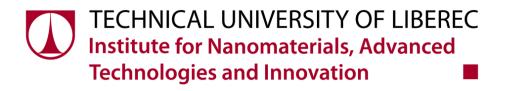
Diversity of mycobiont-photobiont associations correlate with reproductive strategies in *Cladonia* lichen species



Jana Steinová, Pavel Škaloud, Helena Bestová and Lucia Muggia







What may influence the choice of photobiont?

- 1) Mycobiont and photobiont specificity
- **2)** Environmental conditions (climate, altitude, (micro)biotope, rain vs. sun exposure)
- 3) Photobiont availability at the locality ?
- 4) Reproductive strategy ?

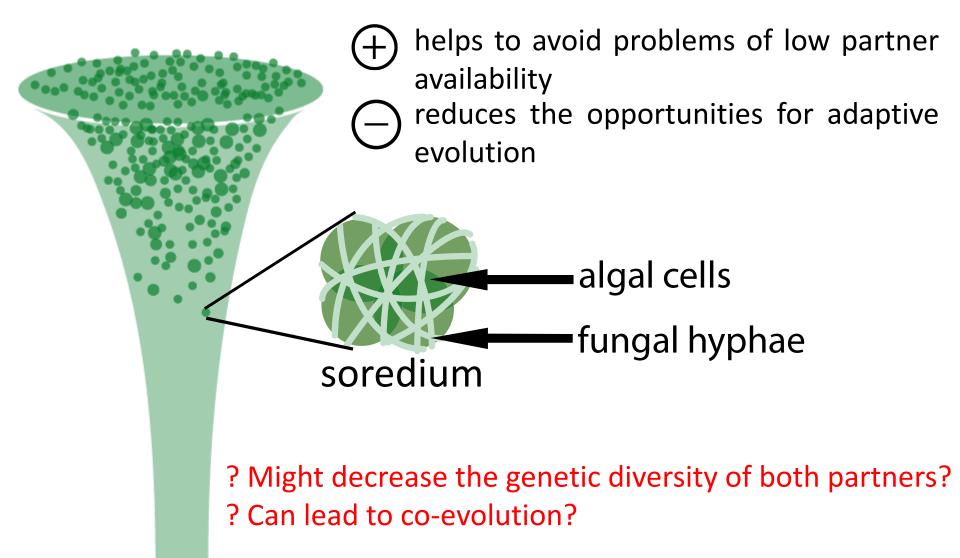
Sexual mode of reproduction

– by fungal spores \rightarrow fungal spores must obtain a compatible partner

produces new genotypes and +tends to increase the likelihood of successful dissemination by long range dispersal symbiosis must be always established de novo - it might be difficult to find a partner ascospores **Compatible** partner (is not always available...)

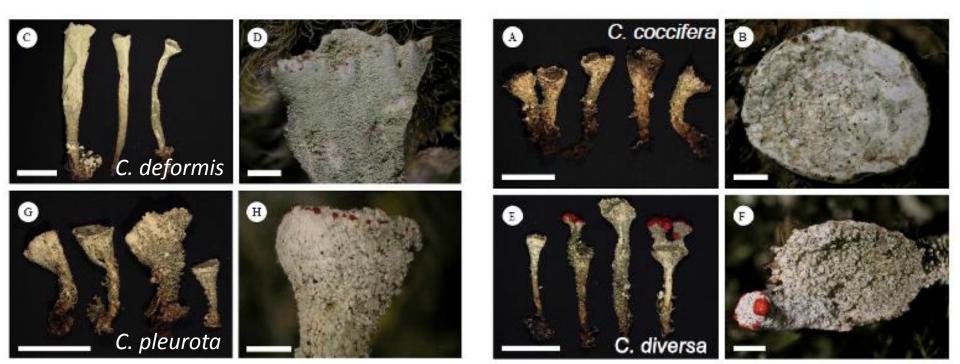
Asexual mode of reproduction

 both partners simultaneously dispersed within specialised asexual propagules (e.g. soredia, isidia)

