

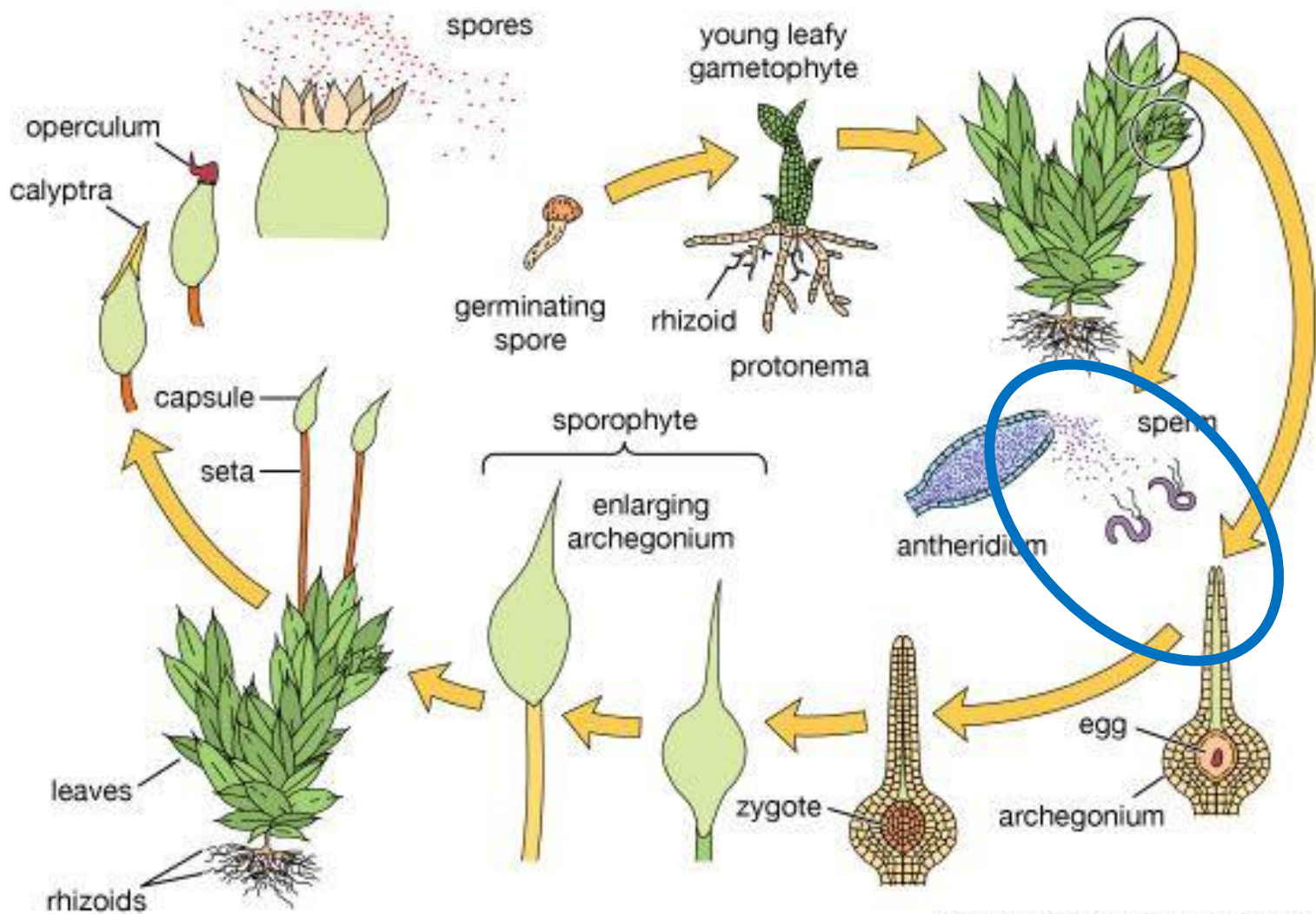
Ekologie mechorostů a lišejníků: Interakce mechorostů II.



Lukáš Janošík

Katedra botaniky PŘF UK

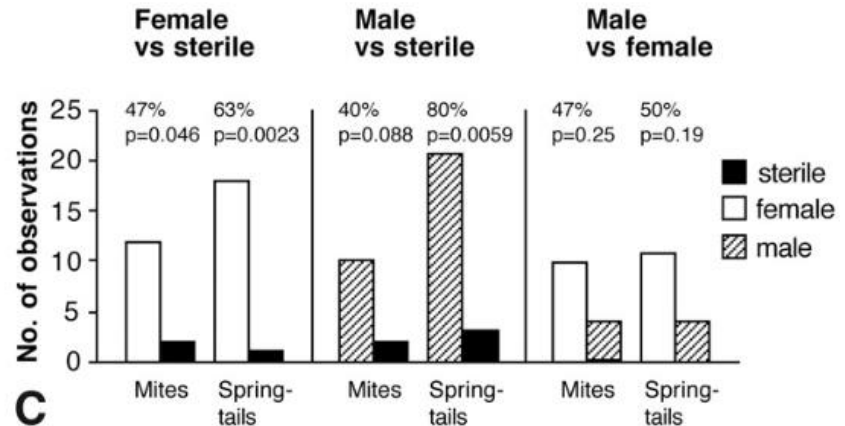
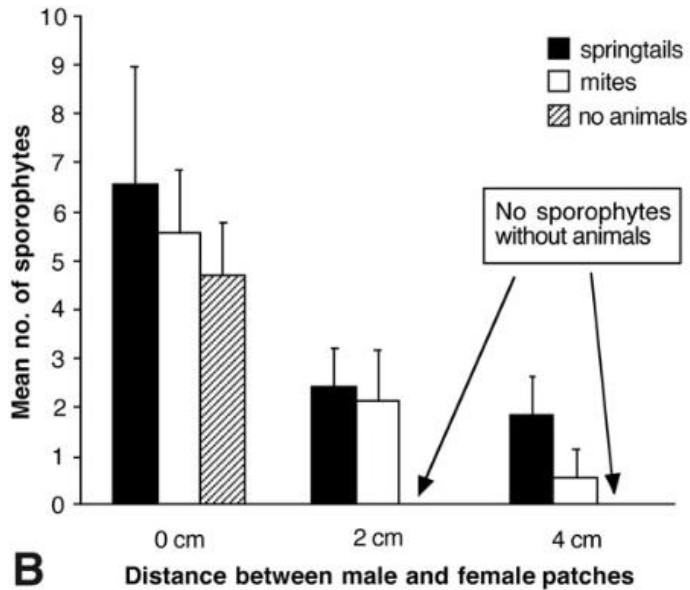
luk.janosik@gmail.com



Spermonoši - „opylovači“ mechorostů?

