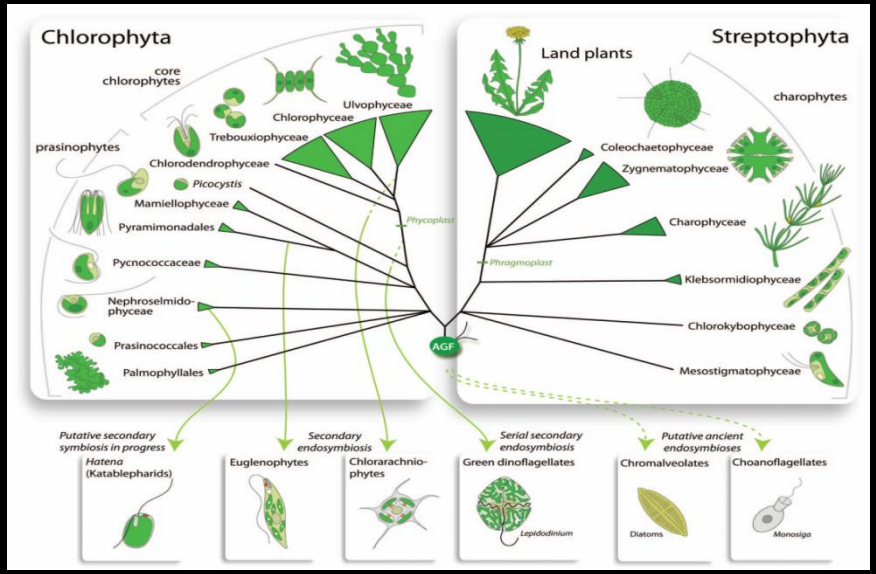
Terrestrial algae of the genus *Klebsormidium* (Streptophyta) in the light of the hypothesis „Everything is everywhere, but the environment selects“

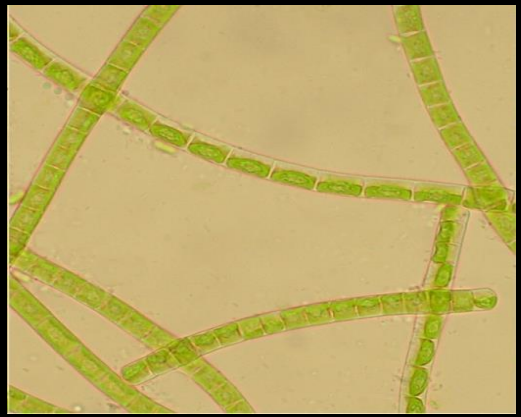
David Ryšánek
Charles University in Prague

algal speciation & evolution

The genus *Klebsormidium* as a model organism

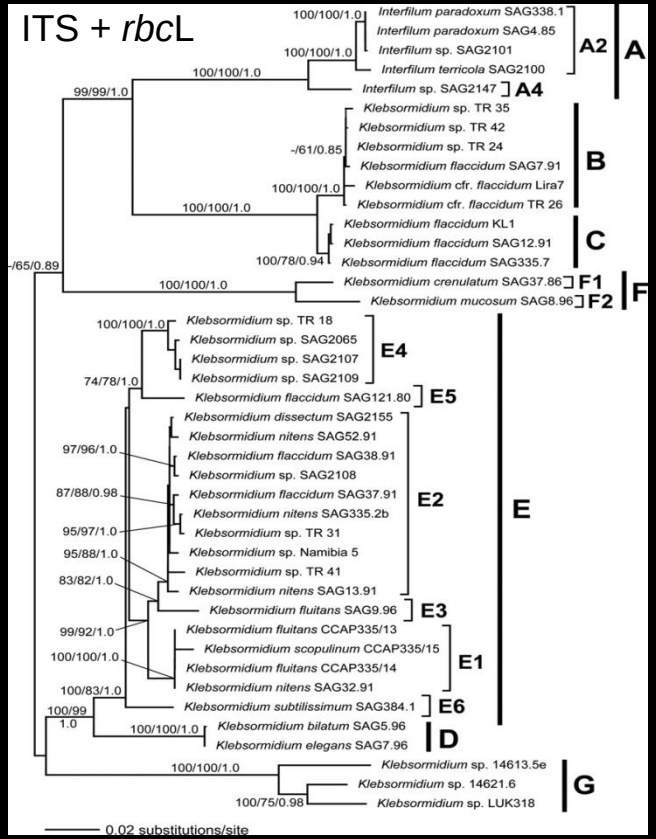
- uniseriate filamentous green algae
- Streptophyta
- aeroterestrial habitats, also freshwater
- cosmopolitan distribution

