species)
Mediterranean

Isolated but not yet described from the cold



Considerations

based on Dothideomycetes

- T- association is a character spanning entire genera of RIF
 - 9 genera cold (*Friedmanniomyces, Elasticomyces, Recurvomyces, Monticola, Incertomyces, Oleoguttula, Extremus, Meristemomyces, Rachicladosporium*)
 - 3 genera hot (*Lapidomyces, Petrophila, Saxophila*)
 - 2 genera cold & hot but species related with T (*Constantinomyces, Vermiconia*)
- Some taxa show disperse distribution, other are spreading in very restricted areas. Dispersal may be efficient but settlement limited by conditions (COLD/HOT).
- High genetic variability (round 4.5%): accumulation of mutations/parasexuality?

Conclusions

➤ **Slow growth**



➤ **Inactive life** (starvation, dehydration, freezing...)



➤ **No sexuality**



**They are spreading, adapting and actively evolving
even at the cold edge for life**



Thank you for your attention



Flavio Riotto



Claudia Pacelli



Fabiana Canini



Alessia Cassaro



Federica D'Alo



Claudia Coleine



Laura Selbmann



Laura Zucconi



Silvano Onofri



Daniela Isola



Valentina Funari



Federica Licari



Ilaria