Cronberg et al. 2006 (Science)

Microarthropods Mediate Sperm Transfer in Mosses



Spermonoši - „opylovači“ mechorostů?

Rosenstiel et al. 2012 (Nature):

Sex-specific volatile compounds influence microarthropod-mediated fertilization of moss

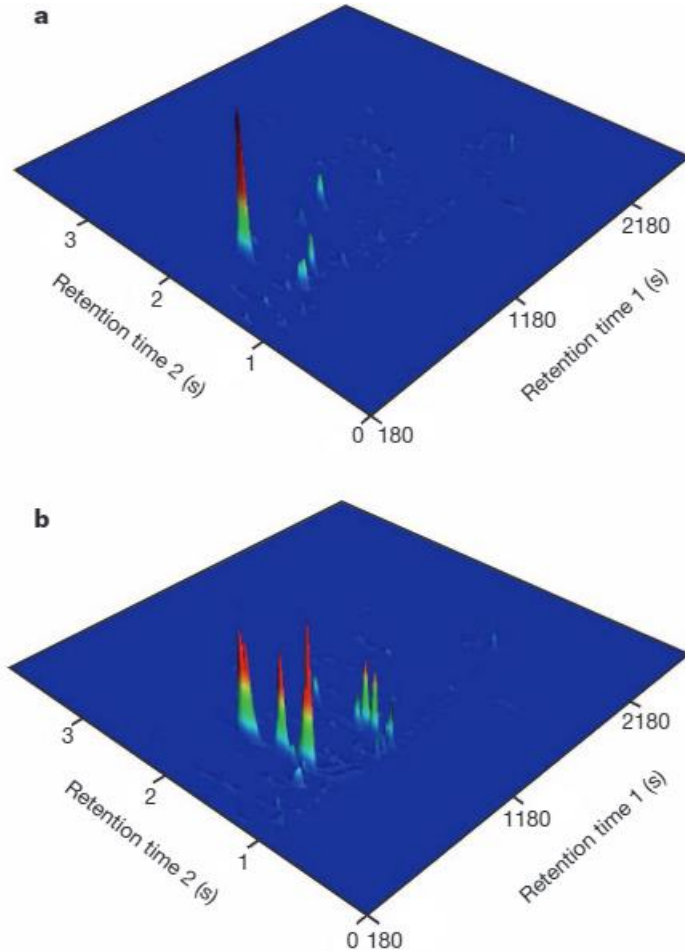


Figure 1 | Sex-specific volatile profiles. a, b, Representative two-dimensional GC x GC-TOFMS chromatograms of volatile compounds from intact shoots of a reproductive male (a) and a reproductive female (b) of the cosmopolitan moss *C. purpureus*. Colours indicate relative measures of compound abundance; red indicates compounds that are greater than 50% of the largest individual peak area.

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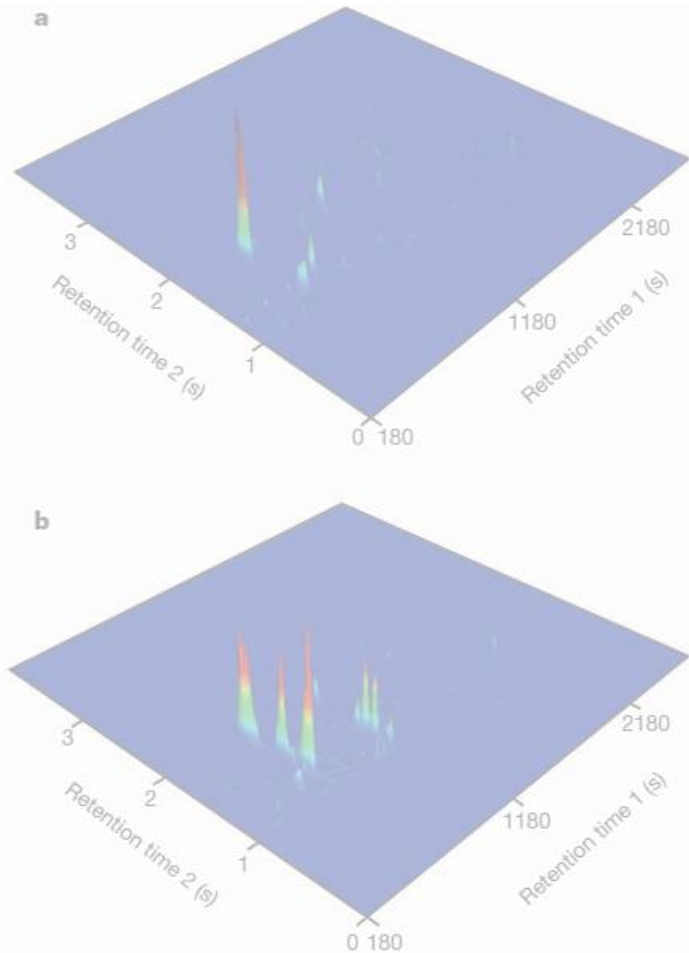