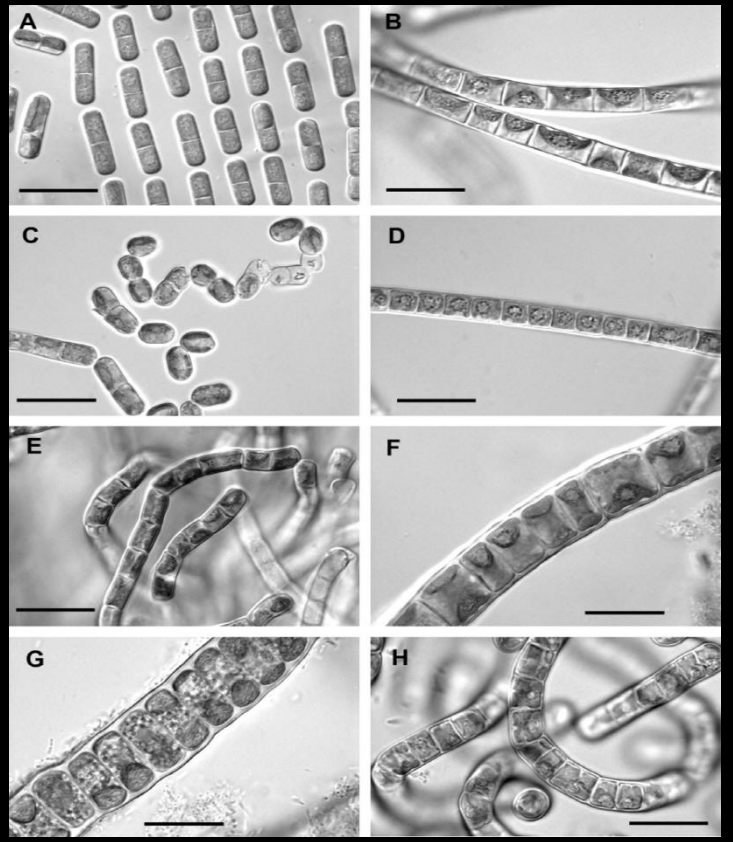




Leliaert et al. (2012)

Cryptic diversity of the genus *Klebsormidium*





Rindi et al. (2011)

Biogeography of protists

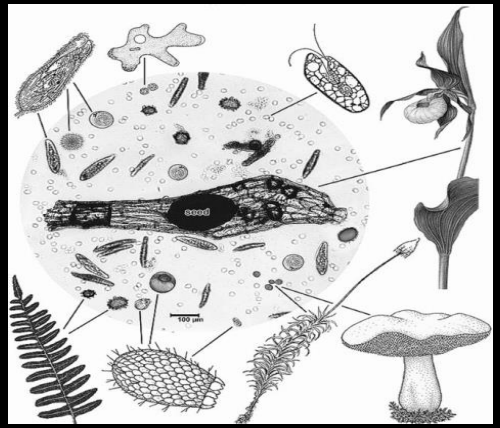
Ubiquity model

- Cosmopolitan distribution

Finlay (2002)

Moderate endemicity model

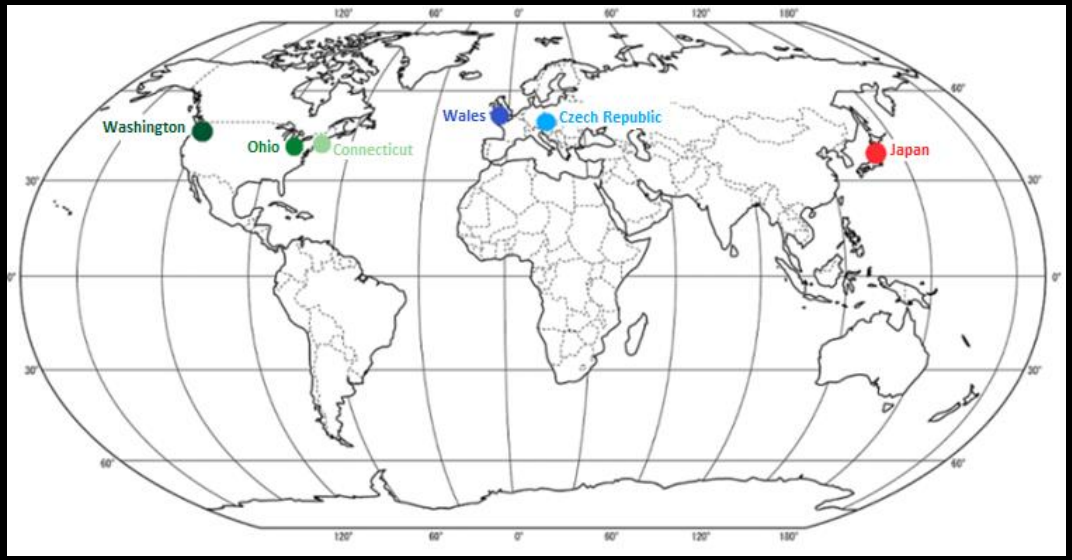
- Limited distribution



Foissner (2008)

Biogeography of genus *Klebsormidium* in temperate zone

- mixed forests of the Northen temperate zone
- 3 continents (Asia, Europe, North America)
- 6 localites: 2-4 sampling places
- Total: 15 samples
- 186 strains
- *rbc*L