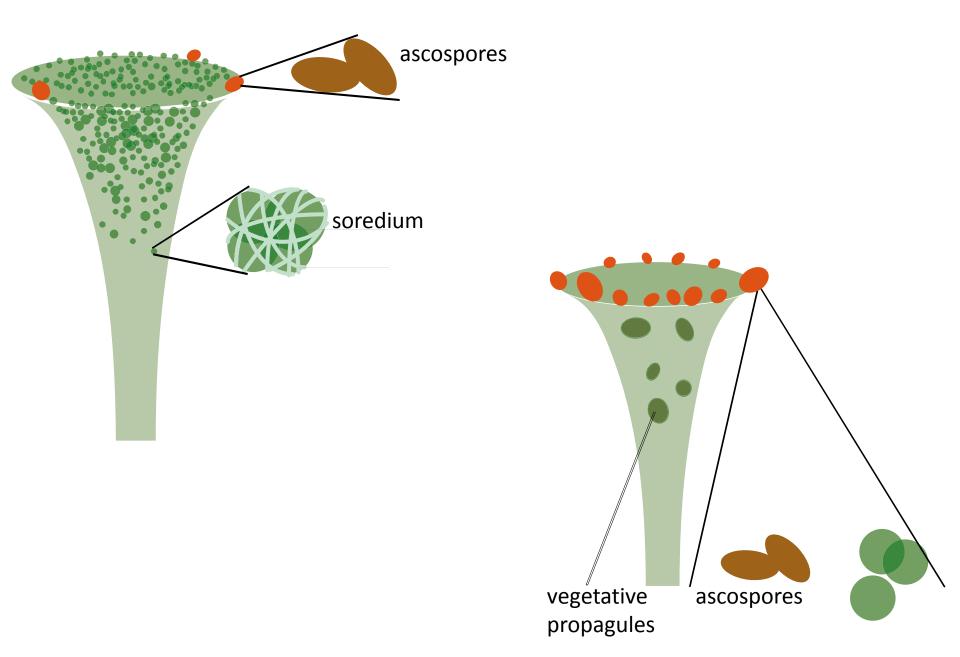


Zeorin-containing red-fruited Cladonia species

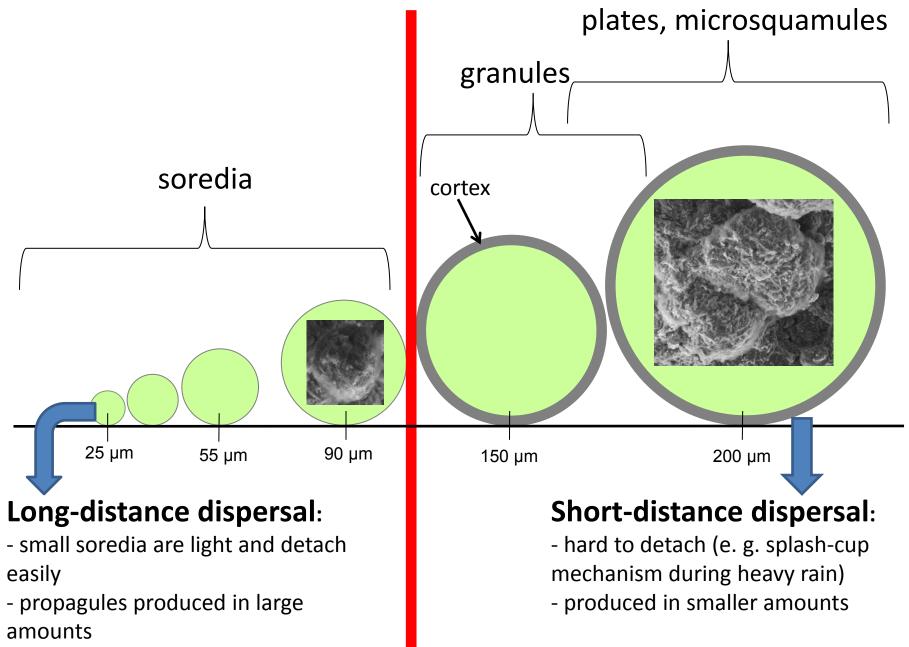
- genus Cladonia, section Cocciferae
- associated with Asterochloris spp.
- 5 species worldwide, 4 species in Europe: sorediate *Cladonia deformis, C. pleurota* and esorediate *C. coccifera* and *C. diversa*
- chemically almost identical species delimitation based on morphology
- different distribution patterns