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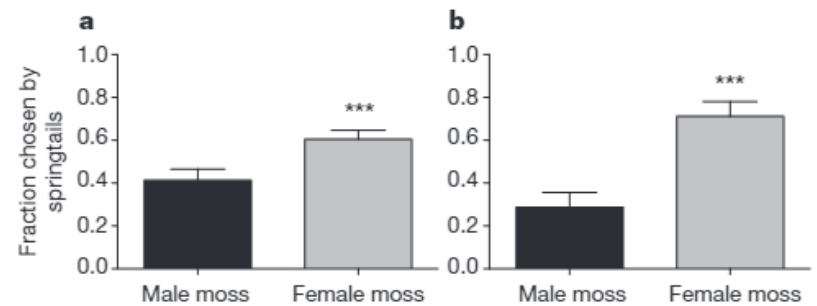


Figure 3 | Springtails prefer female moss. a, b, The fraction of *C. purpureus* samples chosen by springtails (error bars, mean \pm s.e.m.) in preference assays of male versus female samples in Petri dishes (a, $n = 24$ assays, 491 springtails counted); and male versus female samples in an olfactometer (b, $n = 10$ assays, 276 springtails counted). *** $P < 0.0001$.

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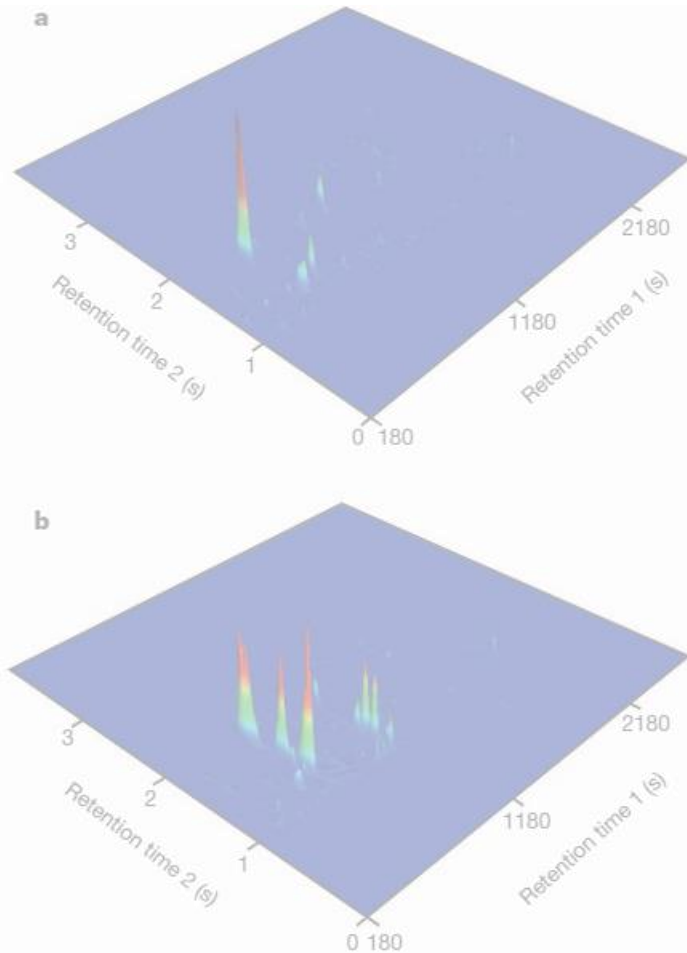


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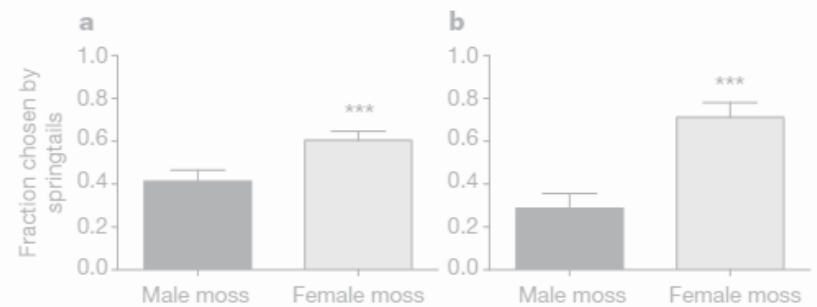


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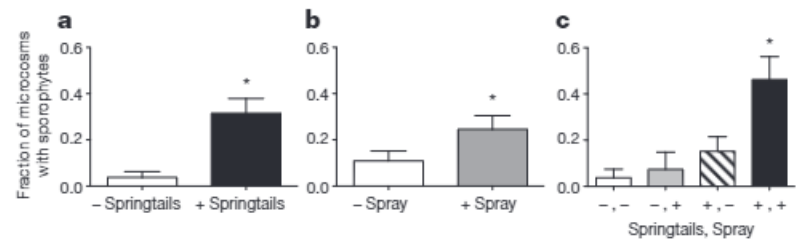


Figure 4 | Springtails enhance fertilization in moss microcosms.

a–c, Fertilization success in *C. purpureus* and *B. argenteum* microcosms, measured as the fraction of microcosms that developed sporophytes (error bars, mean \pm s.e.m.). The effects of springtail treatment (a), water spray treatment (b) and the interaction between these treatments (c) on fertilization success. Plus and minus symbols represent the presence and absence of springtails and water spray. $n = 108$ microcosms. * $P < 0.05$.

Spermonoši - „opylovači“ mechorostů?