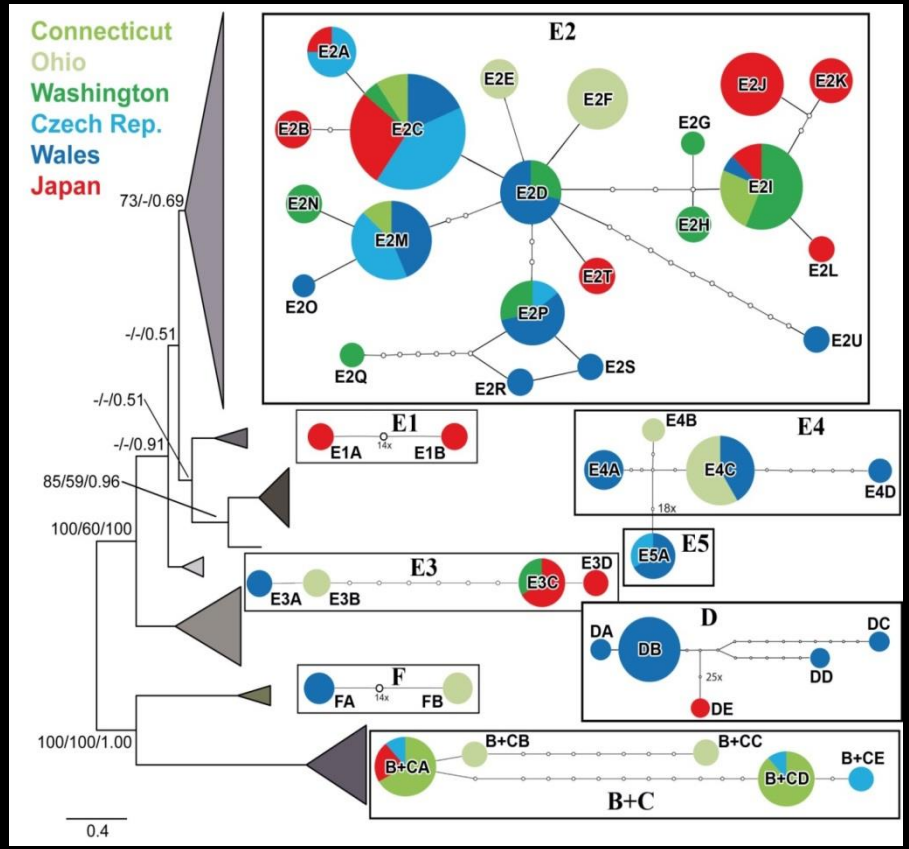


Ryšánek, D., Hrčková, K., Škaloud, P. (2015): Global ubiquity and local endemism of free-living terrestrial protists: phylogeographic assessment of the streptophyte alga *Klebsormidium*. *Environmental Microbiology*

Biogeography of genus *Klebsormidium* in temperate zone

- 3 continents, 6 localites
  ~15 sampling place
- 186 strains
- *rbc*L
- 44 genotypes
- 66% reported first time

Localities	Number of strains
Connecticut	22
Ohio	22
Washington	21
Czech Rep.	24
Wales	63
Japan	38



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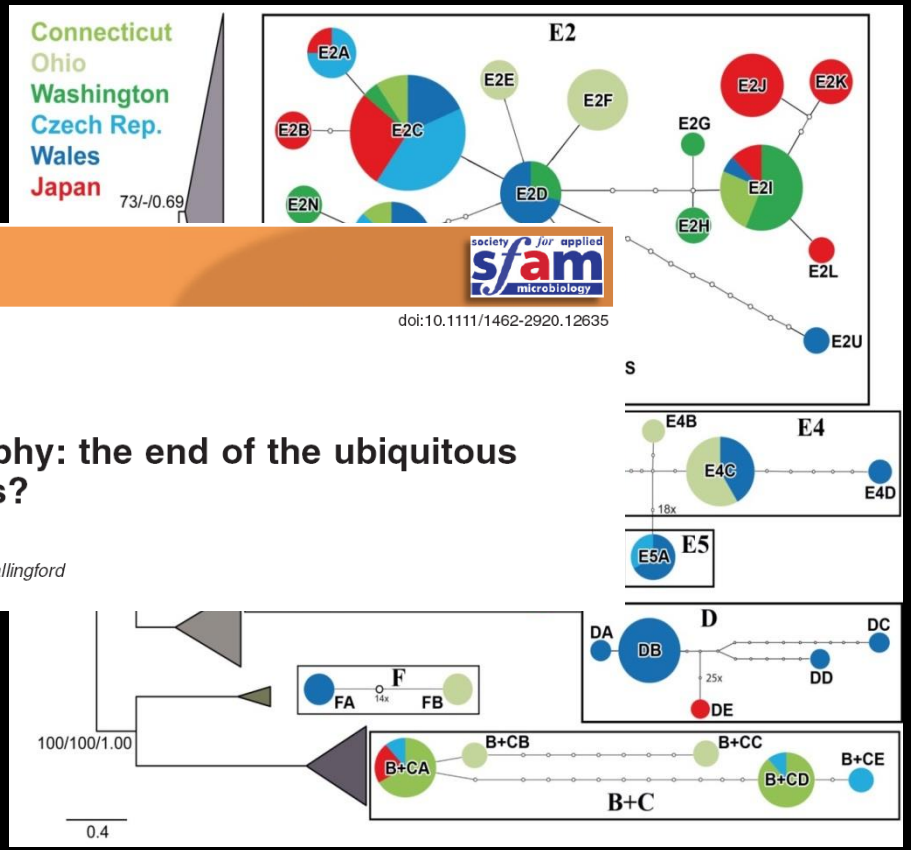


environmental microbiology

Environmental Microbiology (2014) doi:10.1111/1462-2920.12635

Highlight

Microbial biogeography: the end of the ubiquitous dispersal hypothesis?

Christopher J. van der Gast*
NERC Centre for Ecology & Hydrology, Wallingford OX10 8BB, UK.

Ryšánek, D., Hrčková, K., Škaloud, P. (2015): Global ubiquity and local endemism of free-living terrestrial protists: phylogeographic assessment of the streptophyte alga *Klebsormidium*. *Environmental Microbiology*

