Pythium:
morphological taxonomy
after the molecular revision

Arthur de Cock[a], Gloria Abad[b], André Lévesque[c], Gregg Robideae[c] & Henk Brouwer[a]
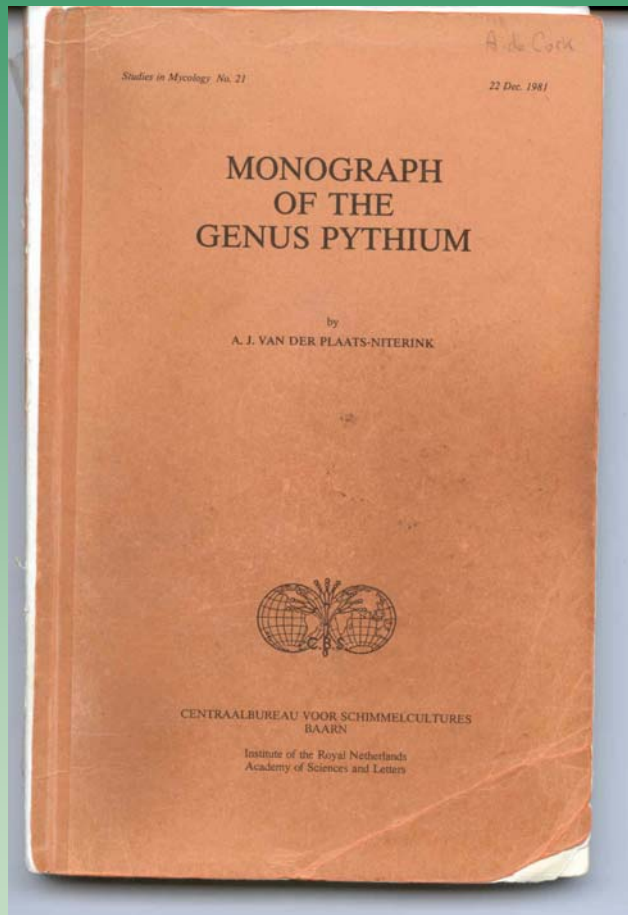
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[b]USDA-APHIS-PPQ-PHP-PSPI-MDL, Beltsville, MD USA
[c]Agriculture & AgriFood Canada, Ottawa, ON Canada
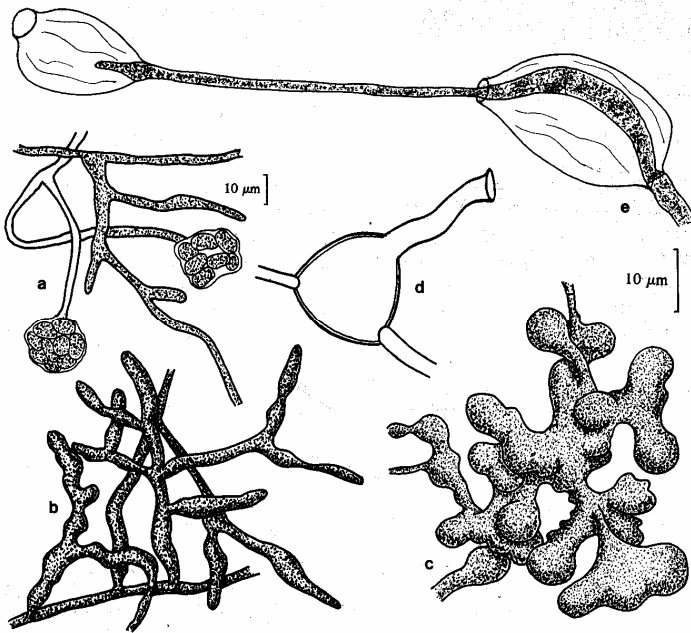
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Van de Plaats-Niterink -1981

Lévesque & De Cock - 2004

Sporangium types in Pythium

filamentous

filamentous-inflated

globose

globose,
internally proliferating

ITS tree of 125 Pythium species
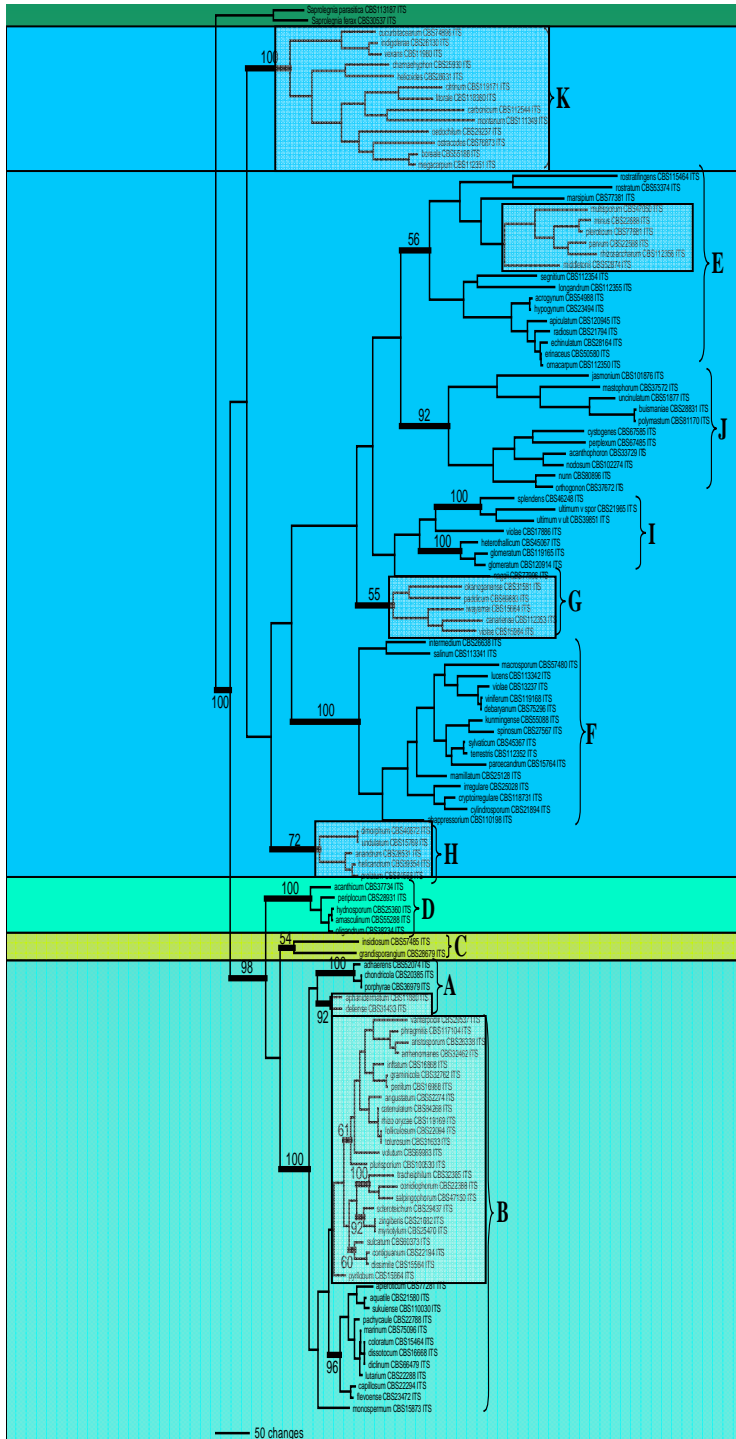
Correlation of clustering and sporangium type