Zatím ale zdokumentováno jen u dvou druhů v *in vitro* podmínkách

Bryum argenteum



Ceratodon purpureus



Isotoma caerulea



Scutovertex minutus



Folsomia candida



Sinella curviseta

Zoochorie mechorostů

U některých skupin výrazné **morfologické** i fyziologické adaptace:
Splachnaceae - výrazná apofýza (barva, velikost), lepkavé spory

Splachnum rubrum

S. ampullaceum

S. luteum






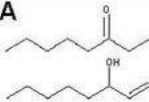
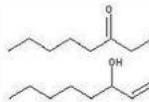
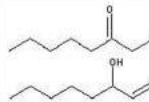
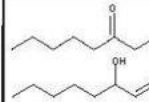
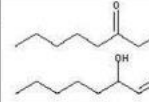
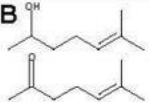
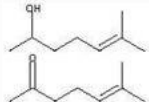
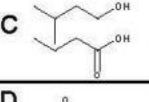
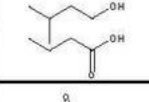
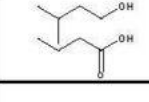
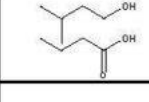
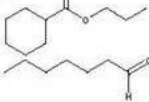
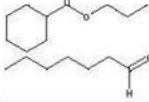
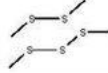






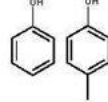




Tetraplodon mnioides



Zoochorie mechorostů

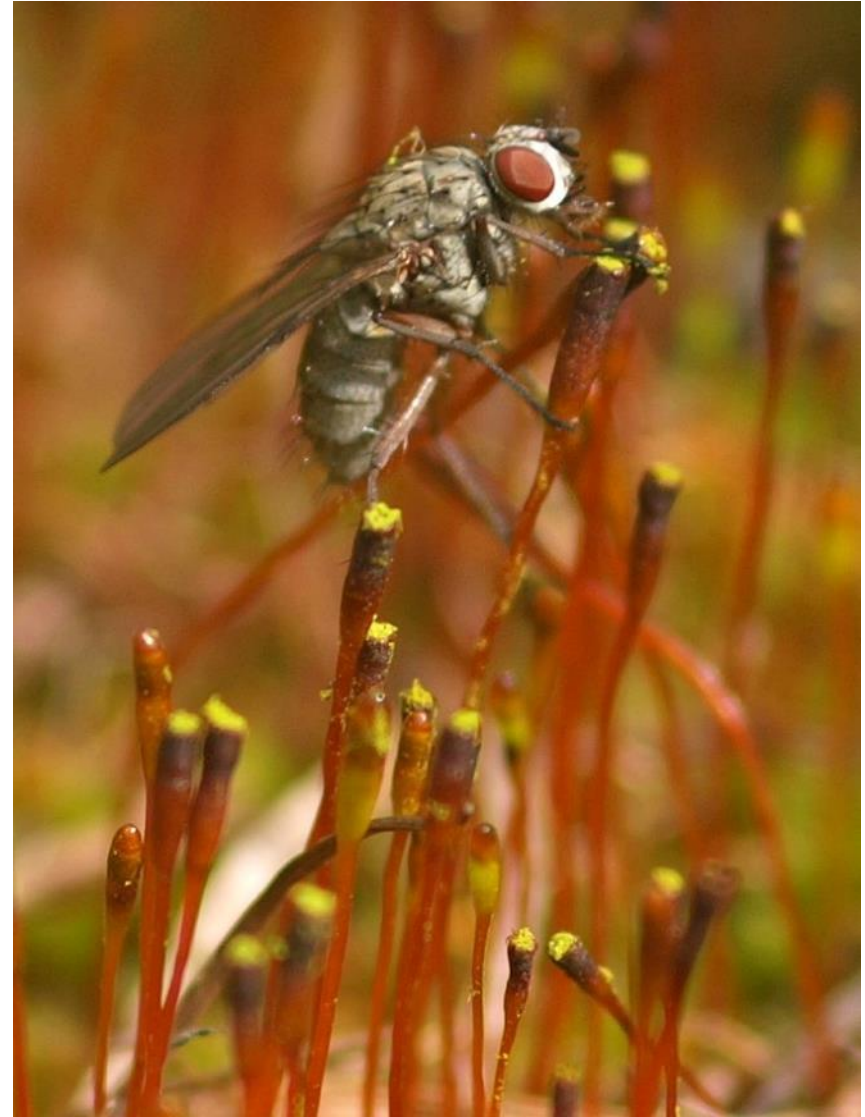
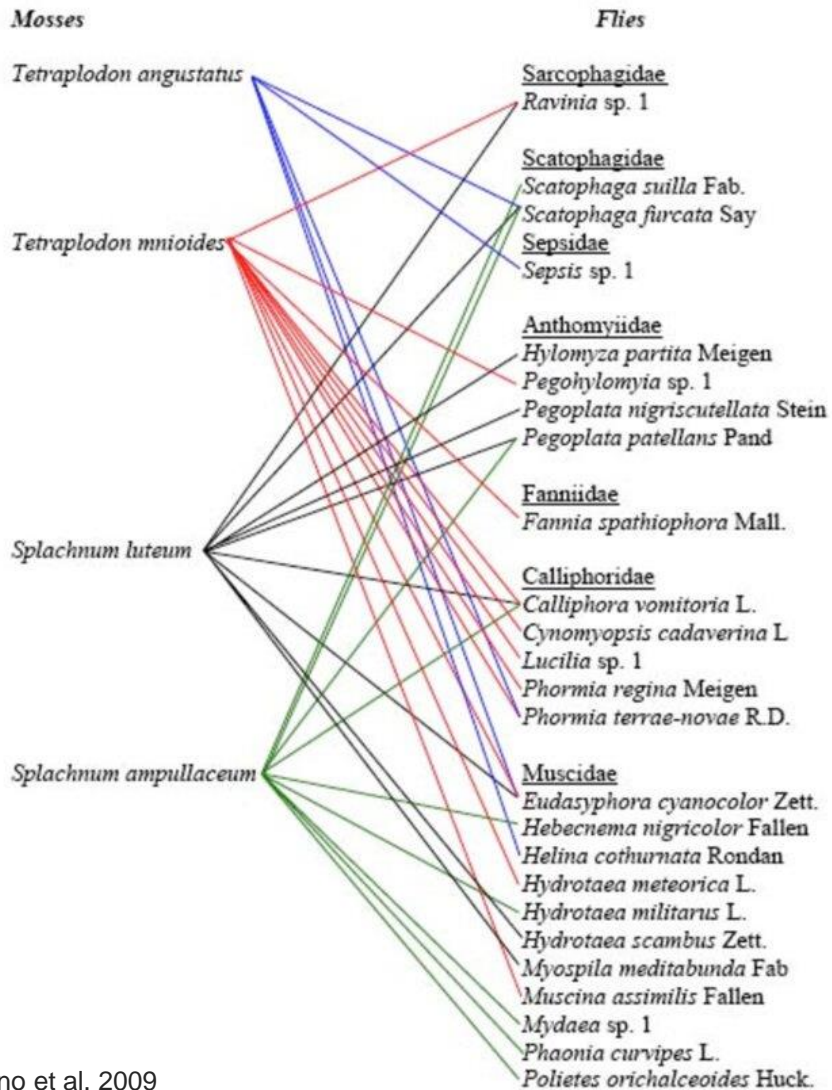
U některých skupin výrazné morfologické i **fyzilogické** adaptace:
Splachnaceae – produkce „vůní“ na lákání hmyzu

