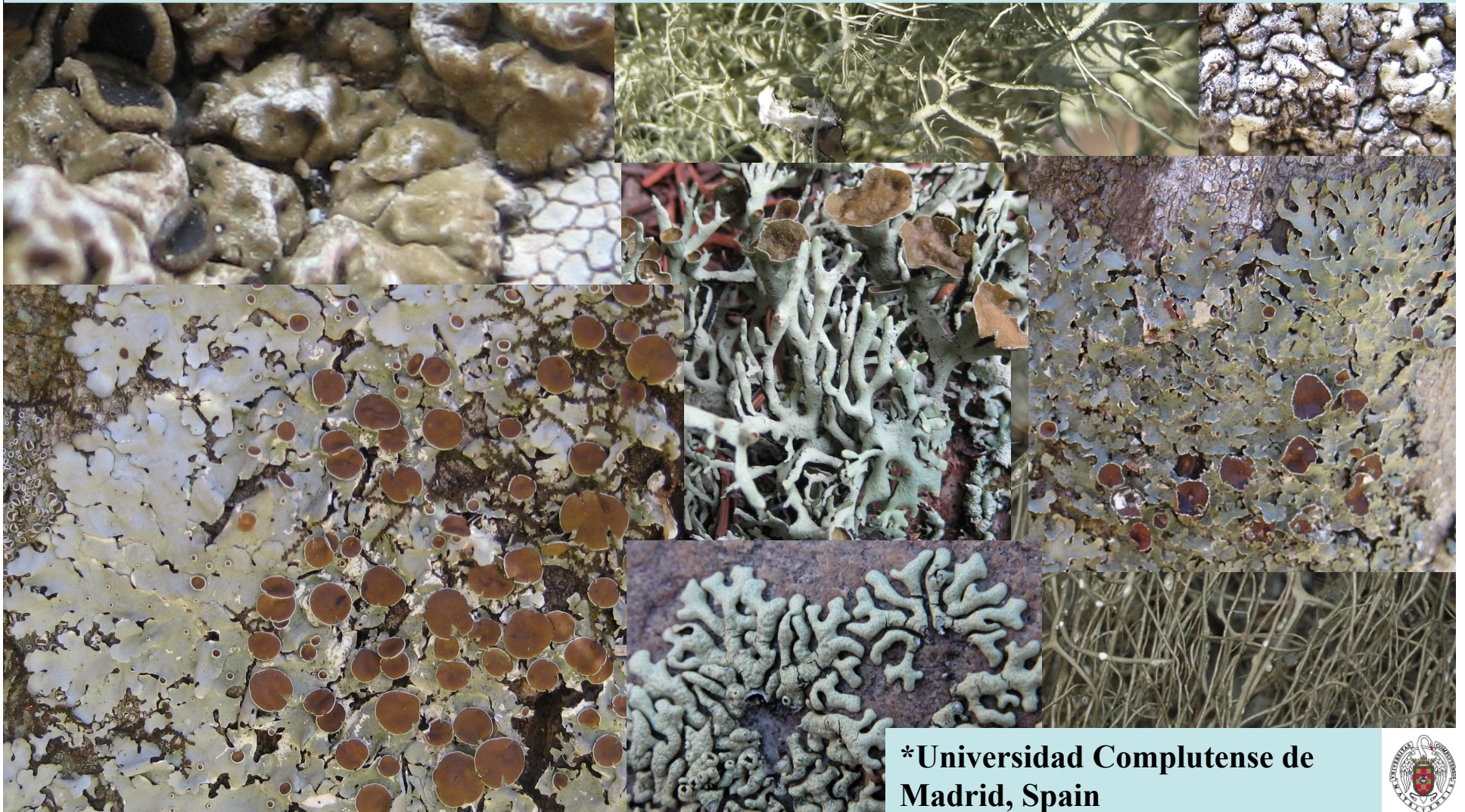


# An overview on hidden diversity in lichens: Parmeliaceae

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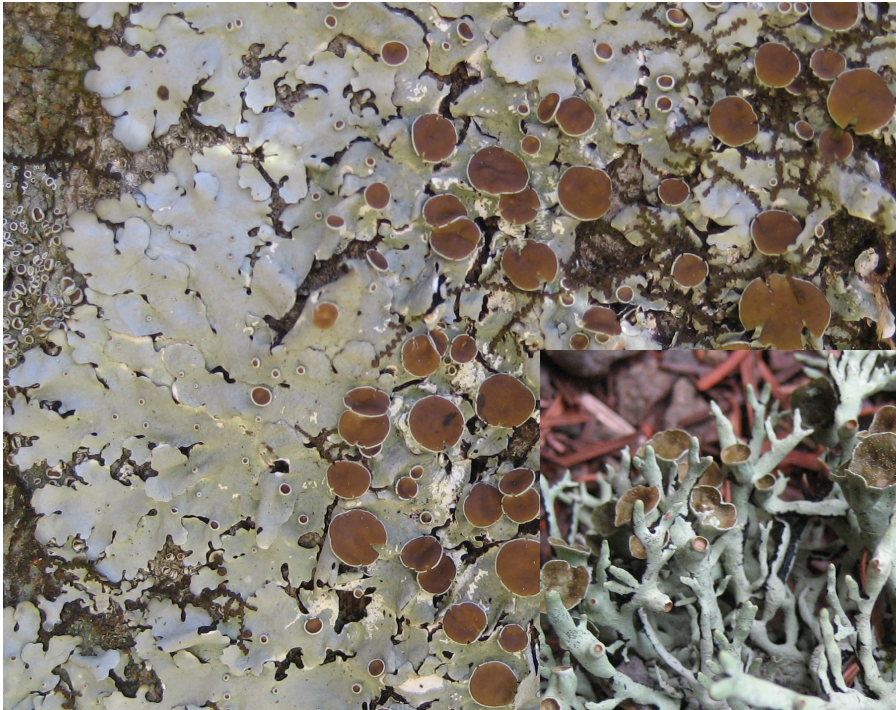
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- **Parmeliaceae is one of the largest and diverse family in Ascomycota with about 2000 described species and have wide distribution (Crespo et al. 2007).**
  
- **Traditionally, reproductive mode (asexual; isidia, soredia and sexual; apothecia) has been frequently used to differentiate species in Parmeliaceae and in lichens in general.**
  
- **Medullary and cortical chemistry has also been used to distinguished species in Parmeliaceae, even cortical chemistry has been used to segregate genera (e.g. *Flavopunctelia* vs *Punctelia*, *Bulbothrix* vs *Relicina*).**



➤ **Do Parmeliaceae have cryptic species?**



➤ **Are they common in particular taxonomic groups, or species with different reproductive modes, and distribution area?**



➤ **As it is happening in other fungal groups; Parmeliaceae also presents high number of cryptic species.**

➤ **Parmeliaceae is the first member in lichenized fungi where cryptic lineages were detected (Kroken & Taylor 2001 *Letharia vulpina-L. columbiana*). A total of 500 described species are sequenced out of c. 2000 species (data taken from NCBI till 28 07 10). Till date about 70 cryptic lineages that could be species, have been detected, although some of them have not been described formally.**

➤ **Moreover, new cryptic lineages were found in each and every species that have been studied at species level.**



➤ I present some examples in the following order:

*Sexual “cosmopolitan” species*

*Vegetative propagules (isidiate) cosmopolitan species*

*Vegetative propagules (sorediate) cosmopolitan species*

*Sorediate vs apotheciate species “species pair” (Contrary to cryptic incident)*



*Sexual “cosmopolitan” species*



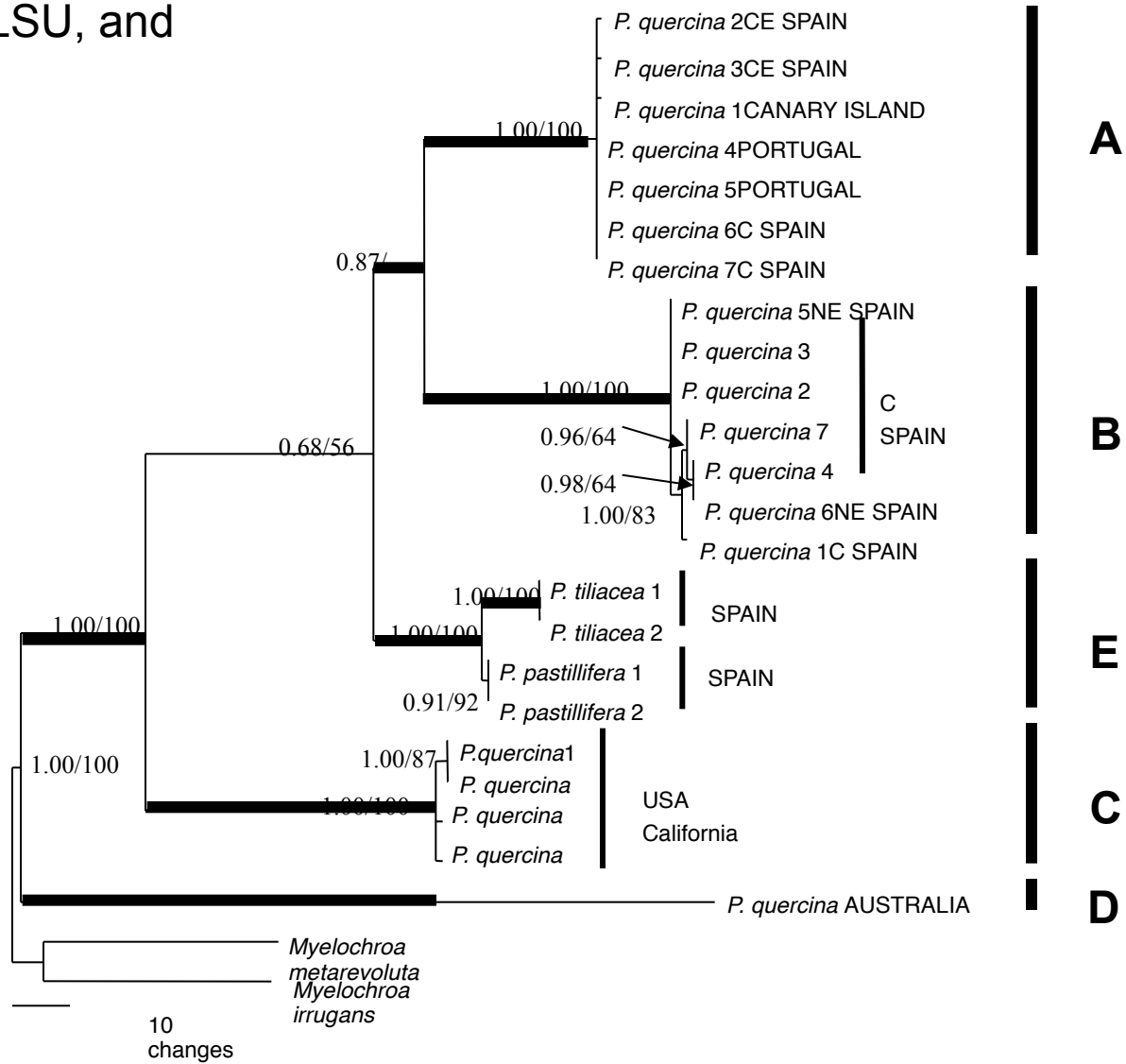
***Parmelina quercina***

**Geographic distribution of a “cosmopolitan” species**



*Sexual “cosmopolitan” species*

Molecular phylogenetic tree based on 3 genes (nuITS, LSU, and mtSSU)

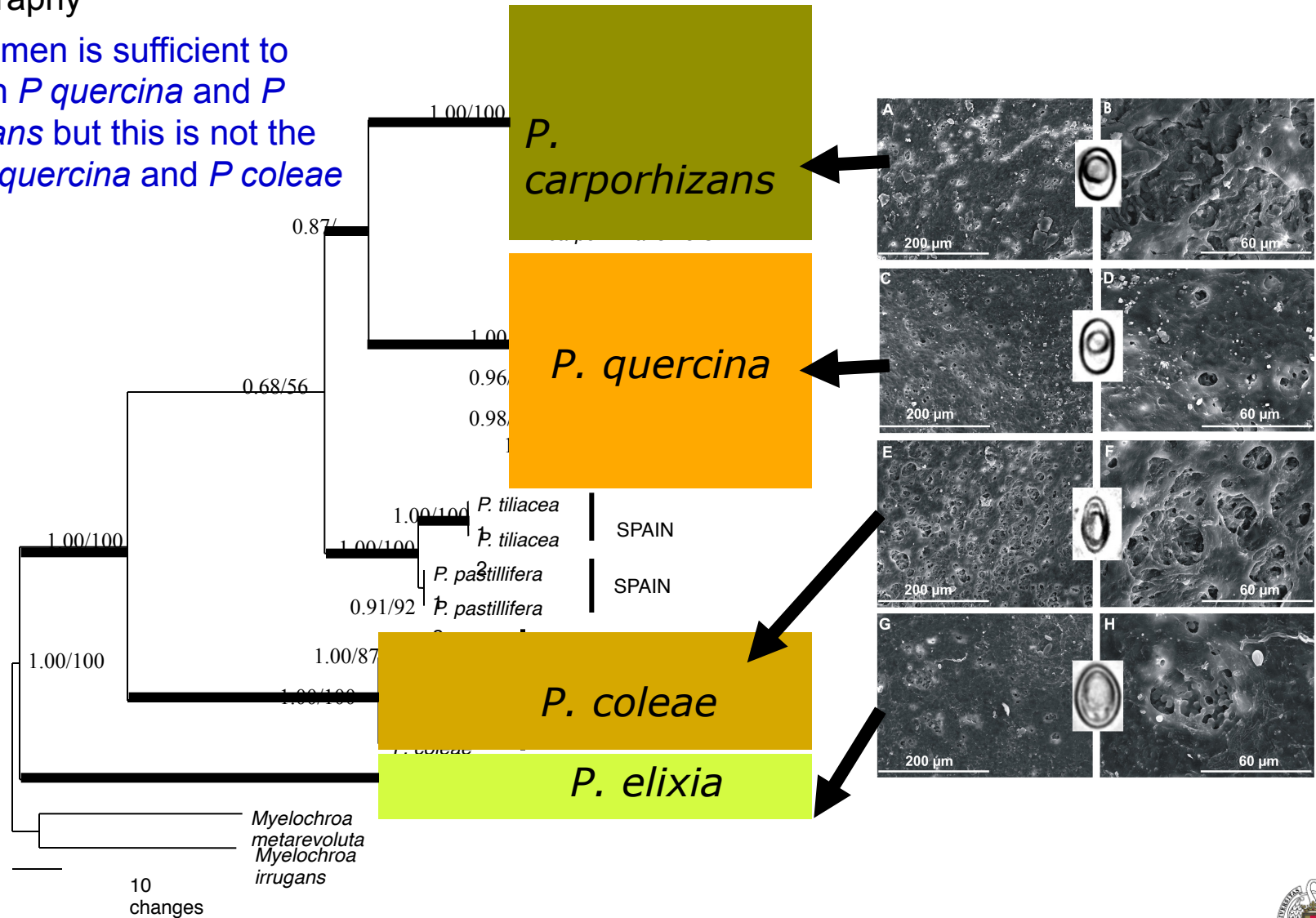


## Sexual “cosmopolitan” species

Morphological characters of clades:

Ascospores, pored epicortex structure and geography

One specimen is sufficient to distinguish *P. quercina* and *P. carpophizans* but this is not the case of *P. quercina* and *P. coleae*