Globose

internally proliferating

Contiguous

Filamentous

inflated

Tree generated by parsimony analysis with PAUP of ITS sequences of all *Pythium* species available in culture. Clades are labeled as in Lévesque and De Cock (2004).

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Sporangium types in Pythium

filamentous

filamentous-inflated
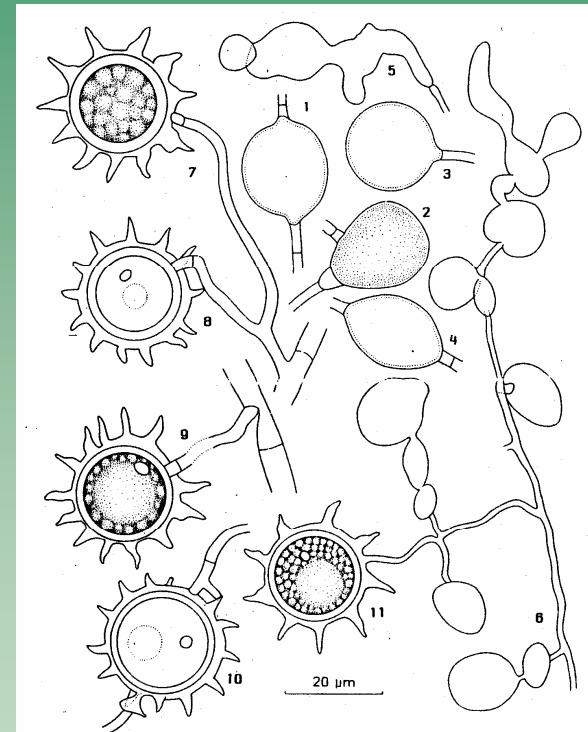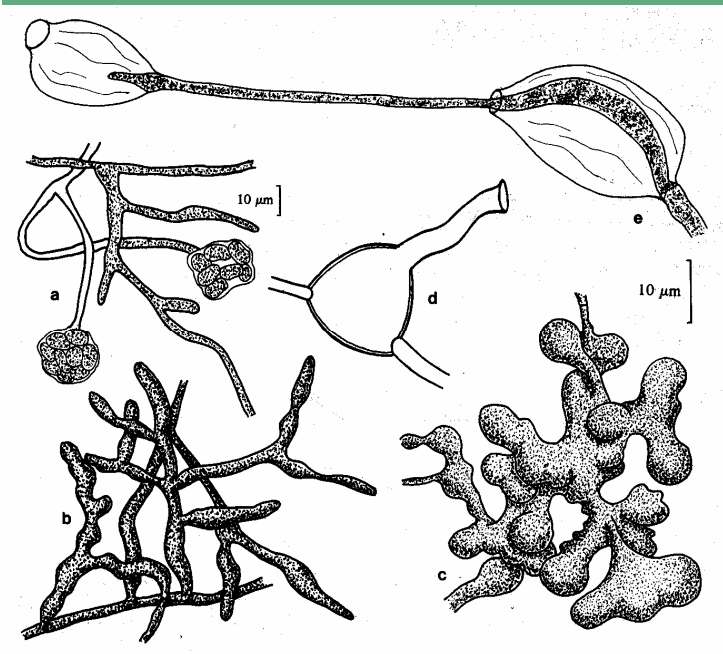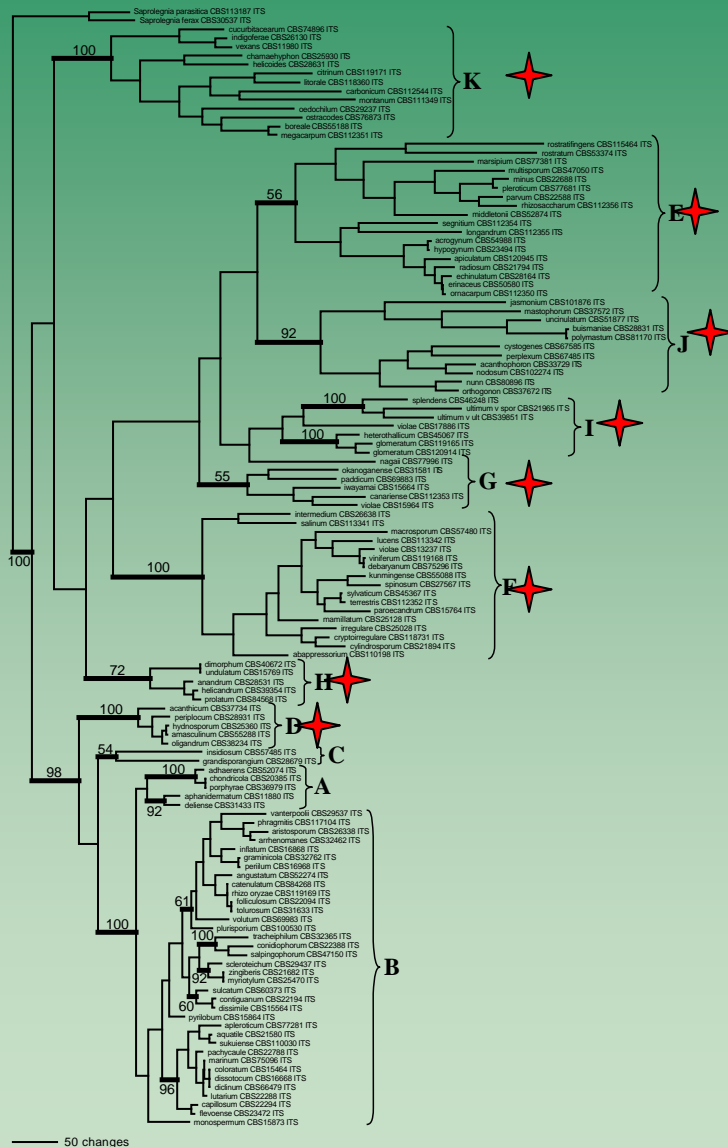
contiguous

globose

globose,
internally proliferating

Fig. 4 *Pythium amasculinum* Yu. 1–4. Sporangia; 5.6. Contiguous sporangia (hyphal swellings); 7–11. Oogonia, antheridi and oospores [S 69–6, type].