				
<i>Splachnum</i> (56) <i>sphaericum</i>	<i>Splachnum</i> (45) <i>ampullaceum</i>	<i>Splachnum</i> (31) <i>rubrum</i>	<i>Splachnum</i> (9) <i>luteum</i>	<i>Tetraplodon</i> (20) <i>mnioides</i>
A 				
B 				
C 				
D 				
E				
F				
G 				
H 				

Sporophyte odours identified from Northern Hemisphere Splachnaceae. Numbers in parentheses are the number of distinct volatile compounds identified per species. A. 1-octene-3-ol and 3-octanone common to peat moss and mushrooms. B. 6-methyl-5-hepten-2-one and -ol, derived from carotenoids. C. Butanoic acid and other short-chain fermentation products. D. cyclohexane carboxylic acid esters and heptanal, both common to mammalian urine. E. Dimethyl disulfide and -trisulfide, common to rotting flesh. F. Indole, G. Phenol and cresol, all common to herbivore dung. H. 2-phenyl ethanol and benzyl alcohol; floral odours.

Zoochorie mechorostů

U některých skupin výrazné morfologické i **fyzilogické** adaptace:
Splachnaceae – produkce „vůní“ na lákání hmyzu

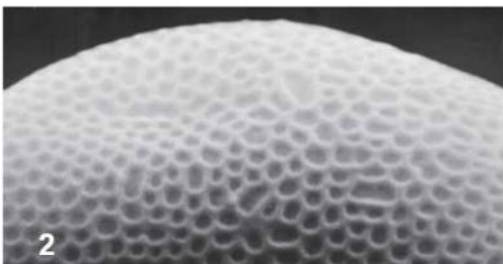


Zoochorie mechůstů

Zřejmě ale i u jiných skupin mechů:

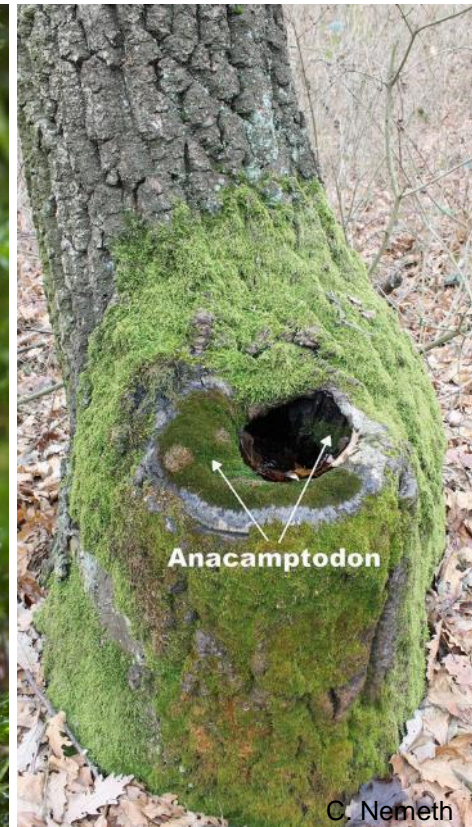
Schistostega pennata (Dicranales s.l.)

- ornamentika spor jako u Splachnaceae
- spory lepkavé, špatně se šíří větrem



Anacamptodon splachnoides (Hypnales)

- spory lepkavé, opakovaně nalezeny na těle hmyzu, co se specializuje na dendrotelmy (Wyatt et al. 2022)



Zoochorie mechorostů

Rudolphi (2009) Ant-mediated dispersal of asexual moss propagules

Aulacomnium androgynum



Lasius platythorax



R. Becker

ale taky mnohonožky či ptáci:

Zona (2013) Millipedes transport gemmae of *Calymperes palisotii* (Bryophyta: Calymperaceae)

Chmielewski et al. (2019) Forest passerines as a novel dispersal vector of viable bryophyte propagules