Argüello et al. 2007 *Biol. J. Linn. Soc.* 91: 455-467





*Sexual “cosmopolitan” species*

## Geographical pattern of different clades



● *P. coleae*

● *P. carporhizans*

● *P. elixia* = *Austroparmelina*

● *P. quercina*

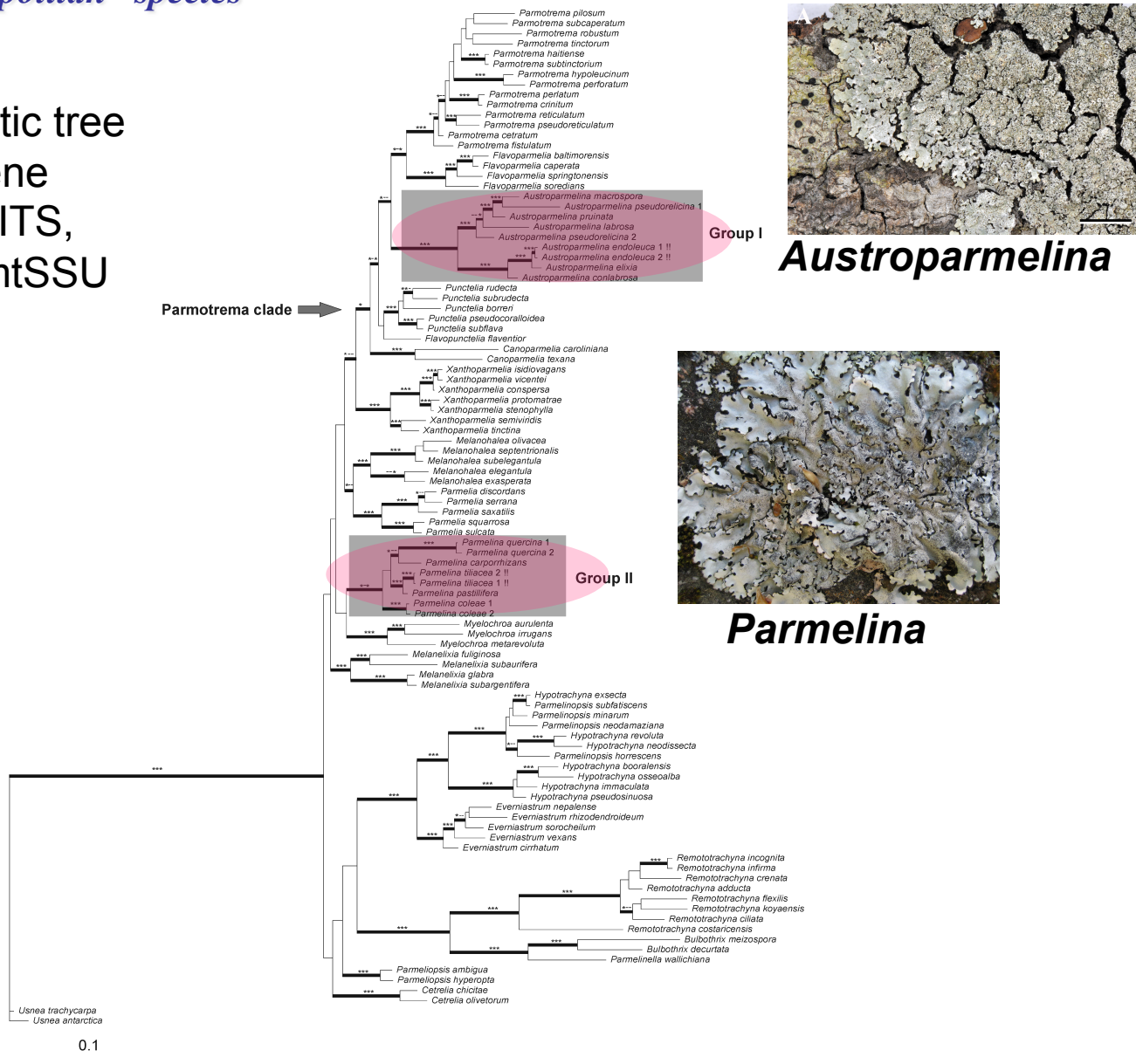


*Parmelina carporhizans*



## Sexual “cosmopolitan” species

Molecular  
Phylogenetic tree  
of three gene  
dataset nuITS,  
LSU and mtSSU



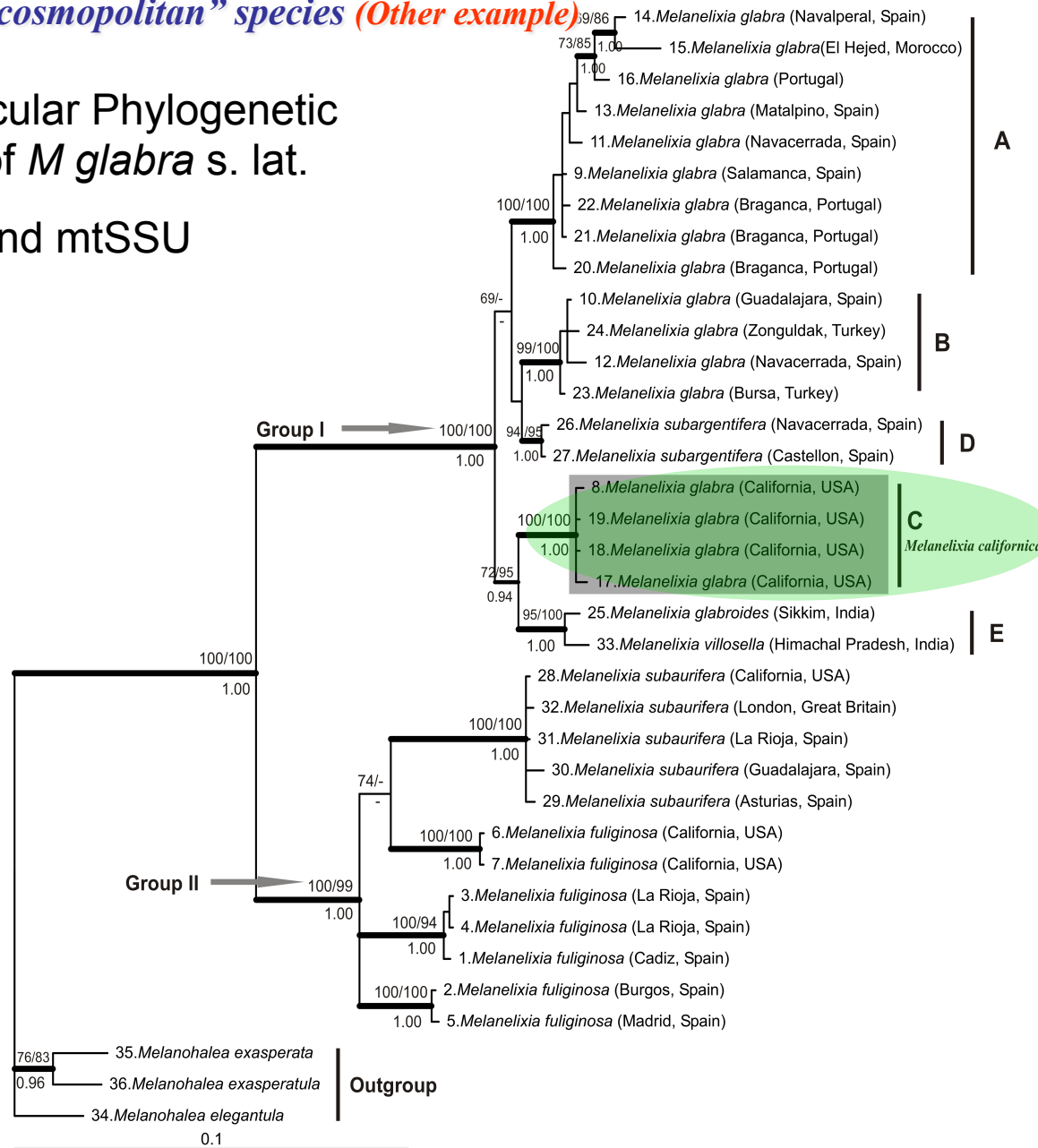
Crespo et al. 2010 *Systematics and Biodiversity* 8: 209-221



Sexual “cosmopolitan” species (Other example)

Molecular Phylogenetic tree of *M. glabra* s. lat.