Klebsormidium in polar habitats

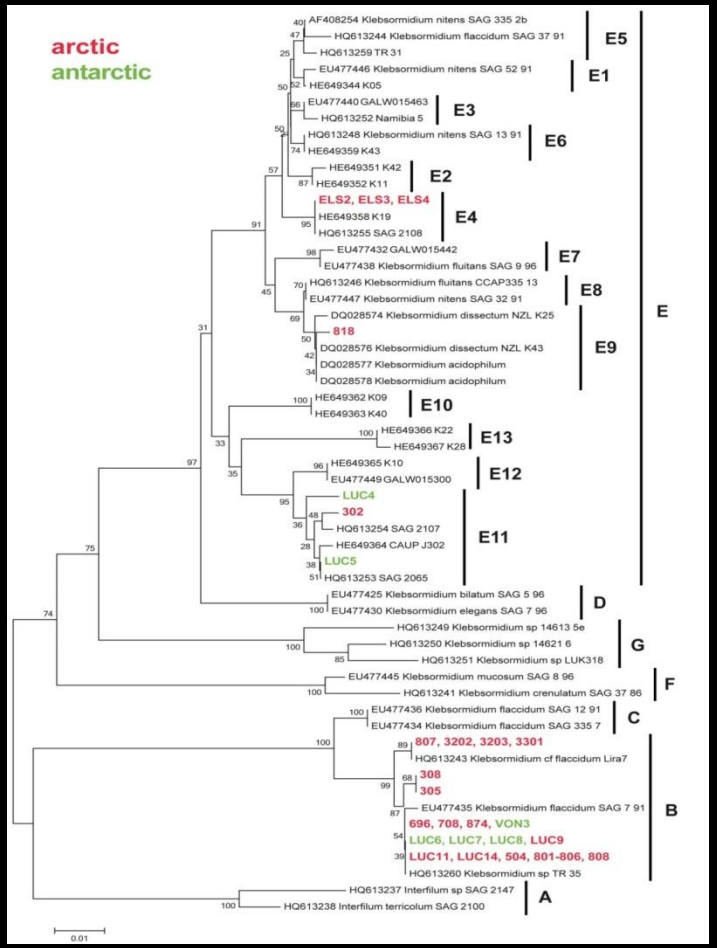
- from 1989 to 2014
- 12 expeditions (6 arctic and 6 Antarctic)
- 526 samples
- 32 strains

Year/month	Number of samples	Numebr of strains	Localities
2014/08	26	16	Svalbard
2010/02	34	0	Maritime Antarctica, King George Island, Admiralty Bay
2009/01	33	1	Maritime Antarctica, James Ross
2008/08	28	3	Svalbard
2007/01	10	1	Sweden
2004/08	16	1	Svalbard
2003/12-2004/01	49	2	Maritime Antactica, King George Island, Admiralty Bay
2002/12-2003/01	54	3	Maritime Antarctica, King George Island, Admiralty Bay
2002/05	50	3	Svalbard
1992/12-1993/01	105	0	Maritime Antarctica, Elephant Island
1991/03	9	2	Canada, Nunavut
1989/12-1990/01	112	0	Maritime Antarctica, King George Island, Admiralty Bay
total:	**526**	**32**	

Ryšánek D., Elster J., Kováčik L., and Škaloud P. (2016): Diversity and dispersal capacities of a terrestrial algal genus *Klebsormidium* (Streptophyta) in polar regions. *FEMS Microbiology Ecology*

Klebsormidium in polar habitats

- from 1989 to 2014
- 12 expeditions (6 arctic and 6 Antarctic)
- 526 samples
- 32 strains (25 strains clade B)
- *rbc*L



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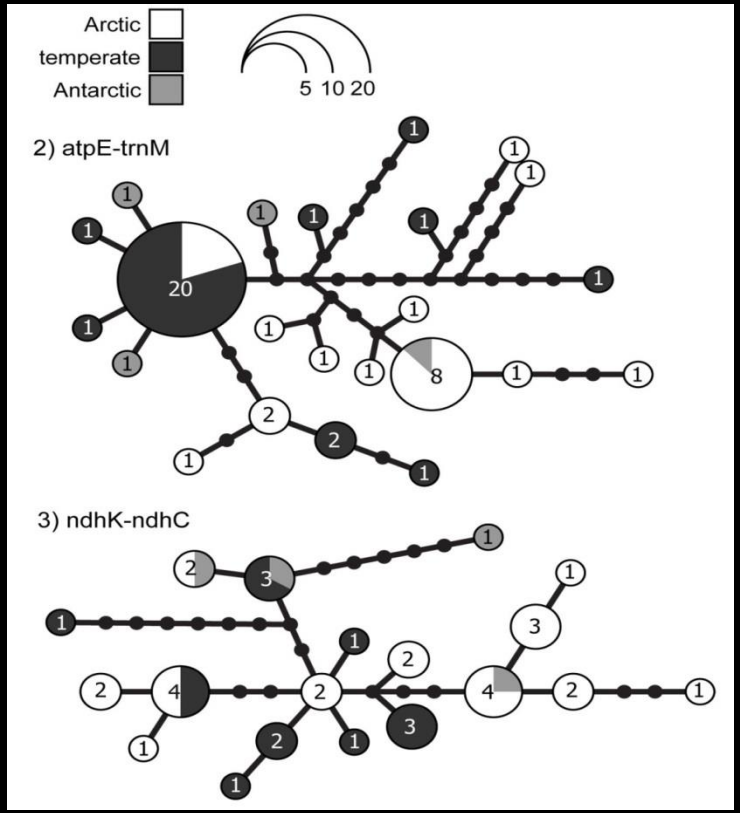
Population differentiation of the superclade B strains

- 21 Arctic
- 4 Antarctic
- 26 temperate strains
- Two highly variable plastid-encoded spacers
  - atpE – trnM (691bp)
  - ndhK – ndhC (698bp)