Habitat pro široké spektrum protist a drobných živočichů

krásnoočka



nálevníci



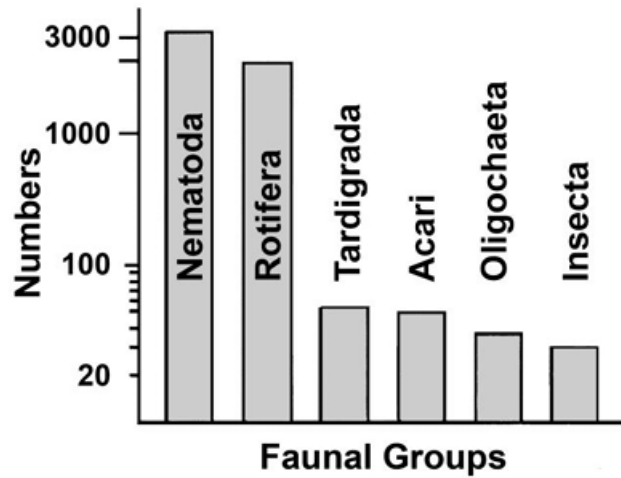
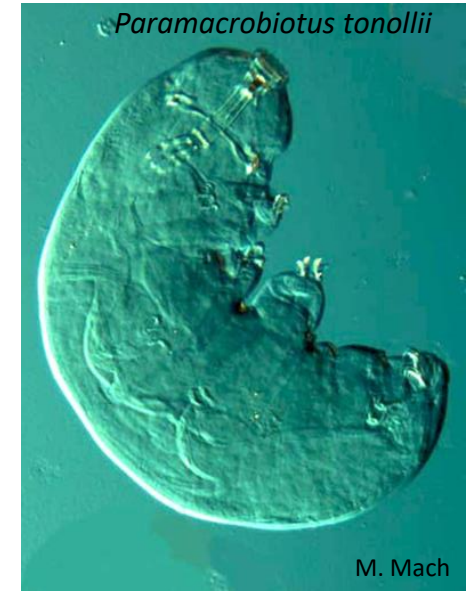
měňavky



vířníci



želvušky



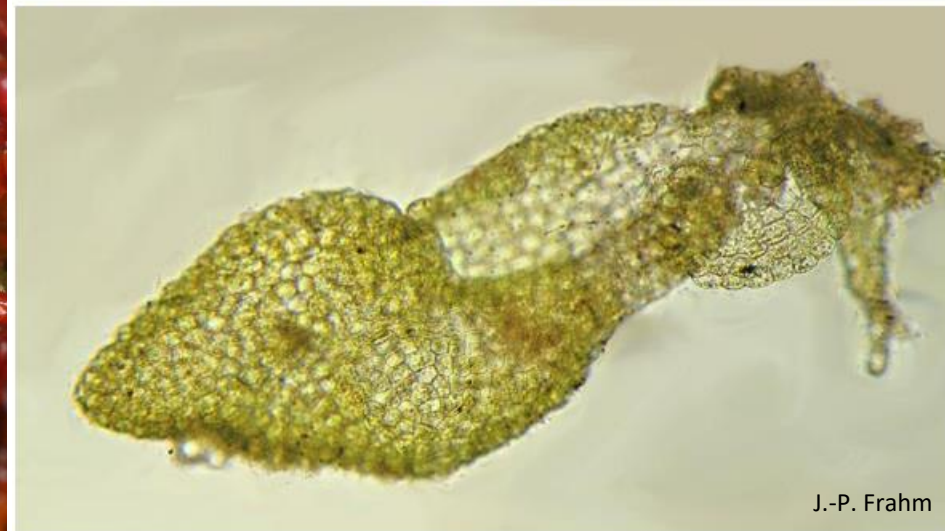
Masožravé játrovky?

- kapsovité laloky listů na zachytávání vody (někdy s víčkem)
- často obsahují živé i mrtvé nálevníky, vířníky a roztoče
- experimenty s kulturami nálevníků ukázaly, že se akumulují uvnitř laloků – past?
- masožravost? vhodný mikrohabitat?