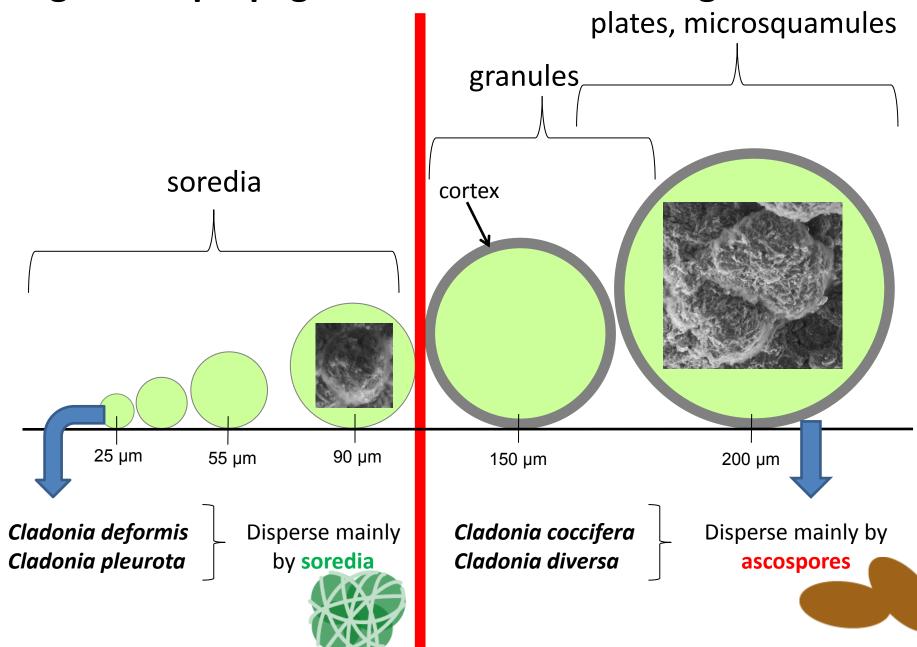
Combined mode of reproduction



Vegetative propagules of zeorin-containing *Cladonias*

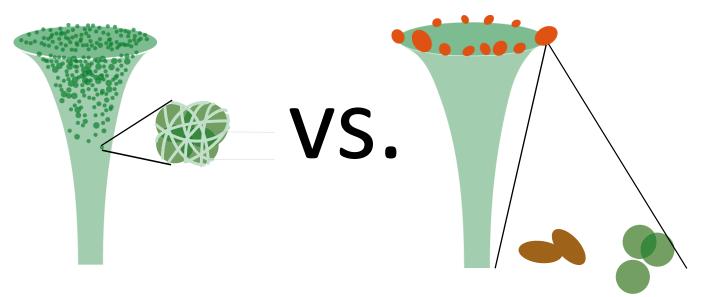


Vegetative propagules of zeorin-containing *Cladonias*



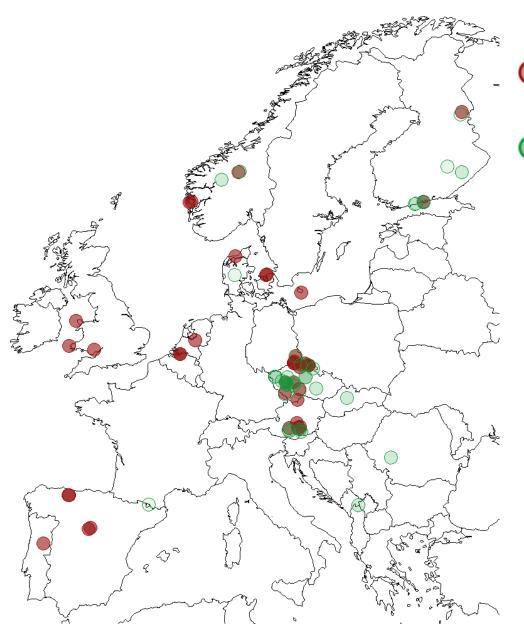
Is photobiont diversity of zeorin-containing *Cladonia*s influenced by prevailing distribution strategy?

• 43 sorediate (*C. deformis* and *C. pleurota*) and 42 esorediate (*C. coccifera* and *C. diversa*) samples from Europe



- Algal internal transcribed spacer region (ITS) and partial actin I
- Fungal internal transcribed spacer region (ITS) and β-tubulin
- \rightarrow comparing photobiont diversity