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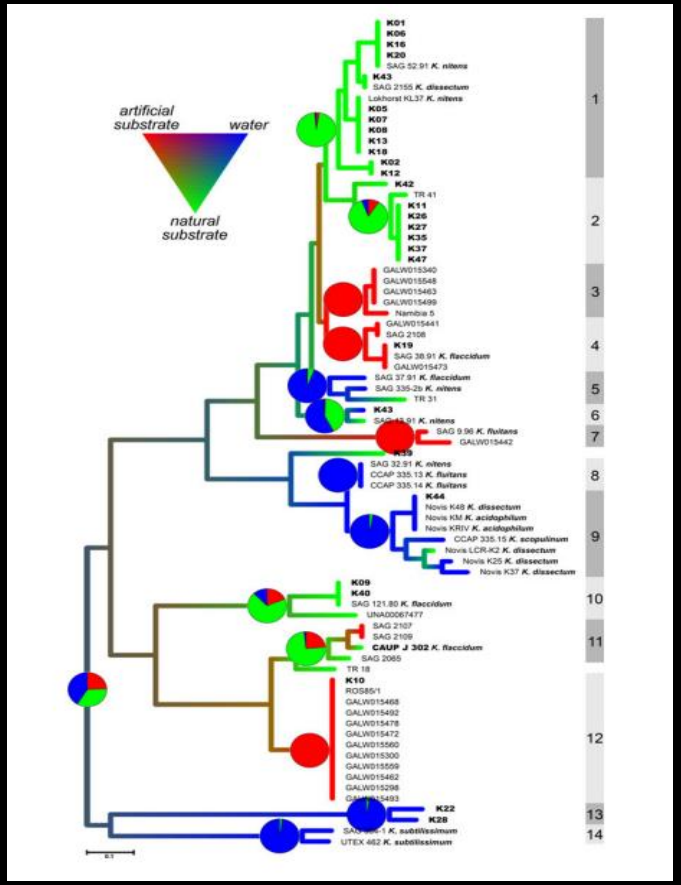
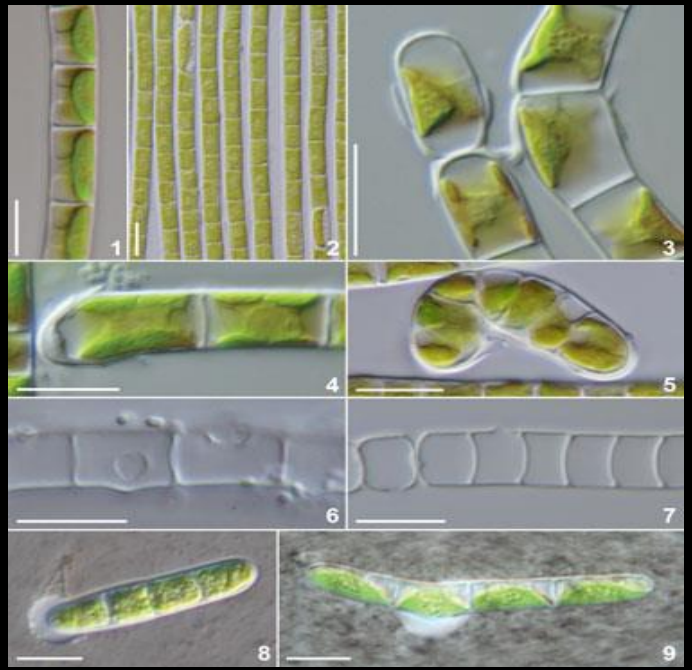
Substrate specificity of the genus *Klebsormidium*

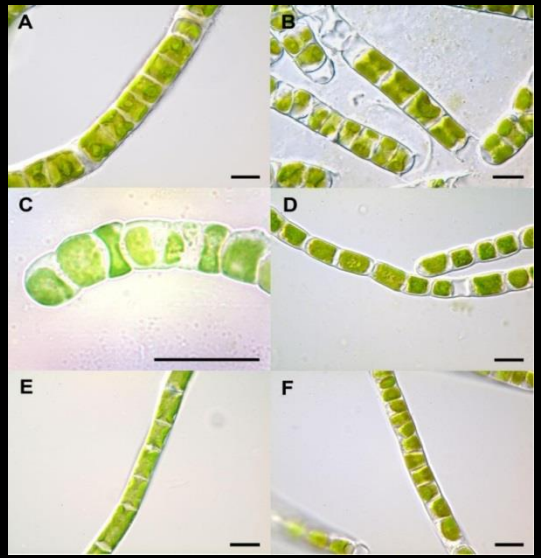


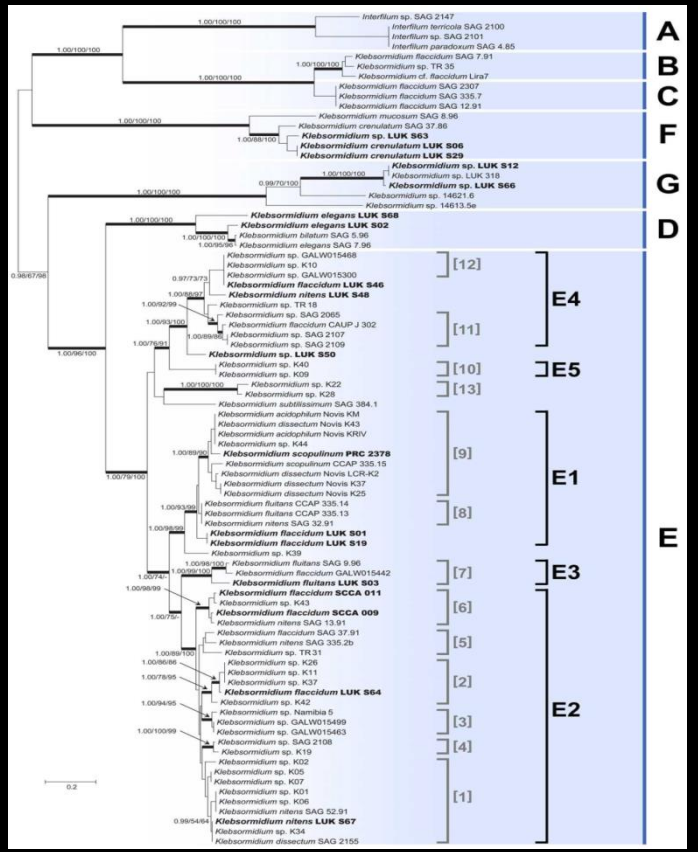


Škaloud and Rindi (2013)