ITS and mtSSU



*Melanelixia californica*

Fig. 1

Divakar et al. 2010 *Fungal Diversity* 8: 209-221



*Sexual “cosmopolitan” species*



***Melanelixia californica***

***Melanelixia glabra***

Geography, ascospores and cortical hairs on upper surface

One specimen is not sufficient to distinguish both species morphologically while sequence from single specimen is adequate to recognize the new lineage

Divakar et al. 2010 *Fungal Diversity* 42: 47-55



*Vegetative propagules (isidiate) cosmopolitan species*

***Parmelia saxatilis* s. lat.**



*Parmelia saxatilis* (Linnaeus 1753) An isidiate species with simple rhizines on lower side



*Vegetative propagules (isidiate) cosmopolitan species*

**Parmelia saxatilis s. lat.**

□ Recent molecular studies detected three species within (two “cryptic” species): *Parmelia saxatilis* s. str.; bipolar (circumpolar in Arctic and Antarctic), *P. ernstiae*; temperate in W. Europe and *P. serrana*; Mediterranean Europe and N. Africa (Thell et al. 2002, Molina et al. 2004)



***Parmelia serrana***



***Parmelia ernstiae***

**No morphological differences**

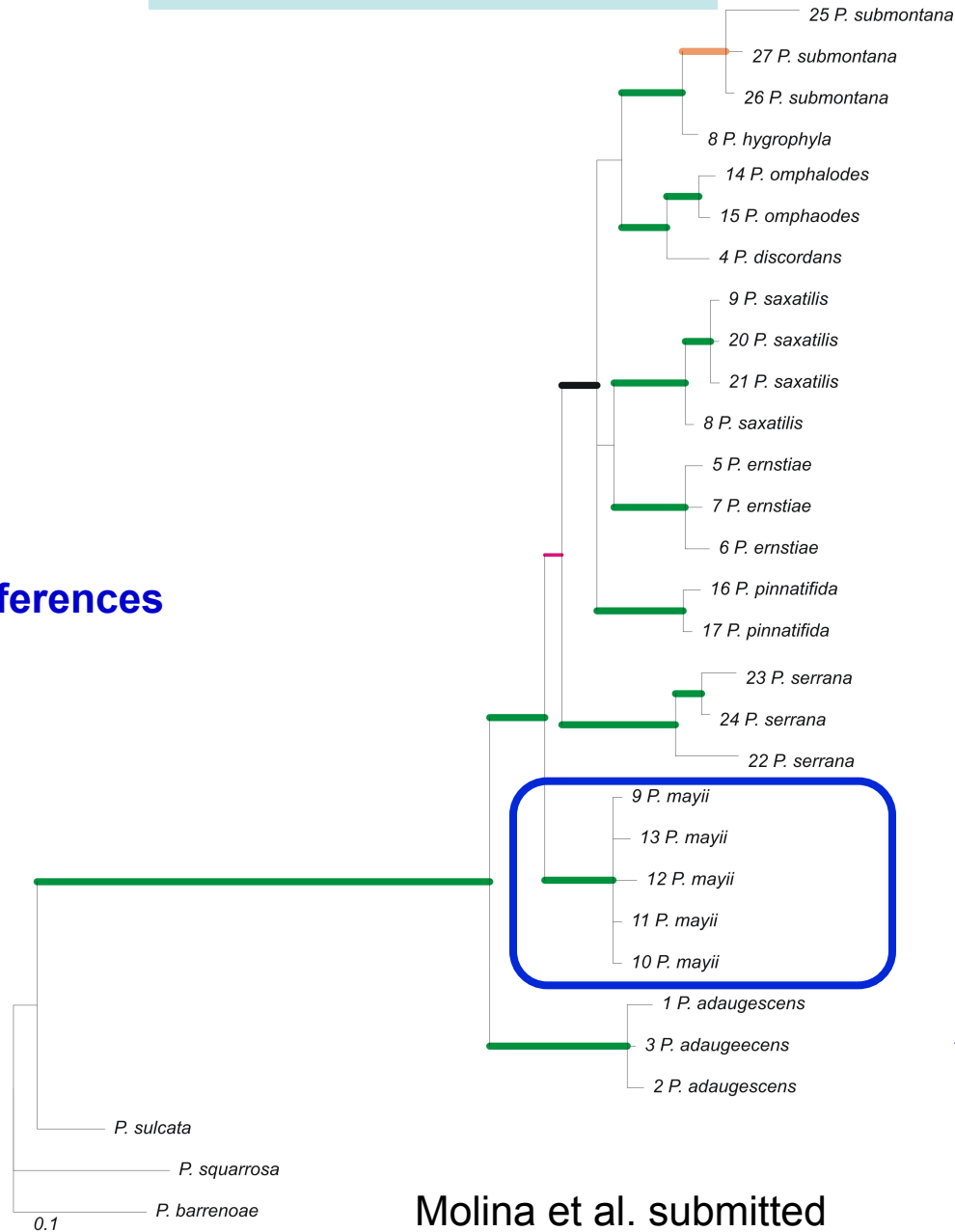


*Vegetative propagules (isidiate) cosmopolitan species*

**Parmelia saxatilis s. lat.**

Molecular phylogenetic tree based on nuITS and Beta-tubulin

No morphological differences were found



*Parmelia mayii*

Low cryorotemperate ultrahyperhumid areas in North America



*Vegetative propagules (isidiate) cosmopolitan species*

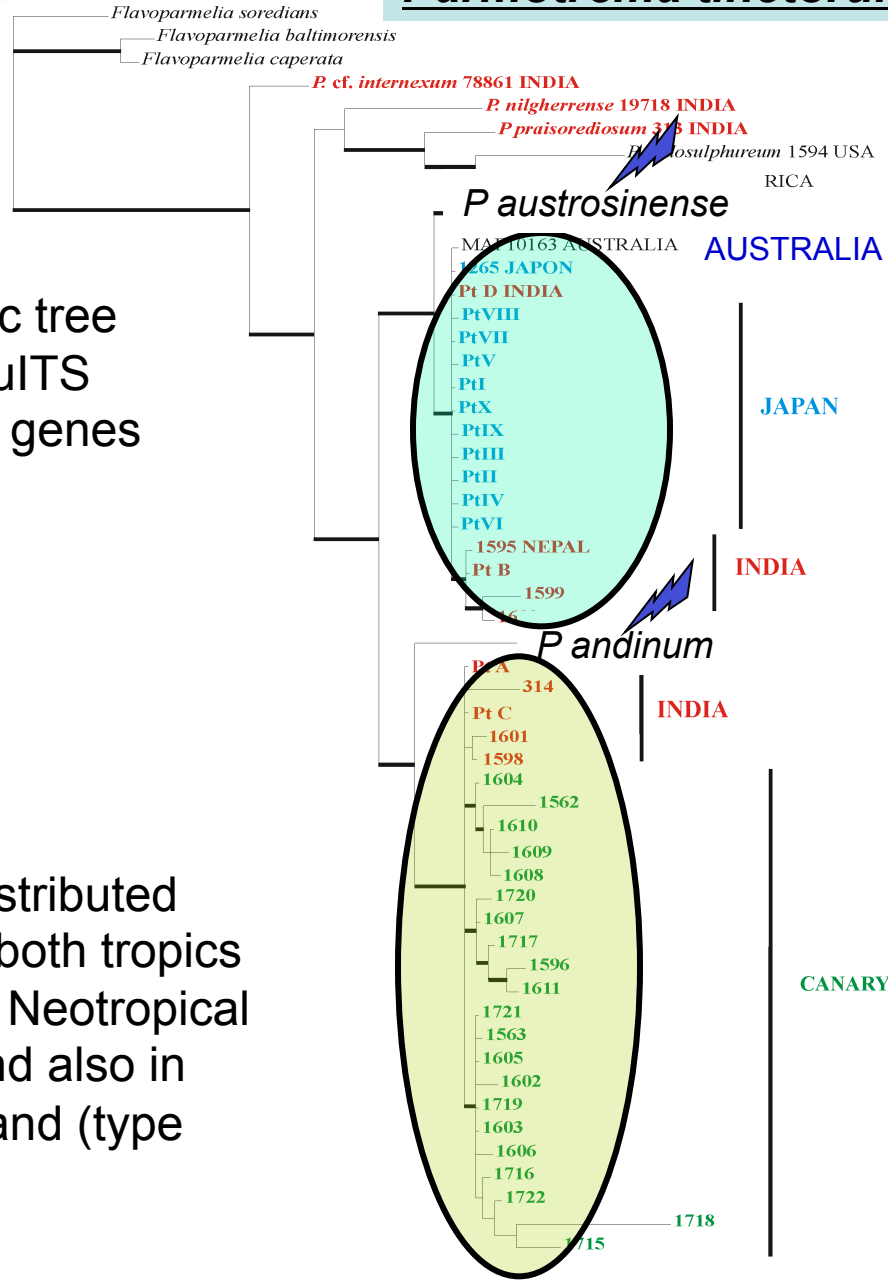
*(Other example)*

**Parmotrema tinctorum**



*Parmotrema tinctorum*

Molecular phylogenetic tree based on nuITS and mtSSU genes



A widely distributed species in both tropics (paleo and Neotropical regions) and also in Canary Island (type locality)