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Oogonium ornamentation

Species with ornamented oogonia are present in

- each of the clades with globose sporangia

- the clade with contiguous spg

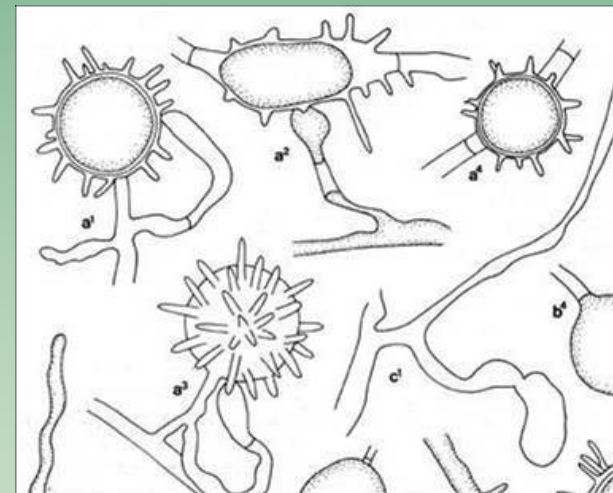- in none of the clades with filamentous sporangia

Oogonium ornamentation

Ornamentation of oogonia in Clade F is typically digitate

Pythium spinosum

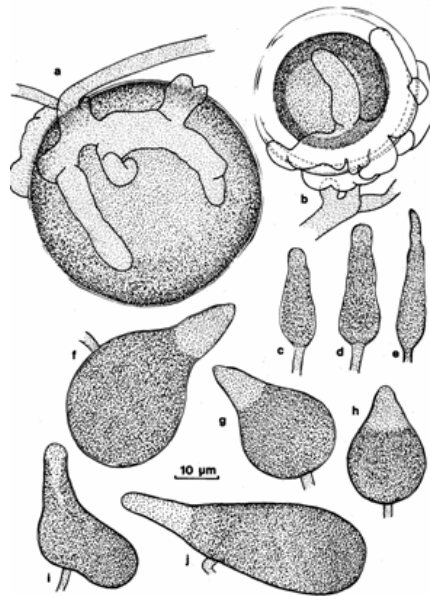# Correlation of clustering and other morphological characters

insidiosum CBS57485 ITS
grandisporangium CBS28679 ITS
}**C**

54

Clade C: Morphology and habitat very different; phylogenetic relatedness not confirmed by COI and showing differences between Maximum Likelihood and Parsimony analyses for LSU.
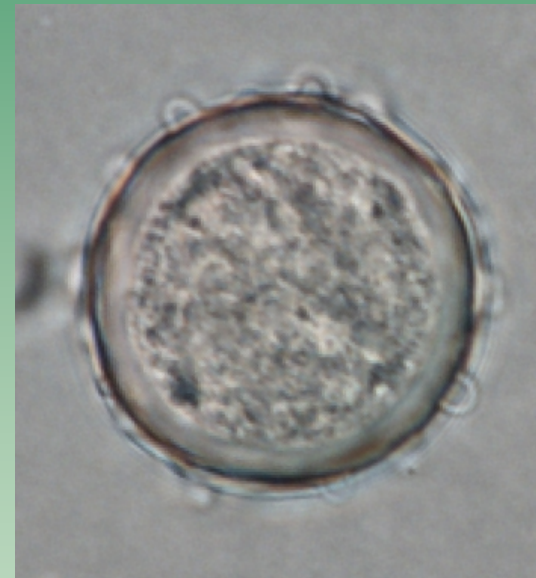

Fig 2. Pythium grandisporangium Fell & Master.-- a, b.
Oogonia.--c-e. Young, developing sporangia.--f-j. Mature
sporangia.

10 µm

P. grandisporangium

An
Ft
Oom
Oos
a
b
c
d
e
f
10 µm
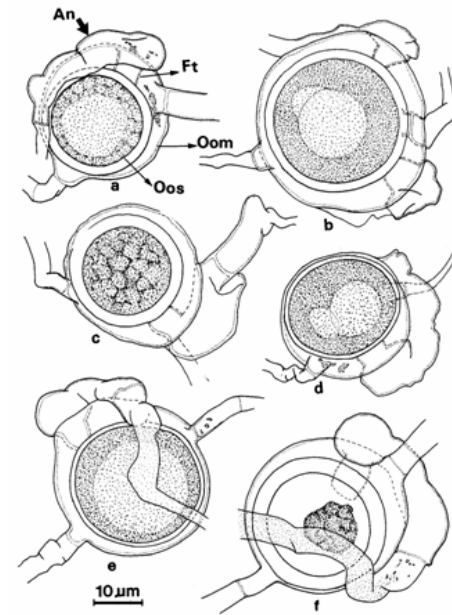
P. insidiosum

Oogonium ornamentation
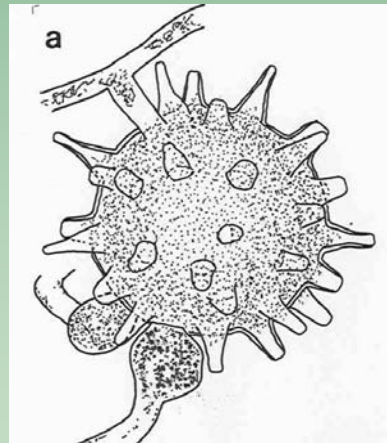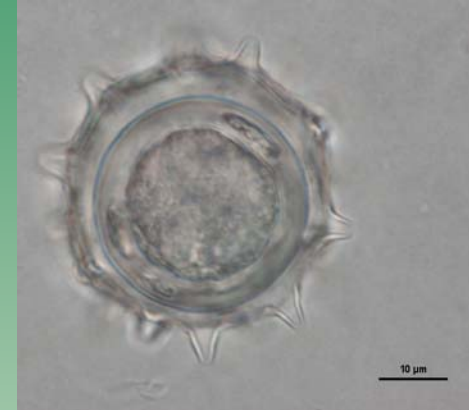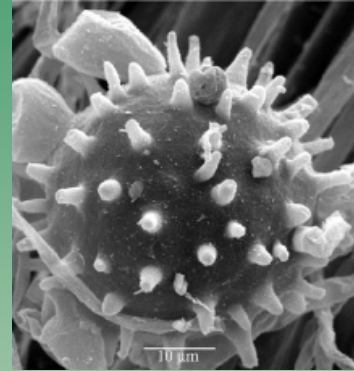