Polyphyletic origin of low pH adaptation

- 18 strains from low pH habitats in Europe and U.S.A.
- *rbc*L and ITS rDNA

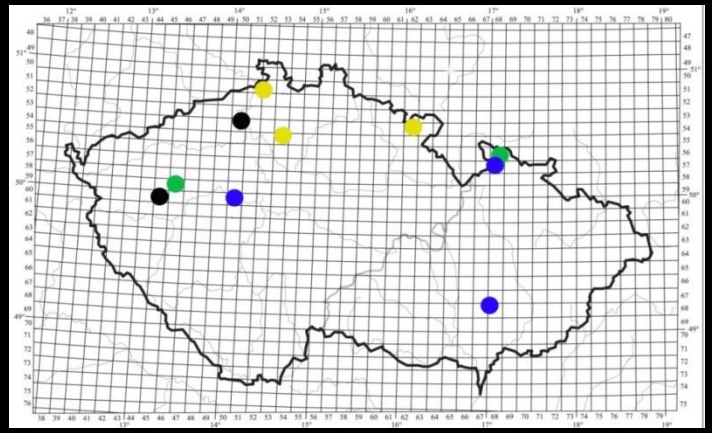




Škaloud, P., Lukešová, A., Malavasi, V., Ryšánek, D., Hrčková, K., Rindi, F. (2014): Molecular evidence for the polyphyletic origin of low pH adaptation in the genus *Klebsormidium* (Klebsormidiophyceae, Streptophyta). *Plant Ecology and Evolution*

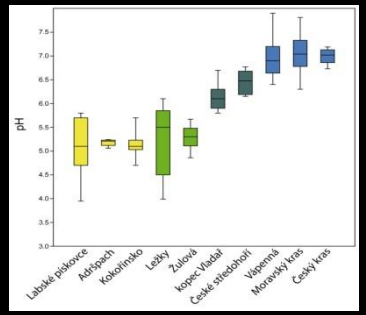
Substrate specificity of the genus *Klebsormidium*

absorbability 0.8 - 3.3%
porosity 16 - 30%



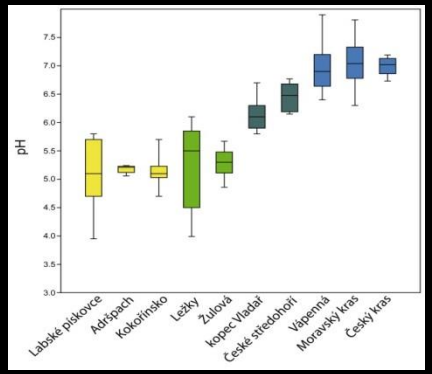
absorbability 4.5 - 6.5%
porosity 13.6 - 26%

absorbability 0.2 - 0.4%
porosity 0.6 – 1%

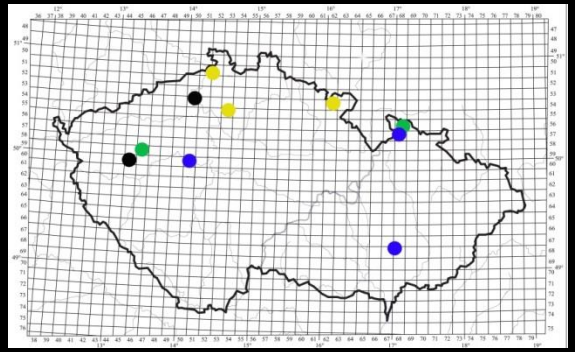


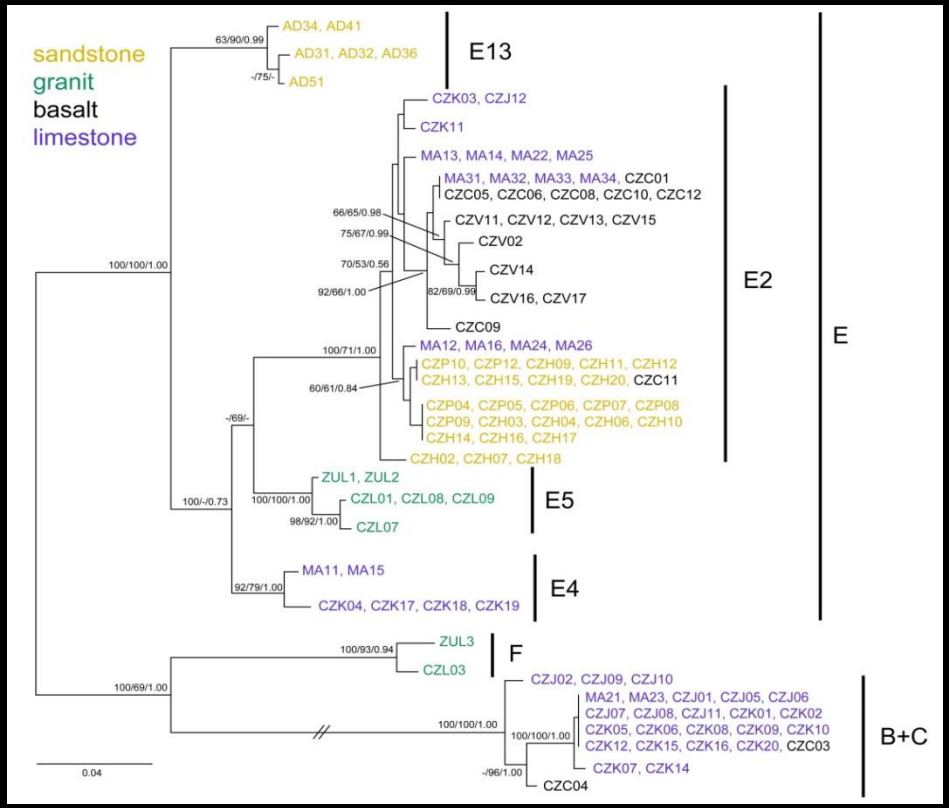
absorbability 0 - 2 %
porosity 0 %

Substrate specificity of *Klebsormidium*?