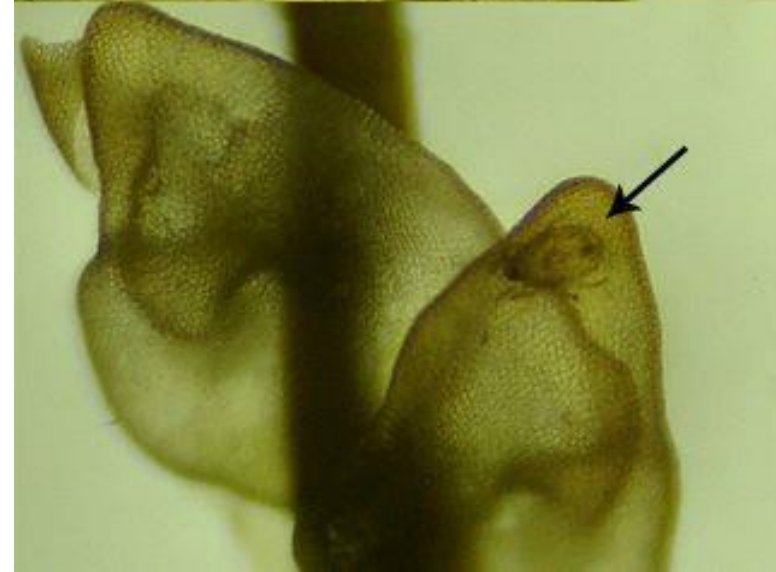
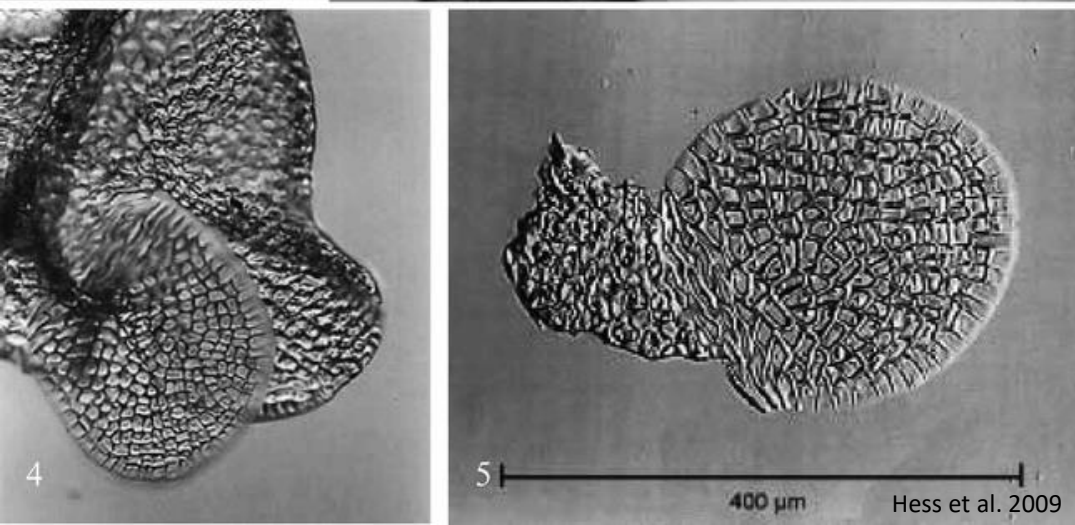
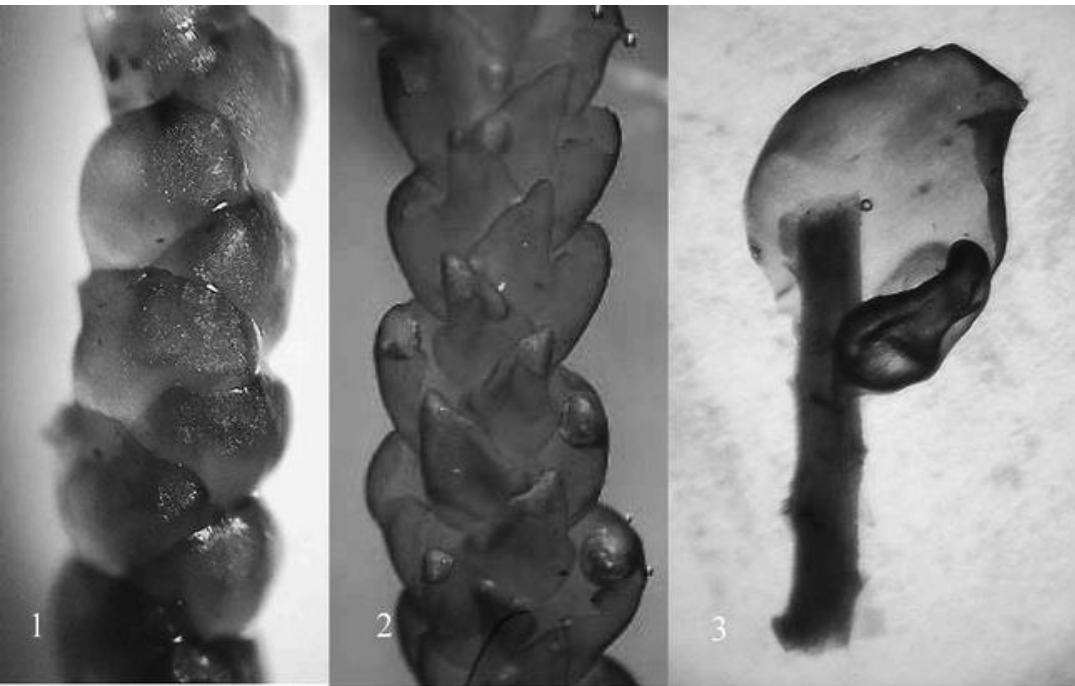
Pleurozia purpurea



Colura kilimanjarica



Masožravé játrovky? - *Pleurozia purpurea*



Endofyty mechorostů

- metabarcoding povrchově sterilizovaných mechů ukazuje na přítomnost širokého spektra hub v jejich stélkách