Pythium carbonicum
clade K

Oogonium ornamentation

P. erinaceus
clade E

cross septa are present in part of
the spines in Pythium ernaceus,
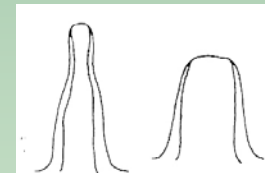P. echinulatum, P. radiosum, and
P. ornacarpum

Oogonium ornamentation

P. jasmonium sp. nov.
clade J

Oogonium ornamentation

Pythium solare sp. nov.
Clade I

50 changes

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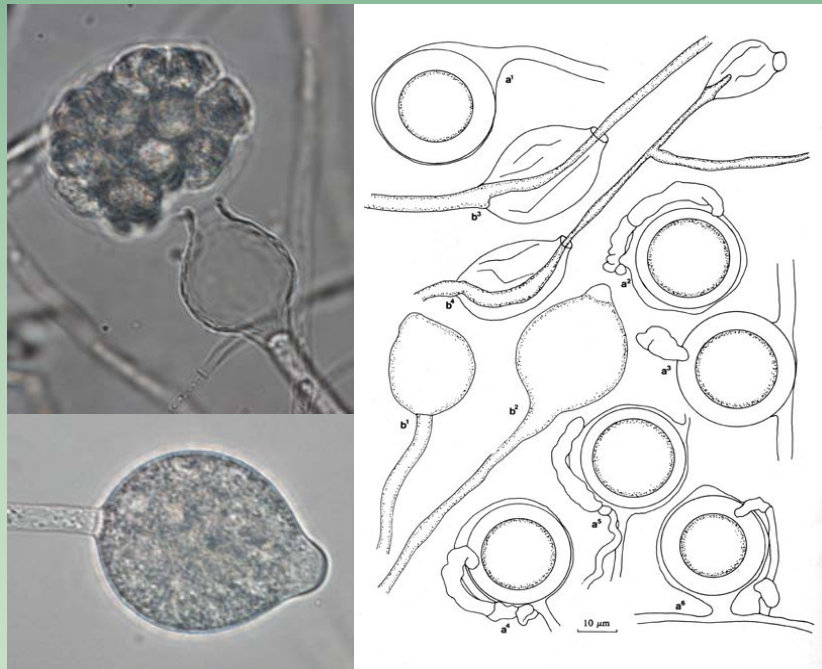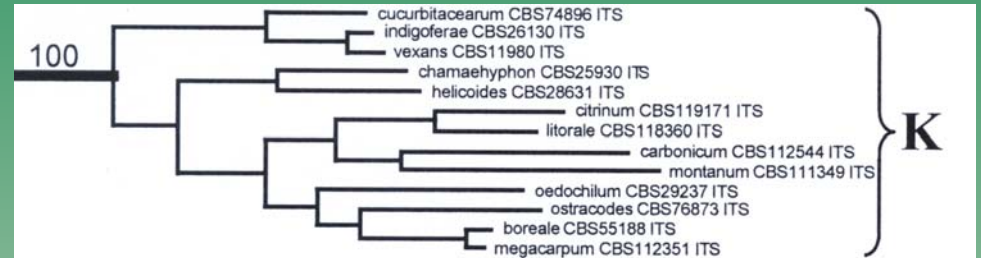*Oogonium ornamentation*
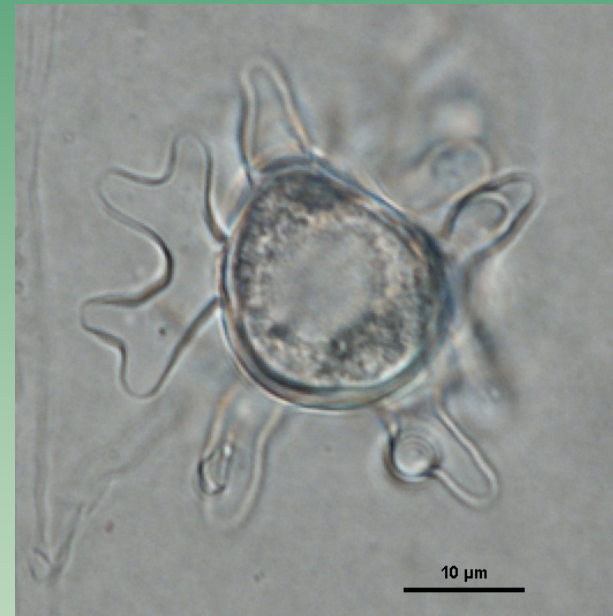
Pythium paddicum
Clade G

10 μm

Correlation of clustering and other morphological characters

Correlation of clustering and other morphological characters

Clade K: sporangia globose to ovoid with papilla and often proliferating internally, large, oogonia, thick-walled oospores, 1–2 elongate antheridia, laterally applied to the oogonium.


Sequence analysis shows this clade to be closer to *Phytophthora*.

Sporangia and oogonia may show similarity to *Phytophthora*, however, zoospore discharge is *Pythium*-like.
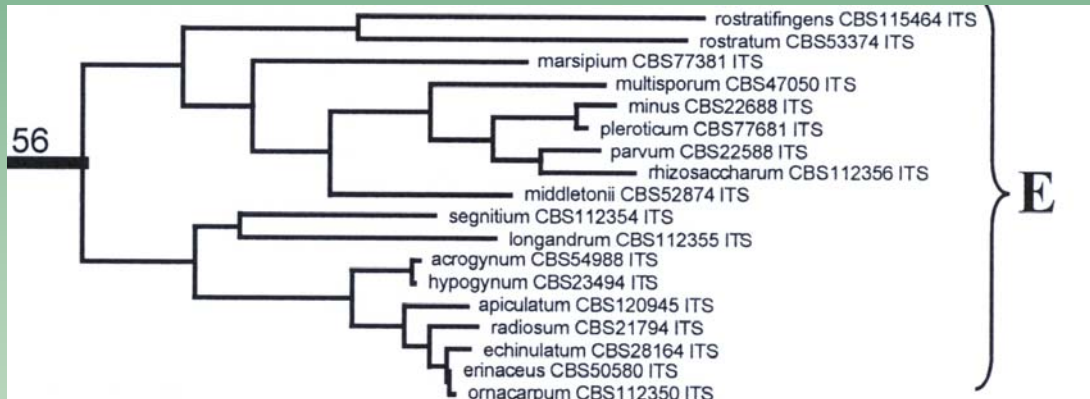
The clade represents a genus intermediate between *Phytophthora* and *Pythium* for which the name *Phytopythium* is proposed.
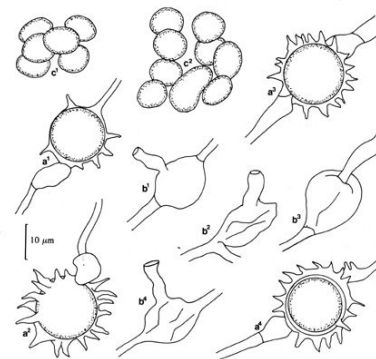