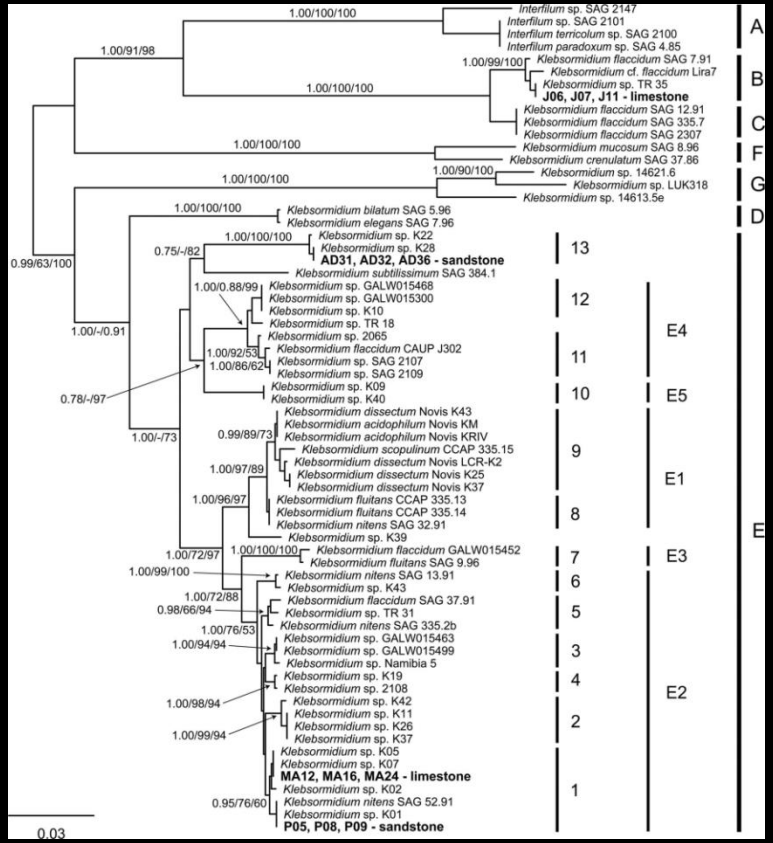


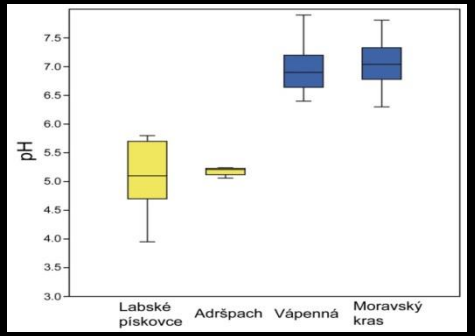
- 10 localities
- 102 strains
- *rbc*L





Influence of pH on strains *Klebsormidium* from sandstone and limestone



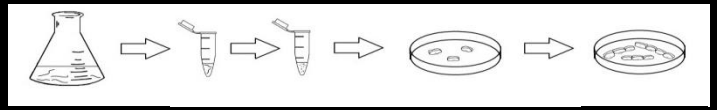


- 2 clade from sanstone and 2 from limestone
- 3 strains per clade
- gradient pH 4 - 8
- pulse-amplitude modulated fluorimeter PAM2500
- direct counting cells

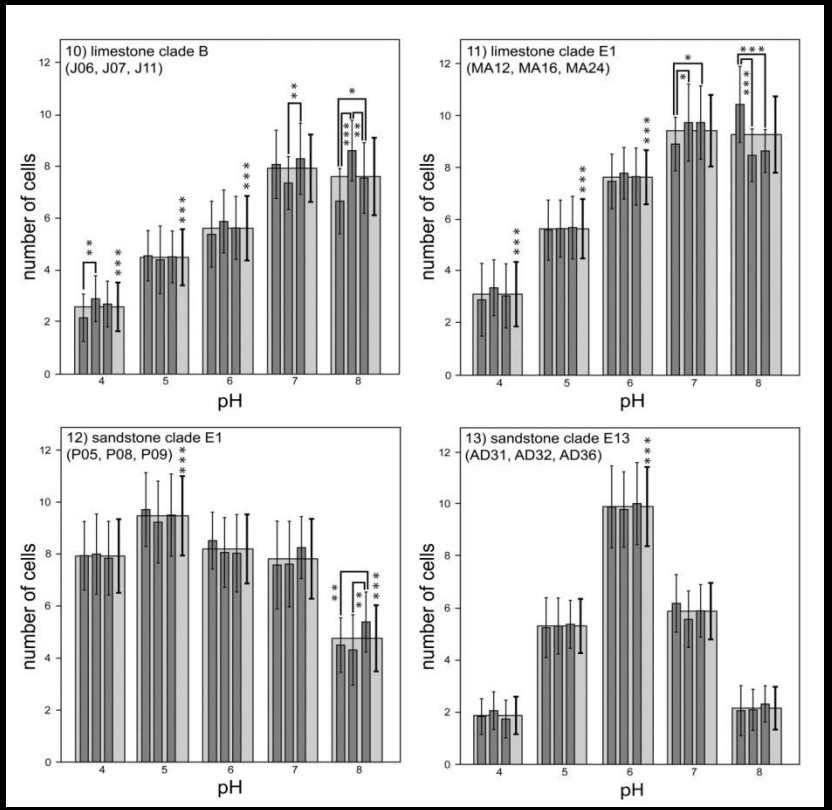
Ryšánek D., Holzinger A., Škaloud P. (2016): Influence of substrate and pH on diversity in the aeroterrestrial alga *Klebsormidium* (Klebsormidiales, Charophyta): A potentially important factor for sympatric speciation. *Phycologia*