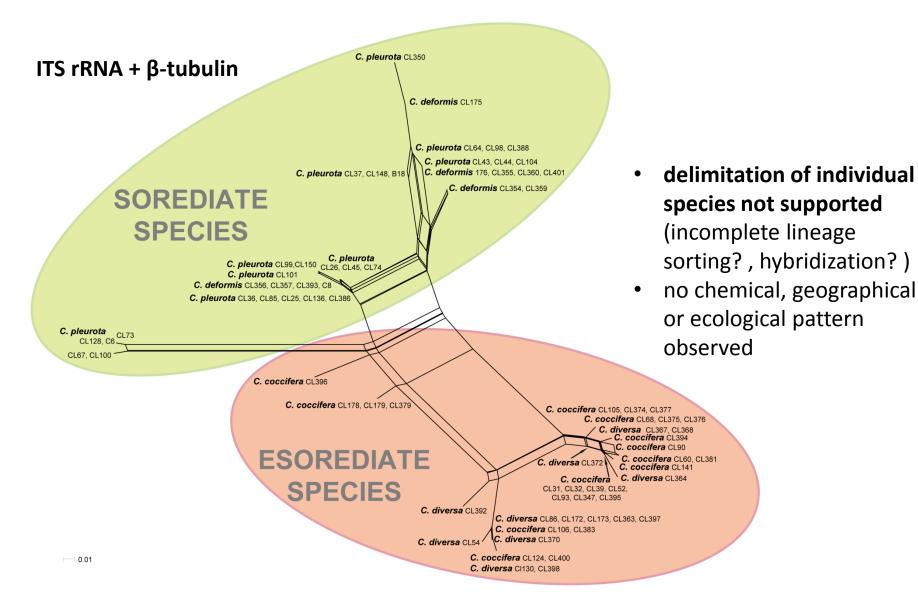
Sampling



- Sorediate taxa (Cladonia deformis + C. pleurota)
- Esorediate taxa (Cladonia coccifera + C. diversa)

Esorediate and sorediate taxa collected several times at the same site.

Fungal molecular diversity



OU/99/98 CLAD 08 - from Cladonia deformis CL355, CL355, CL355, CL355, CL401 - from Cladonia deformis CL355, CL355, CL355, CL355, CL4128, CL385 - from Cladonia pleurota CL354, CL364, CL364, From Cladonia pleurota CL354, CL364, CL364, From Cladonia deformis CL354, CL364, From Cladonia deformis CL354, CL364, From Cladonia pleurota CL354, CL364, From Cladonia pleurota CL35, CL43, CL48 - from Cladonia pleurota CL35, CL43, CL48 - from Cladonia pleurota CL36, CL43, CL48 - from Cladonia pleurota CL36, CL44, From Cladonia pleurota CL36, From Cladonia pleurota CL36, CL44, From Cladonia pleurota CL36, From Cladonia pleurota From Cladon		A. glomerata
CL178 - from Cladonia coccifera CL350, C1386, C1390 - from Cladonia pleurota CL350, C1386, C1390 - from Cladonia deformis CL350, C1386, C1391, CL403 - from Cladonia pleurota CL350, CL396 - from Cladonia dolormis CL350, CL396 - from Cladonia dolormis CL176 from Cladonia dolormis CL176 from Cladonia dolormis CL176 from Cladonia dolormis CL179 from Cladonia dolormis CL179 from Cladonia pleurota CL179 from Cladonia ple	•	A. irregularis
Peksa 513 et al. 1.00/100/96 UTEX 911- from <i>Lefana</i> sp.		A. magna A. erici
CL31 - from Cladonia coccifera	0	
1.00/100/100 Peksa 103 - from Lepraria caesioalba Peksa 204 - from Lepraria caesioalba Peksa 806 - from Lepraria alpina		A. leprarii
0.95/-/- 1.00/100/100 CL143 - from Cladonia coccifera Peksa 529 - from Lepraria caesioalba	0	clade A9
0.96/75/- 50% Peksa 873 - from Lepraria caesioaliba 1.00/100/100LPeksa 870 - from Lepraria ap.		A. excentrica
1.00/97/98 Peksa 868 - from Lepraria rigidula Peksa 236 - from Lepraria rigidula 1.00/94/100 Peksa 886 - from Lepraria ingidula 1.00/94/100 Peksa 886 - from Lepraria ingidula		A. gaertneri
CL141 - from Cladonia coccifera 0.98/-/91 - CL141 - from Cladonia coccifera 0.98/-/91 - CL141 - from Cladonia coccifera CL29 - From Cladonia coccifera 0.98/-/91 - CL141 - from Cladonia coccifera CL29 - from Cladonia coccifera	0	A. woessiae
1.00/100/100 Peksa 234 - from <i>Lepraria caesioalba</i> Peksa 235 - from <i>Lepraria caesioalba</i> Peksa 235 - from <i>Lepraria caesioalba</i>		A. friedlii
Peksa 736 - from Cladonia debicular 1.00/97/88 - CL32 - from Cladonia finibriata CL39 - from Cladonia cocifera 1.00/100/100 - Nelsen 2233 - from Pilophorus cf. cereolus	0	clade A8
0.99/66/- Nelsen 21810 - from Stereocaulon sp. 1.00/94/98 0.95/92/-C27 - from Cladonia foliacea 1.00/96/100 - C23 - from Cladonia foliacea 1.00/96/100 - C23 - from Cladonia foliacea 1.00/96/100 - Peksa 921 - from Cladonia fimbriata 1.00/94/98 0.95/2012 - Peksa 921 - from Cladonia fimbriata		A. mediterranea
0.91/-/ Talboli 101 - from Stereocaulon paschale UTEX 67 - from Cladonia rei CL124, CL374, CL375, CL377, CL381, CL392, CL397, CL400, CL404 - from Cladonia diversa CL124, CL374, CL375, CL377, CL381, CL398 - from Cladonia coccifera CL52 - from Cladonia coccifera 1.00/92/85 - from Ziadonia coccifera 1.00/92/7 - CL68, CL375 - from Cladonia coccifera 1.00/92/7 - from Cladonia diversa		A. italiana
0.96/-/- 1.00/98/100 Peksa 185 - from Lepraria caesioalba CL106 - from Lepraria caesioalba CL106 - from Lepraria gigidula Peksa 186 - from Lepraria gigidula	0	A. echinata
0.93/-/- SAG 26.81 from Arzina cameronivea 1.00/100/99 FPksa 855 - from Lepraria sp.		A. phycobiontica
0.94/7- 0.94/7- 0.98/89/65 0.98/89/85 0.98/85	0	A. lobophora
0.02 CL383 - from Cladonia coccifera	000	