P. carbonicum   P. ostracodes

Correlation of clustering and other morphological characters
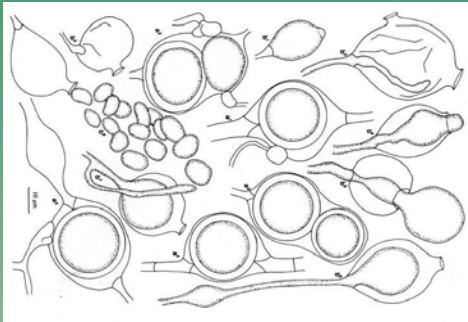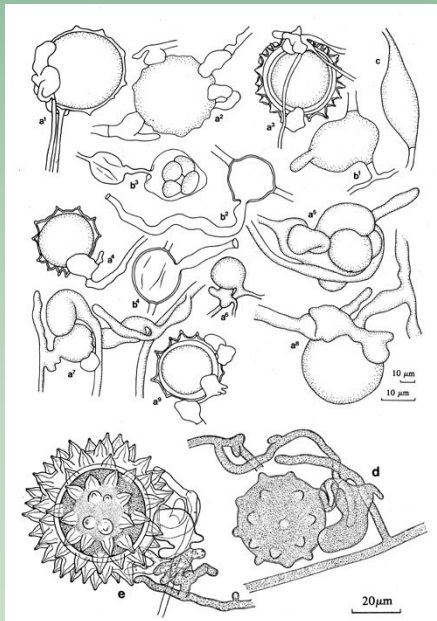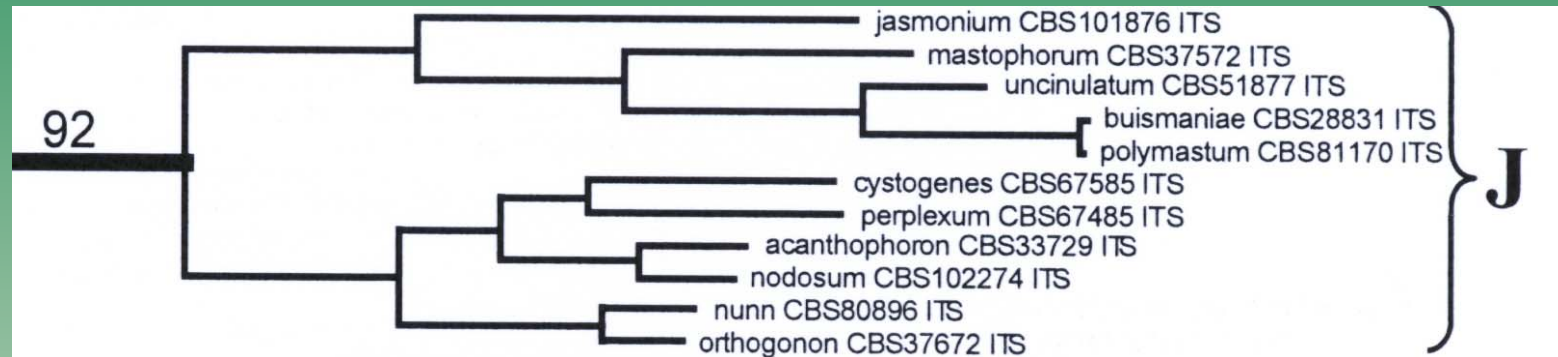

P. multisporum

Clade E: *P. rostratifingens*-clade: globose, proliferating sporangia or globose hyphal swellings. Oogonia smooth
P. segnitium-clade: ovoid to elongate, nonproliferating sporangia; mostly a single, hypogynous antheridium.

P. echinulatum

Correlation of clustering and other morphological characters
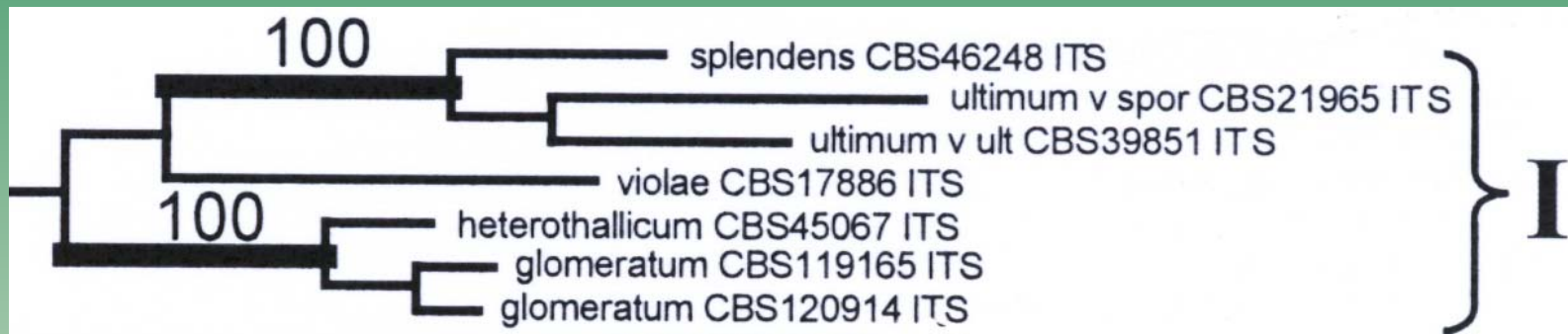

P. polymastum

Clade J: only the subclade *P. jasmonium-polymastum* is morphologicaly distinct: large oogonia with conical spines, thick-walled oospores, large globose sporangia.
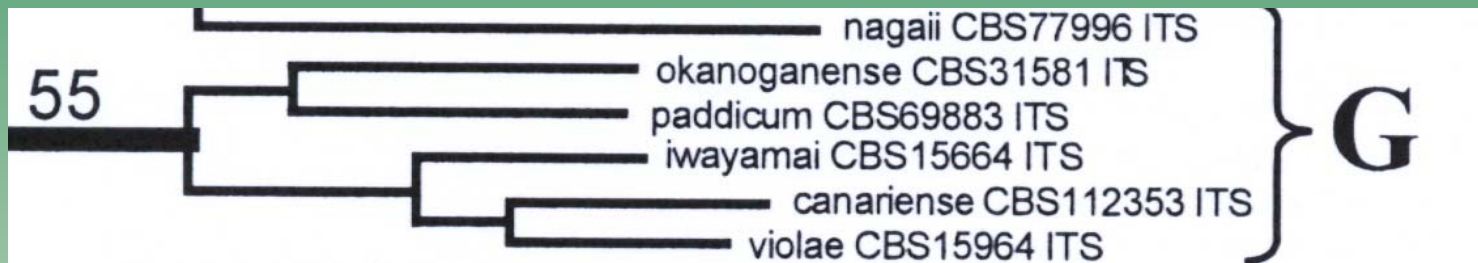
Correlation of clustering and other morphological characters

Clade I: No obvious common morphological characters in this clade. Most species do not produce zoospores.