Direct counting of cells on agar plates

- Cultivation on BBM medium
- pH 4; 5; 6; 7; 8
- 30-40 cells
- 4 days cultivation



2-3 weeks cultivation | vortex | 1st day | 4th day



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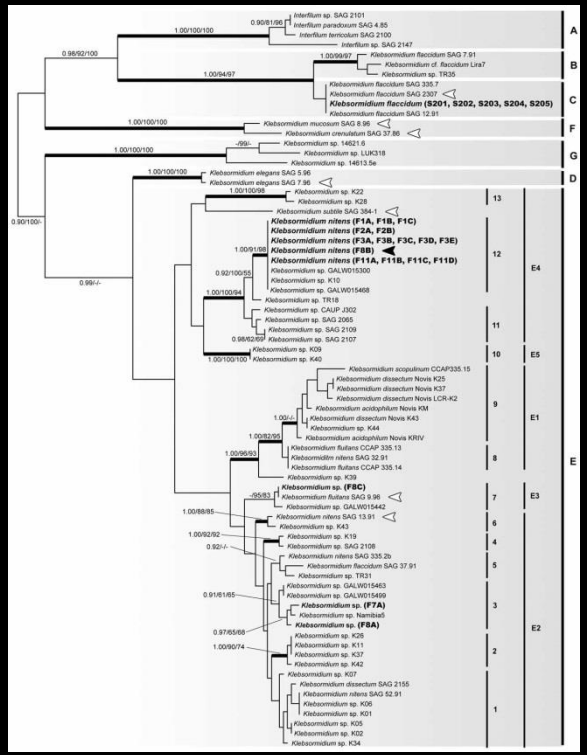
How can we connect species names with fylogenetic lineages?

- 21 species
- oldest species: *Klebsormidium flaccidum and K. nitens*

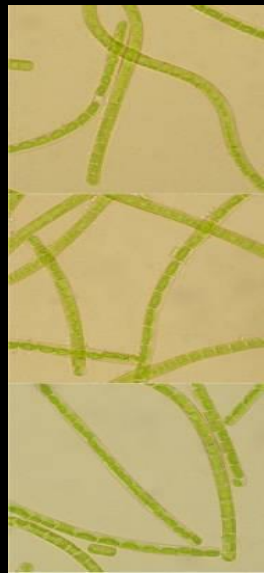


Klebsormidium nitens		
Author	year	width (µm)
Kützing	1849	6.45
Klebs	1896	5.5-7.0
Farooqui	1968	5.0-5.6
Lokhorst	1996	4.7-5.6(-6.5)
Mikhailyuk	2015	5.1 ± 0.30

Rindi F., Ryšánek D. and Škaloud P. (2016): Problems of epitypification in morphologically simple green microalgae: a case study of two widespread species of *Klebsormidium* (Klebsormidiophyceae, Streptophyta). *Fottea* (accepted).

Conclusions

- Substrate and pH have a strong effect on diversity
- We found repeated adaptation to pH and substrate
- We demonstrated an unlimited dispersal and intensive gene flow within one of the inferred lineages (superclade B)
- Majority of *Klebsormidium* clades showed rather a limited distribution
- We detected a significant decrease of species richness towards the poles
- Offer epitype according original description and from type locality



Acknowledgements:

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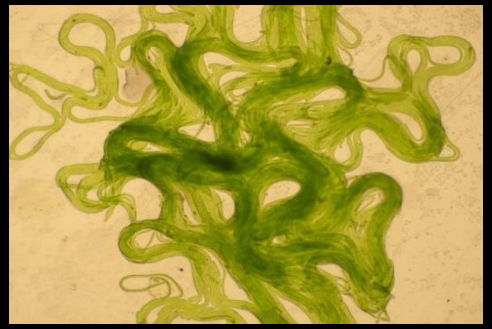
Lubomir Kovačik
Kristýna Hrčková



Nadace "Nadání Josefa, Marie a Zdeňky Hlávkových"

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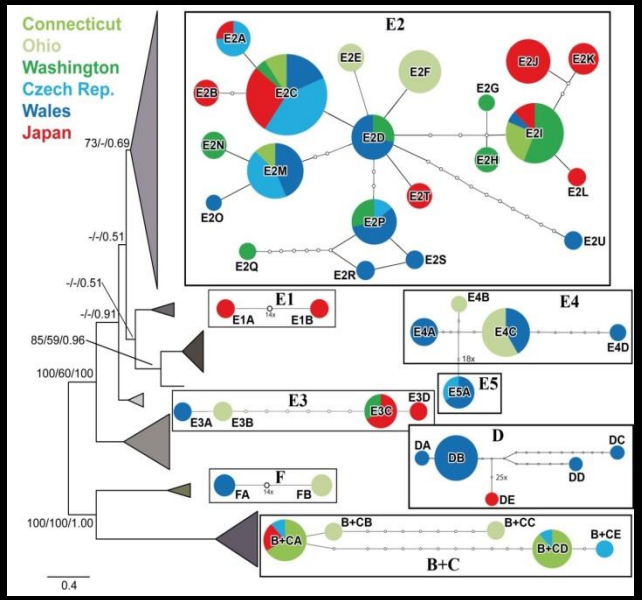
Czech Republic - Austria

GAUK 259564

Thank you for your attention



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