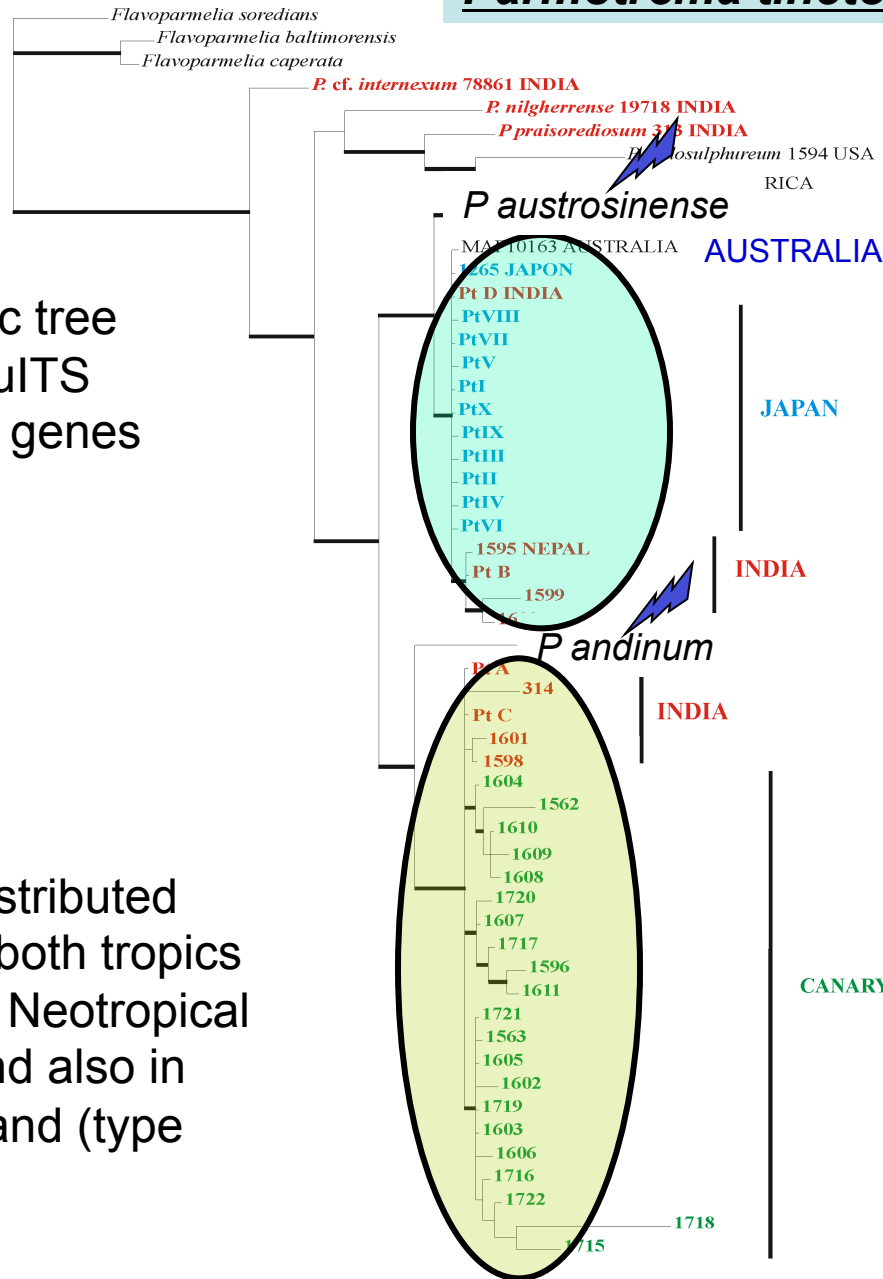




*Vegetative propagules (isidiate) cosmopolitan species*

**Parmotrema tinctorum**

Molecular phylogenetic tree based on nuITS and mtSSU genes



A widely distributed species in both tropics (paleo and Neotropical regions) and also in Canary Island (type locality)



Again no morphological differences were found



*Vegetative propagules (sorediate) cosmopolitan species*

**Parmelia sulcata s. lat.**



A sorediate species with  
squarrose rhizines on lower side



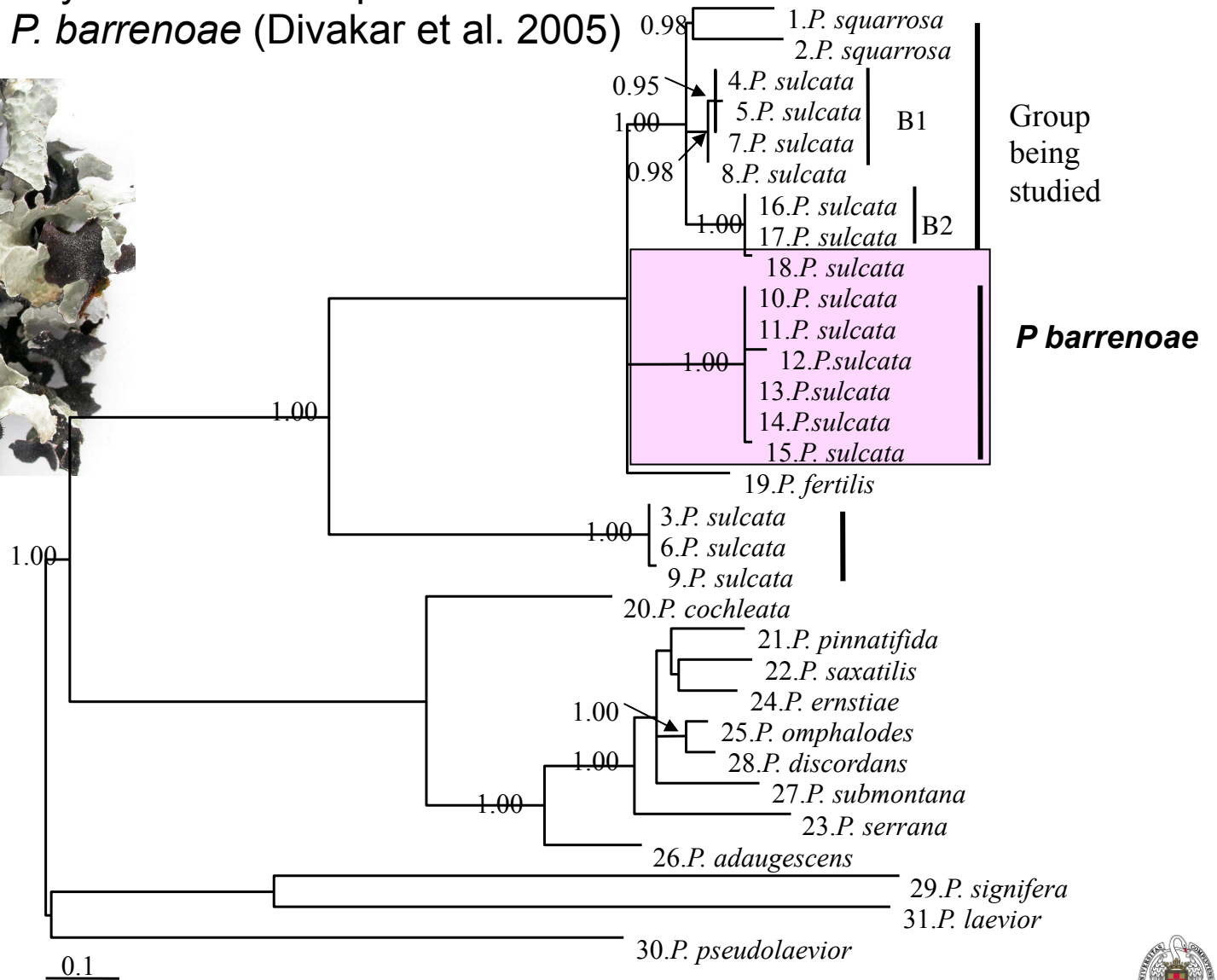
*Vegetative propagules (sorediate) cosmopolitan species*