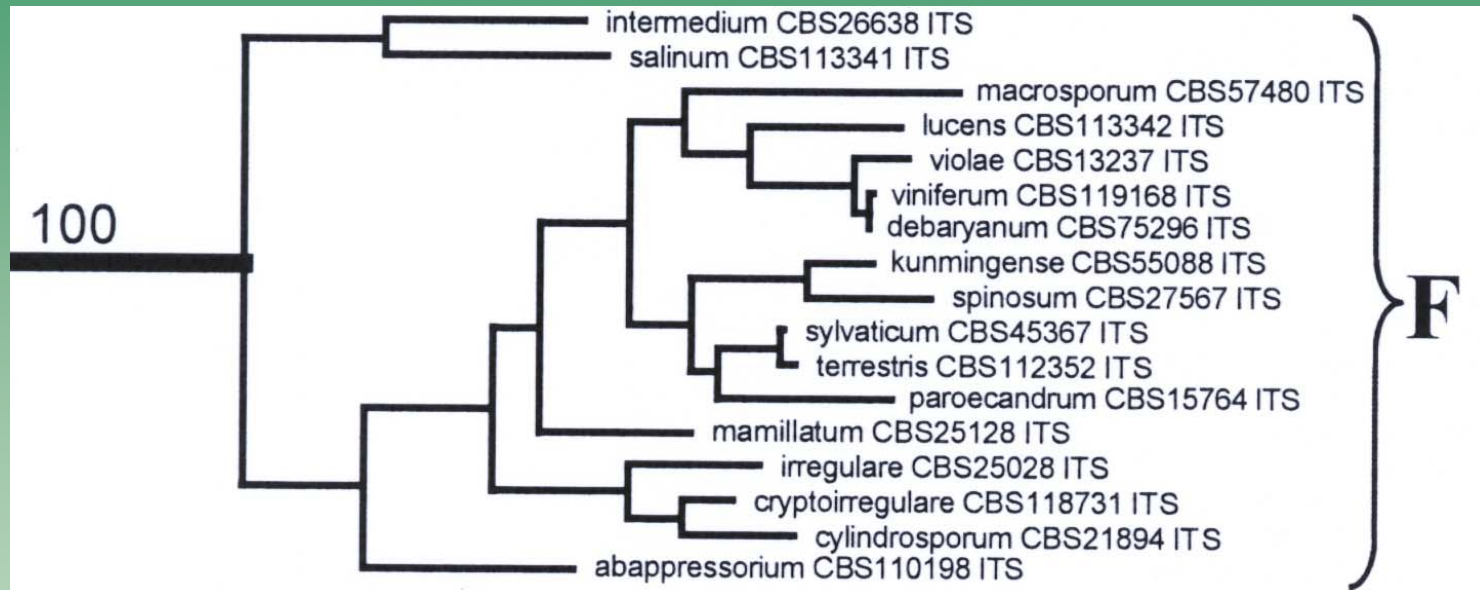# Correlation of clustering and other morphological characters

Clade G: ovoid, internally proliferating sporangia and smooth oogonia. Ornamentation on the oogonia of *P. paddicum* is unique. Other characters variable. Mainly from monocotyledons in Asia and the USA.

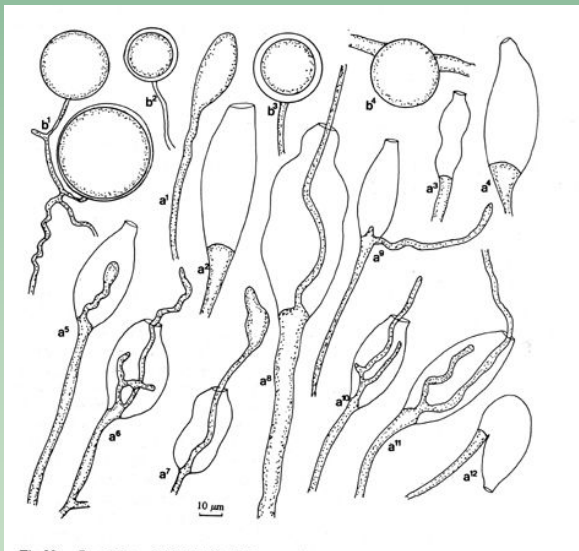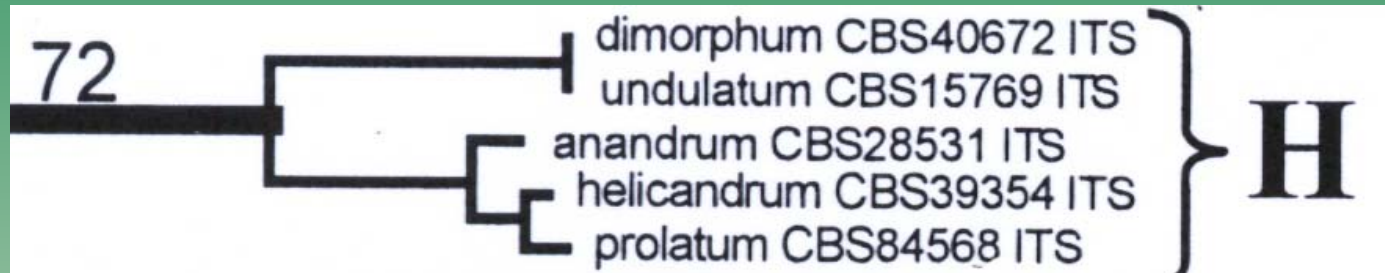# Correlation of clustering and other morphological characters