Algal molecular diversity

sorediate taxa

esorediate taxa

Sorediate taxa associated with 2 algal lineages wheras esorediate taxa contained 7 photobiont species.

Esorediate and sorediate samples collected at the same site contained different photobionts!

Variation partitioning

Photobiont diversity explained by ?:

- 1. Mycobiont (ITS + β -tubulin)
- 2. Climate
- 3. Geography
- 4. Reproduction mode

Climate Mycobiont Geography

Reproduction mode

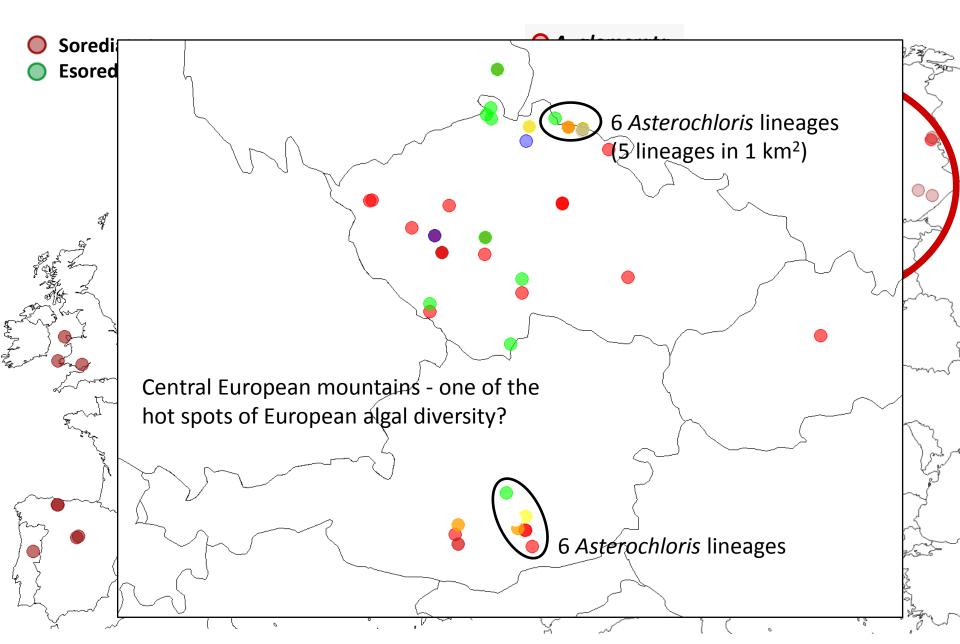
Variation partitioning

Photobiont diversity explained by ?:

- 1. Mycobiont (ITS + β -tubulin)
- 2. Climate
- 3. Geography
- 4. Reproduction mode

Climate 1,5% **Mycobiont** 27,8% Geography 2% **Reproduction mode** 44,5%

Photobiont diversity in Europe



Conclusions

- Reproduction strategy (production of soredia) influences the photobiont diversity in zeorin-containing red-fruited *Cladonia* species lichens reproducing mainly by ascospores are less selective compared to the lichens producing soredia.
- Sorediate taxa can propagate by ascospores too but they associate only with *A. glomerata* or *A. irregularis*.
- At the same sampling site sorediate and esorediate species contain different photobiont species (with the exception of area of Fennoscandia).
- Photobiont availability might influence lichen distribution?
 (C. deformis and C. pleurota lacking in areas dominated by A. italiana??)

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