**Parmelia sulcata s. lat.**

□ Recent molecular study detected two species within *Parmelia sulcata* and *P. barrenoae* (Divakar et al. 2005)



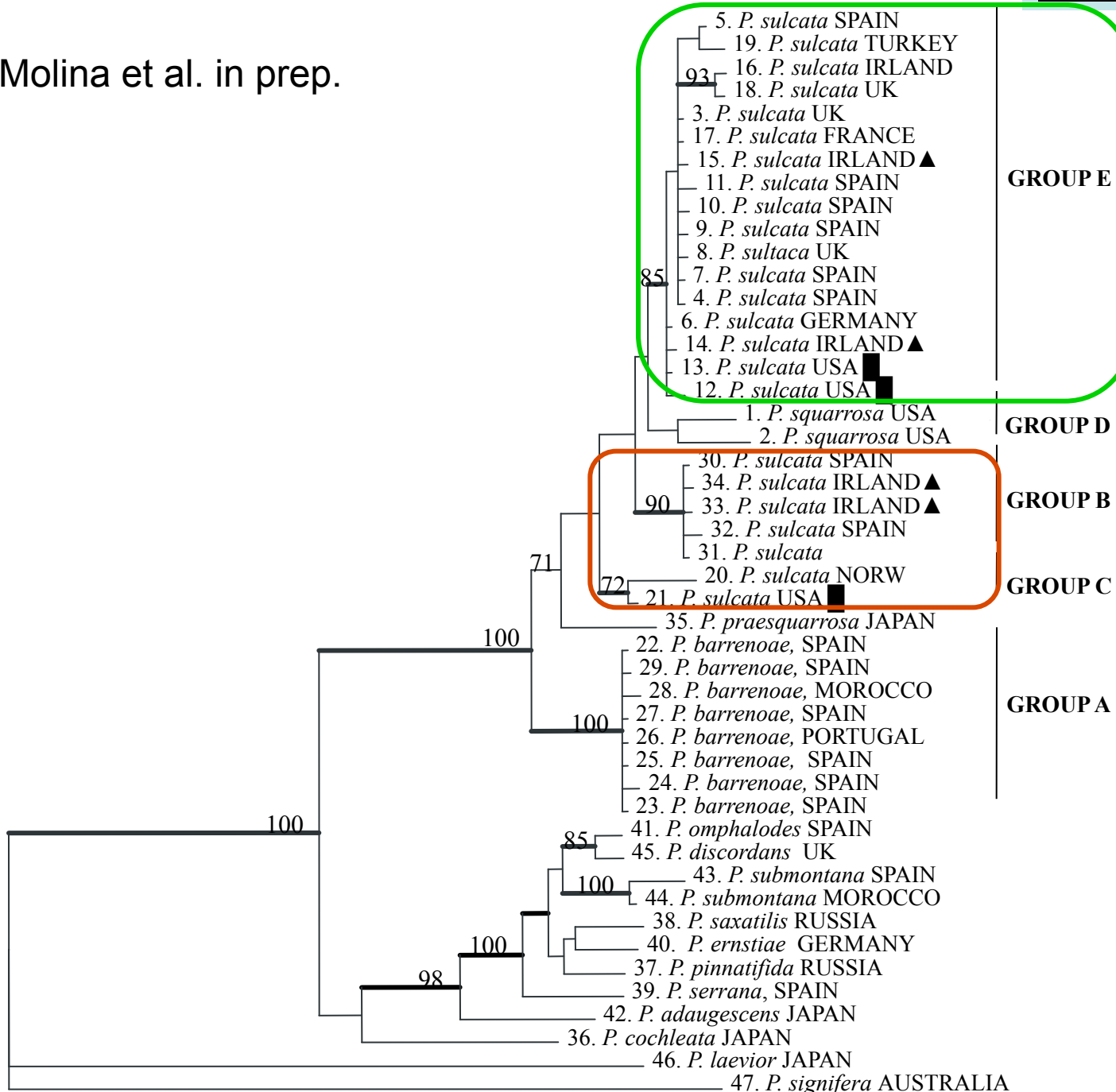
***P. barrenoae***  
Europe and North Africa



Vegetative propagules (sorediate) cosmopolitan species

***Parmelia sulcata* s. lat.**

Molina et al. in prep.



*P. sulcata* s.str.  
 Neither morphology nor geographic differences resulted conclusive but only one sequence (ITS) is sufficient to detect the new lineage  
 New cryptic lineages

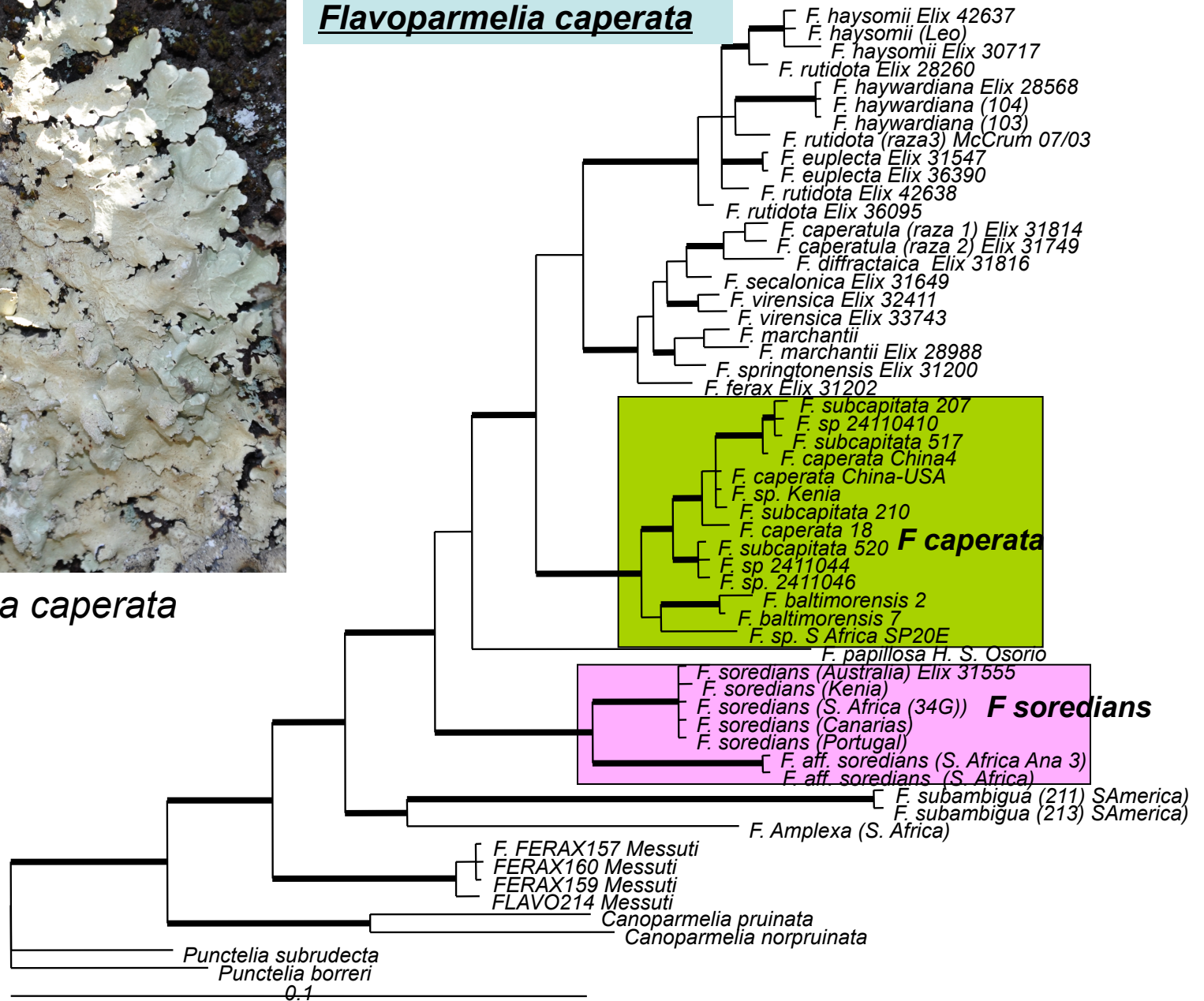


*Vegetative propagules (sorediate) cosmopolitan species*



*Flavoparmelia caperata*

***Flavoparmelia caperata***



*Vegetative propagules (sorediate) cosmopolitan species*

TCS analysis (74 samples)