Clade F: important, fast growing phytopathogenic species with a worldwide distribution. Globose non-proliferating sporangia or hyphal swellings present. Most species do not or rarely produce zoospores.
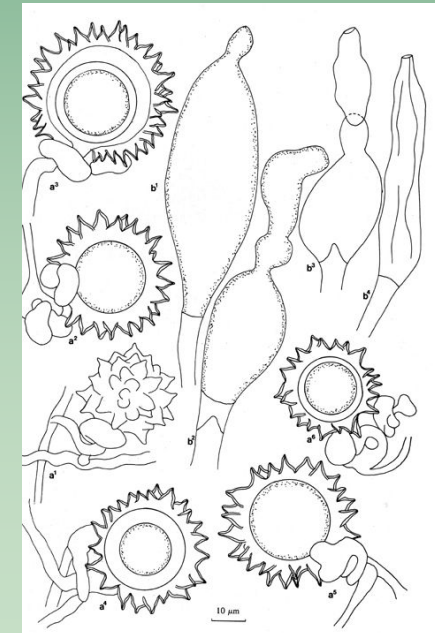
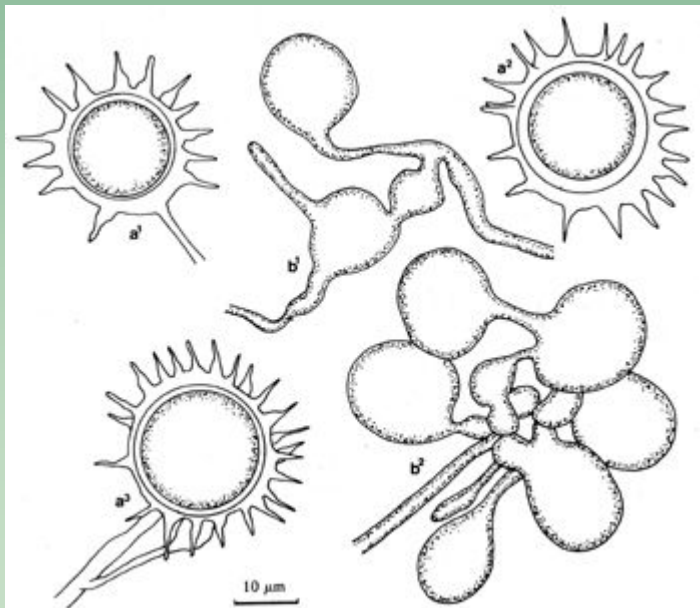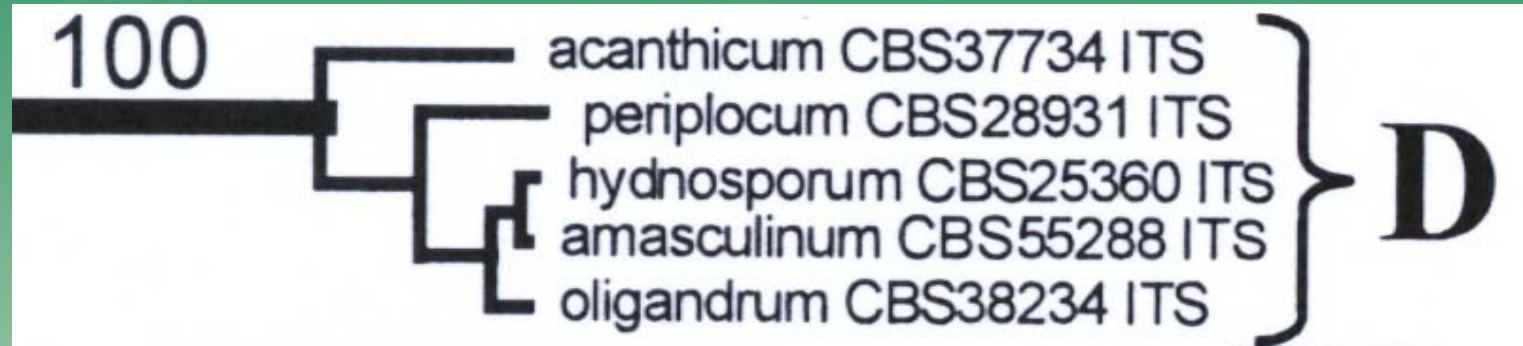# Correlation of clustering and other morphological characters

Clade H. Very large, ovoid to elongate, internally proliferating sporangia and ornamented oogonia.

P. undulatum

P. helicandrum

Correlation of clustering and other morphological characters
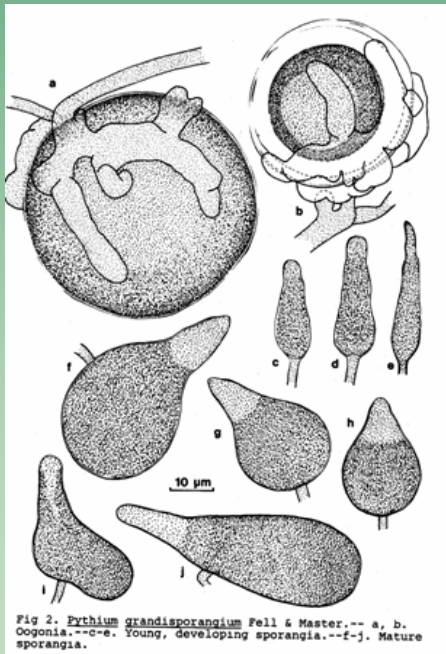

Clade D: Contiguous sporangia, oogonia with acute spines. Antheridia absent or entirely attached to oogonium, constricted. Mycoparasites.
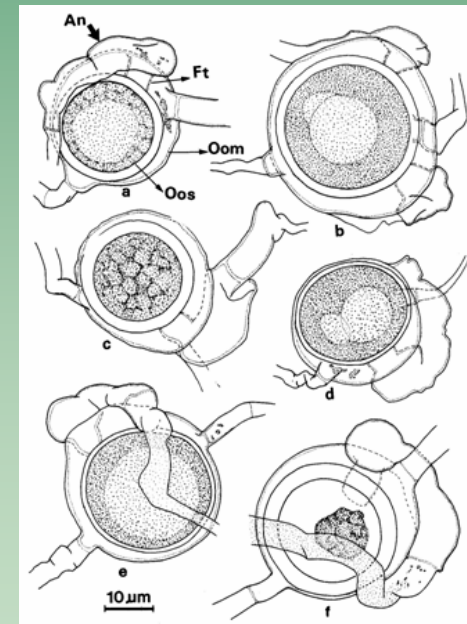
P. oligandrum

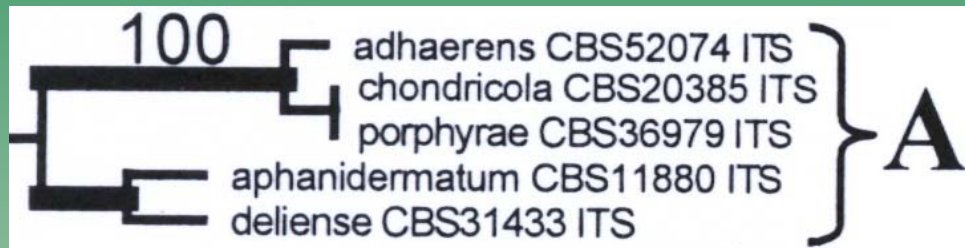# Correlation of clustering and other morphological characters

Clade C: Morphology and habitat very different; phylogenetic relatedness not confirmed by COI and showing differences between Maximum Likelihood and Parsimony analyses for LSU.
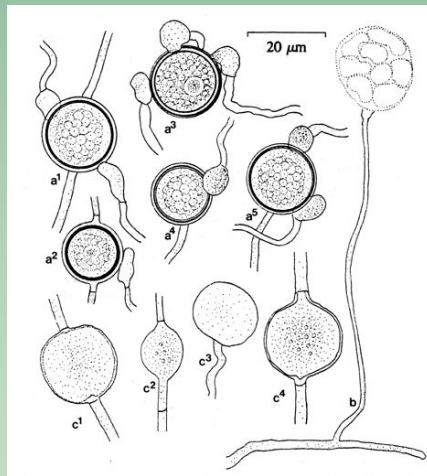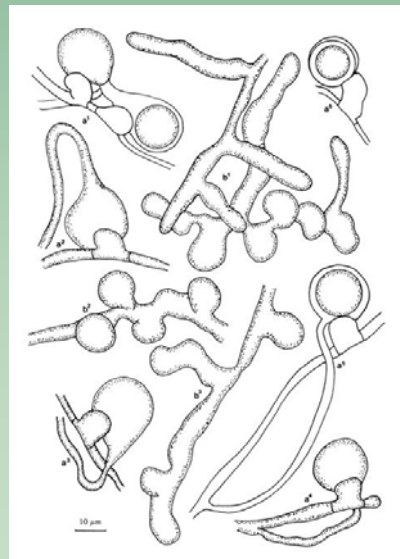
P. grandisporangium

P. insidiosum

Correlation of clustering and other morphological characters

Clade A: *P. adhaerens* cluster: filamentous non-inflated sporangia, very slow growth. From algae. *P. aphanidermatum* cluster: filamentous inflated sporangia, very fast growth, often intercalary antheridia. From dicotyledons in warmer regions.
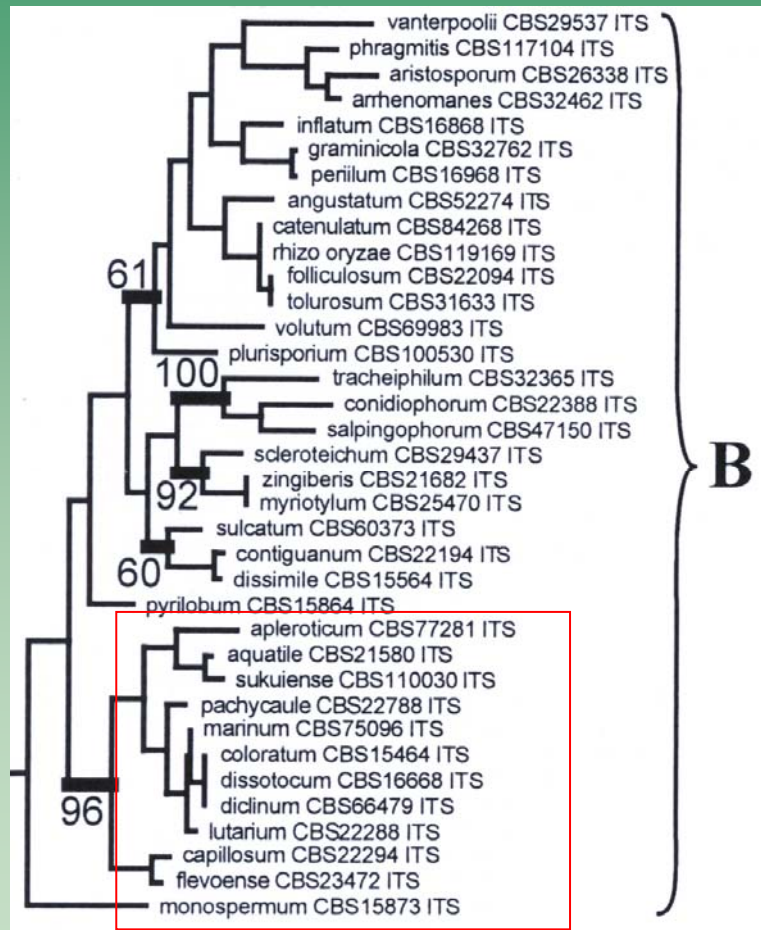
P. porphyrae

P. deliense

Correlation of clustering and other morphological characters


Clade B

P. vanterpoolii cluster: filamentous, inflated sporangia; smooth oogonia. Most other characters variable. Predominantly from grasses.

P. apleroticum-cluster: filamentous non-inflated sporangia, smooth oogonia, moderate growth rate.

"Species specific" morphology:

- ornamentation: P. paddicum, P. carbonicum, P. solare, P. jasmonium

- segmentation: insidiosum

- deciduous sporangia: intermedium, attrantheridium
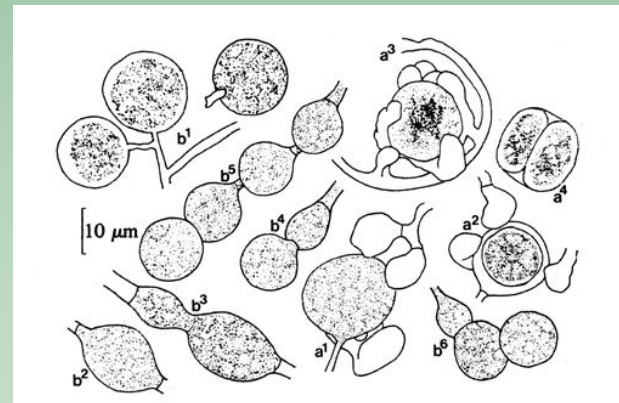
P. intermedium

Characters that show no significant correlation with clustering:

- sporangium size
- antheridium origin and number
- oogonium size
- oospore wal thickness
- apressoria
- heterothallism
- etc.

Conclusions:

- Sporangium type is evolutionary significant
- the contiguous type is a distinct sporangium type
- oogonium ornamentation is polyphyletic but shows correlation with some (sub-)clades
- some clades are characterized by a subset of characters
- most characters do not correlate with evolutionary patterns but they are useful for identification