**Flavoparmelia caperata**

***Flavoparmelia caperata* s. lat**

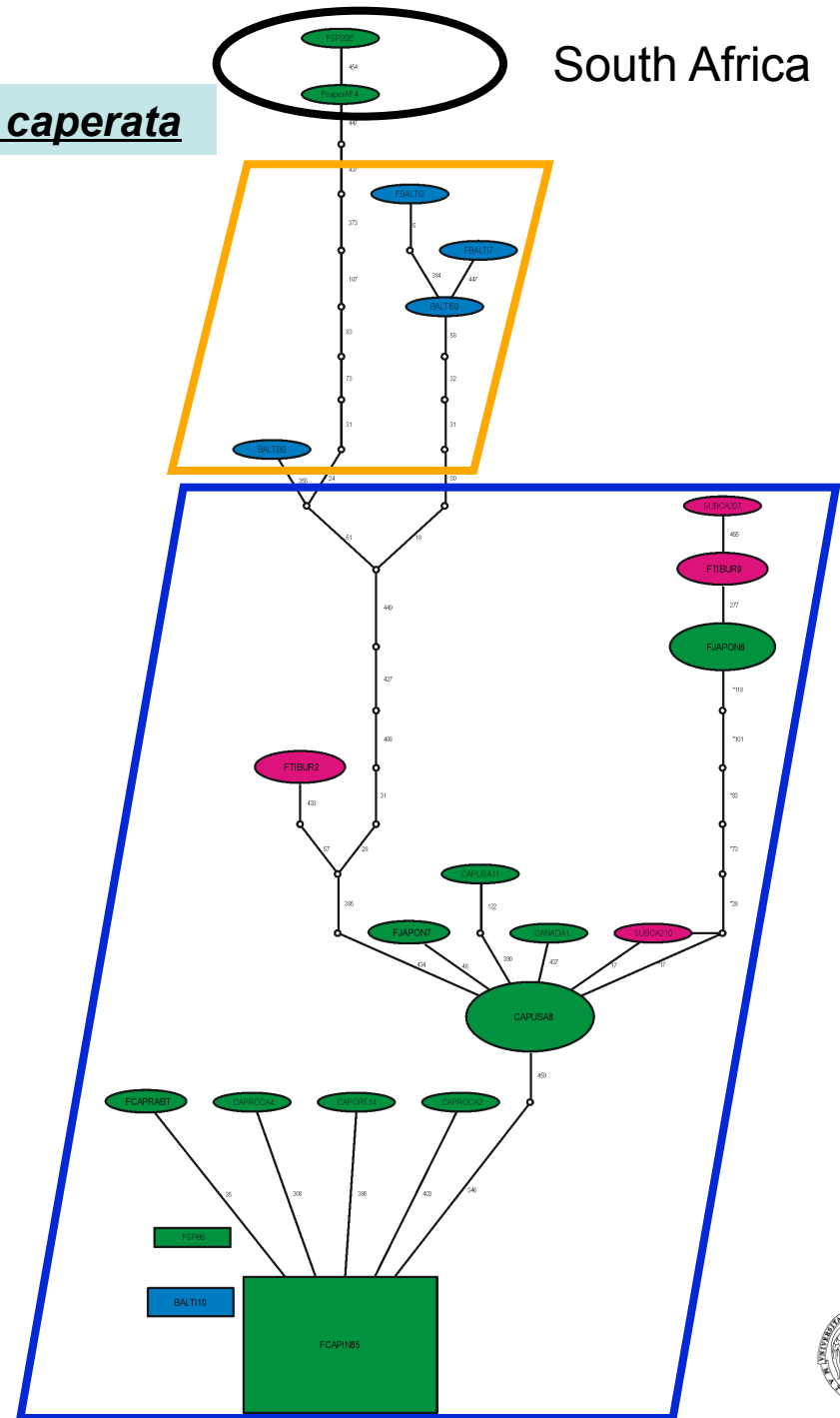
***F caperata:***

East Africa; Morocco, South Africa  
Asia; China, India, Iran, Japan, Turkey  
Europe; France, Germany, Italy, UK,  
Norway, Portugal, Spain  
North America; US, Canada

***F baltimorensis:***  
North America

***F subcapitata:***  
North America

Total number of haplotypes=22 of 74 samples analysed



*Sorediate vs apotheciate species “species pair” Contrary to cryptic incident*

- The term “*species pair*” ( Du Rietz 1924, Poelt 1963) or “primary” and “secondary” species has been used for closely related apotheciate and sorediate morphs.
- Recent molecular studies have shown that closely related apotheciate and sorediate morphs are not distinct lineages but belongs to single monophyletic group (A review by Crespo & Perez-Ortega 2009).
- Such as in Parmeliaceae, *Usnea florida* vs *U. subfloridana* (Articus et al. 2002), in other groups Physciaceae *Physcia aipolia* vs *P. caesia* (Myllys et al. 2001), *Physconia venusta* vs *P. perisidiosa* (Cubero et al. 2004, Divakar et al. 2007)



*Sorediate vs apotheciate species "species pair"*

TCS analysis (41 samples)

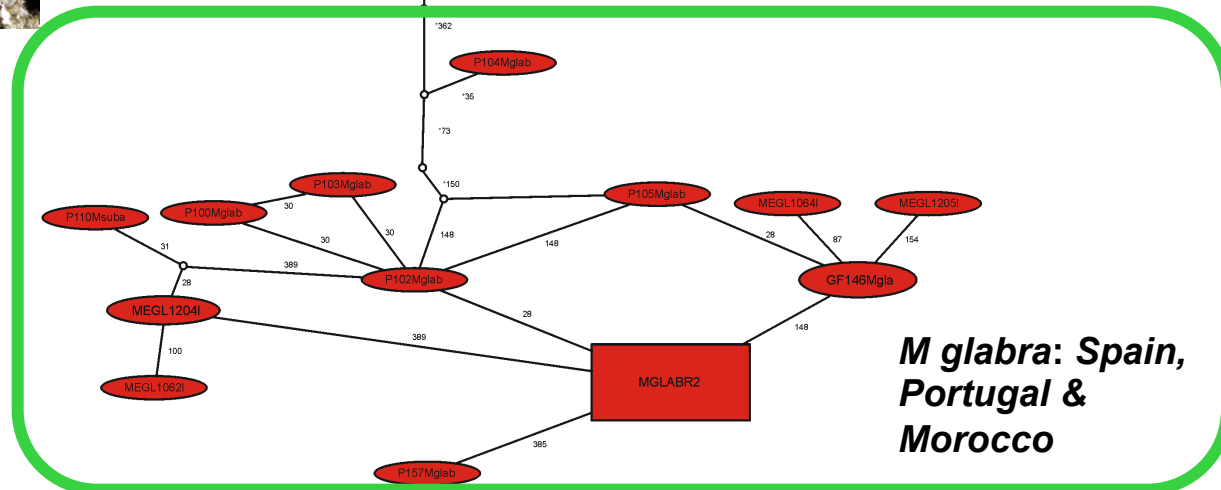
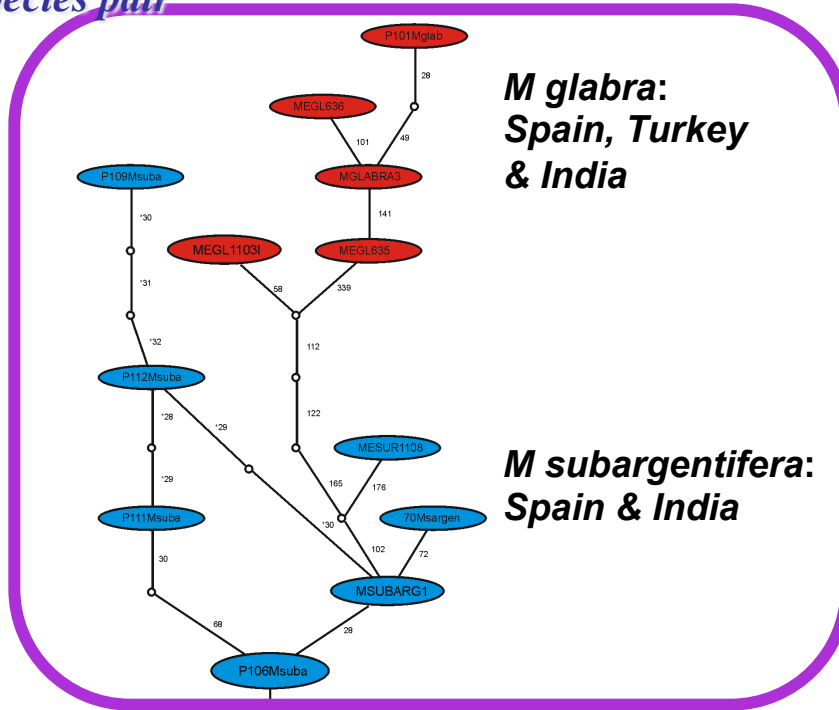


 *M. glabra*



 *M. subargentifera*

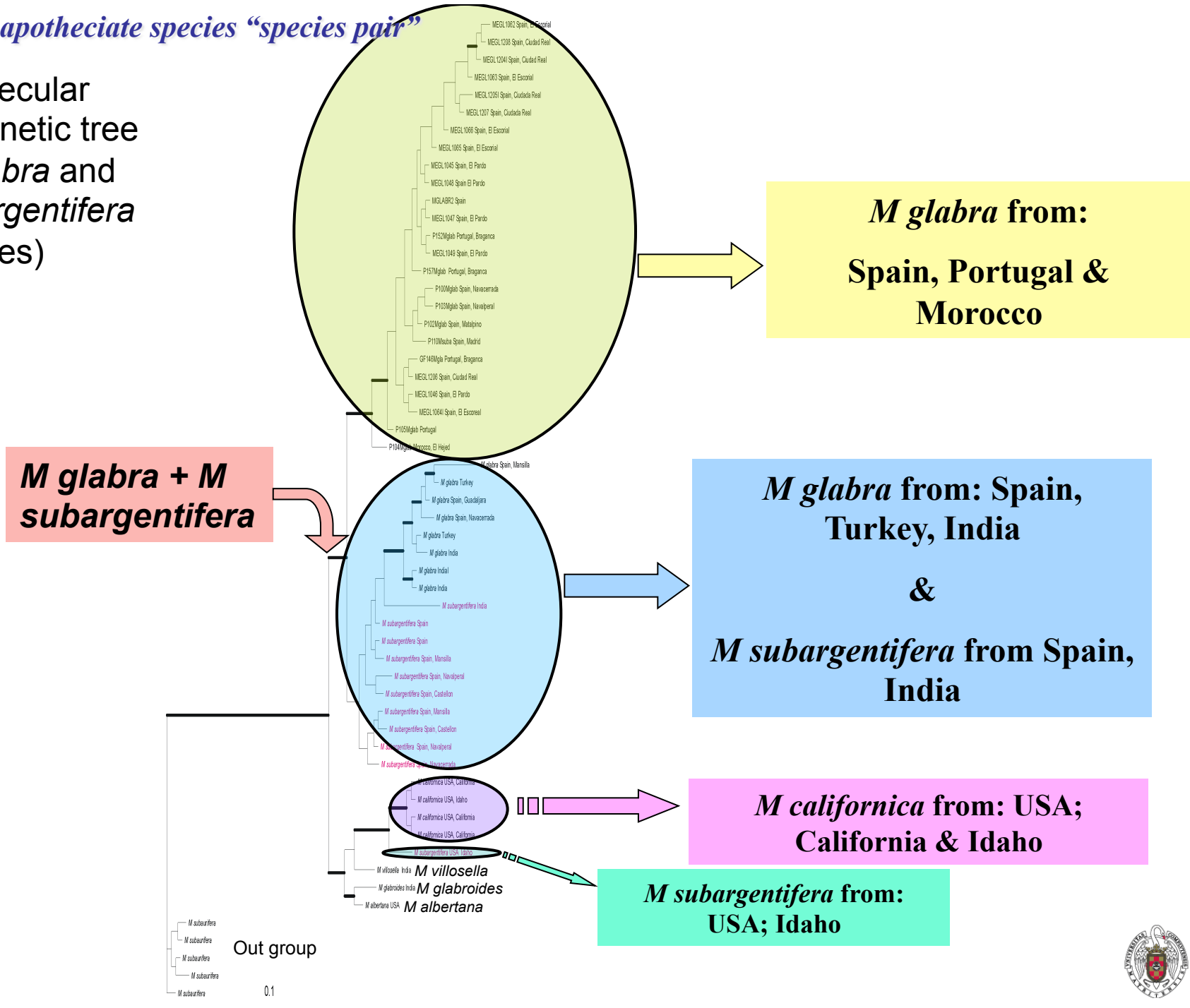
Clear morphologic differences but NO genetic





*Sorediate vs apotheciate species "species pair"*

ITS molecular phylogenetic tree of *M. glabra* and *M. subargentifera* (Mr. Bayes)



*Sorediate vs apotheciate species “species pair”*

**Shared and fixed differences**

Pair-wise genetic differentiation among populations ( $F_{ST}$ )

Numbers of fixed differences and shared polymorphisms and fixation indices ( $F_{ST}$ ) for comparisons of closely related species <i>Melanelixia glabra</i> and <i>M. subargentifera</i>			
Compared species pair and groups	ITS		
	Shared	Fixed	$F_{ST}$
<i>M. glabra</i> vs. <i>M. subargentifera</i> (41 samples)	379	0	-0.048
Group1 ( <i>M. glabra</i> ) vs Group 2 ( <i>M. glabra</i> + <i>M. subargentifera</i> ) (41 samples)	379	0	-0.050

Total number of haplotypes= 25 of 41 samples analysed, *M. glabra*=17 (30 samples)  
( *M. subargentifera*= 8 (11 samples))

## Conclusions

- **About 70 cryptic lineages (15% of sequenced species) have been detected in Parmeliaceae till date.**
- **Sexually reproducing and isidiate cosmopolitan species may includes several cryptic lineages and have usually more restricted or disjunct distribution.**
- **Asexual (sorediate) morphospecies show apparently less cryptic lineages and have large and continuous distribution (gene flow among population).**
- **Geography and micromorphological and sexual feature were found more suitable to corroborate the phylogenetic lineages. But to detect these scarce morphological features several specimens are necessary.**
- **Classic “species pair” are apparently the contrary phenomenon to cryptic species recognition, both members of the pair are not different genetic lineages in apothecia vs. soredia cases. But this hypothesis can not be generalized for apothecia vs isidia species.**
- **PCR is the fast, cheap and easy way to determine species in this group of lichenised fungi**



## Acknowledgements

**SYSTEMOL**

[www.ucm.es/info/systemol](http://www.ucm.es/info/systemol)



Fundación **BBVA**



UNION EUROPEA

**Thanks for your  
attention!**

The **Field**  
Museum

**Lumbsch et al. unpublished**  
**Three species in *Neuropogon* group**