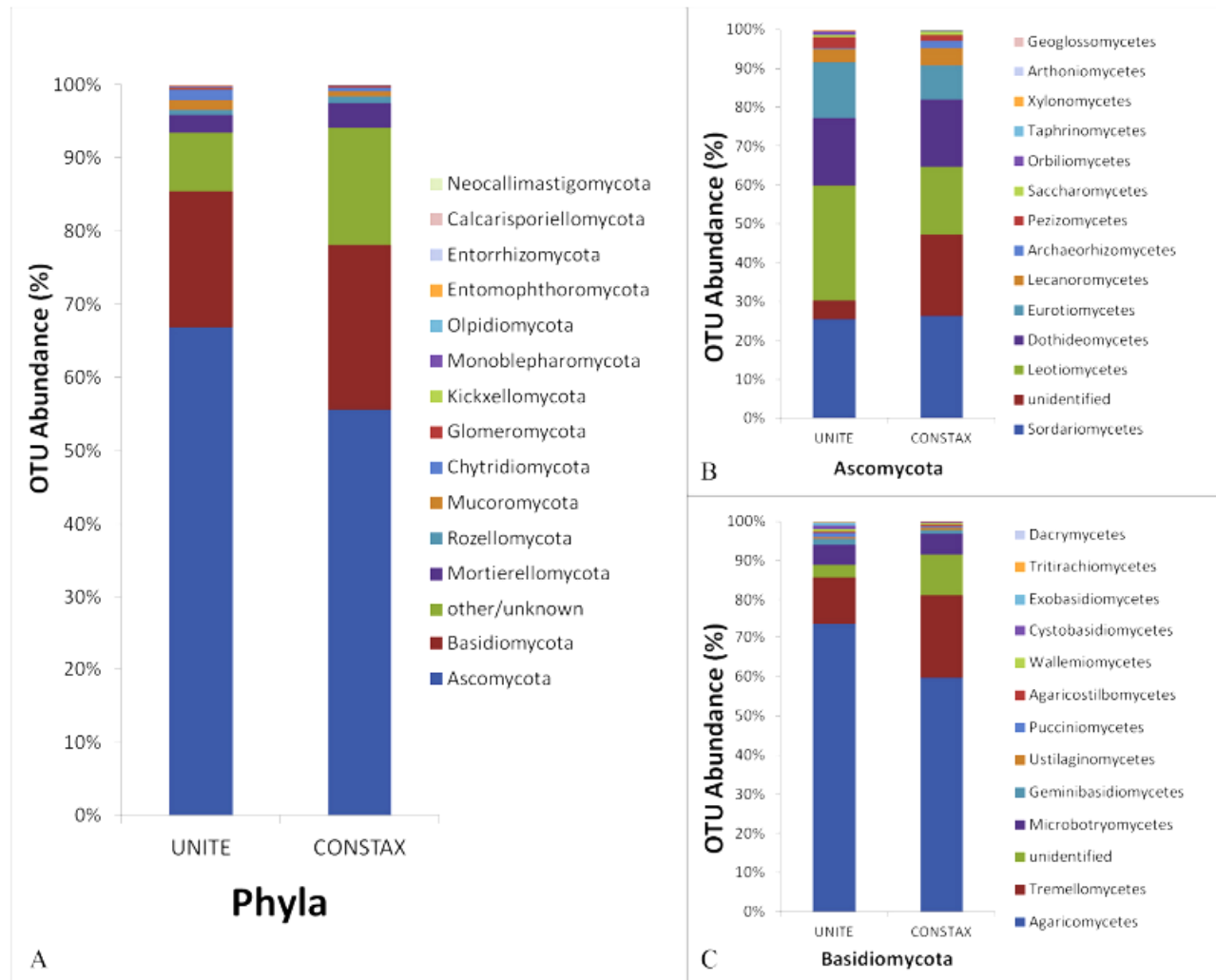
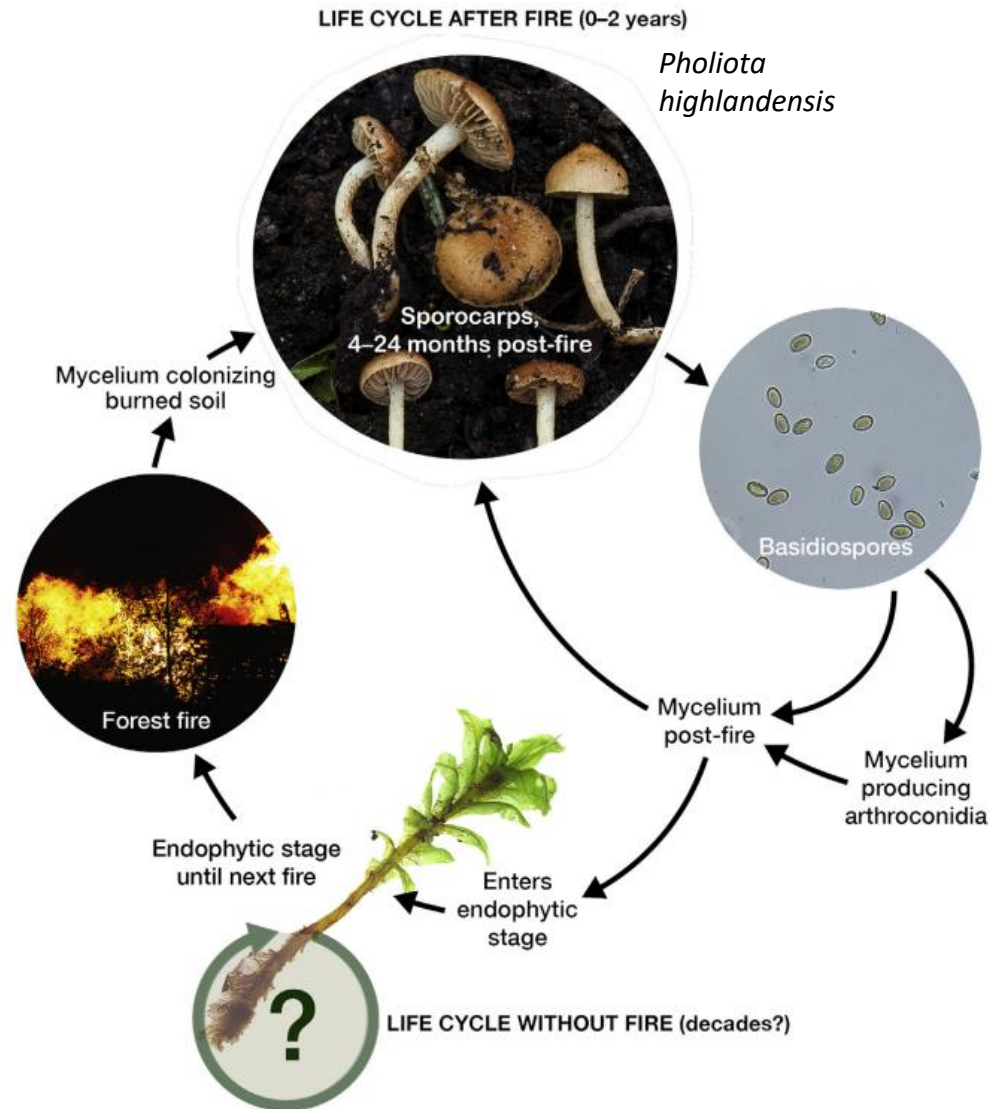


Fig. 1. Distribution of ITS1 OTUs per fungal phylum (A) and at the class level for the Ascomycota (B) and Basidiomycota (C).

Endofyty mechorostů

- sekvenace i kulturační metody zjistily přítomnost několika druhů spáleníšších specialistů ve stélkách mechorostů



Mechorosty jako potrava herbivorů

- kaloricky nejsou o moc méně výživné než cévnaté rostliny, zřejmě ale hůř stravitelné
- významnější složka potravy v arktických oblastech (sob, pišťucha, lumík, pižmoň)
- i tam ale často preference lišejníků
- v rámci hmyzu i specialisti na mechorosty

COMPARISON OF CALORIC VALUES

- roots in *Andropogon* field
- green herbs in *Andropogon* field
- bryophyte minimum (*Dicranella*)
- mangrove forest dominant vegetation
- bryophytes in oak woods
- bryophytes in alpine
- tropical rainforest dominant vegetation
- bryophytes - mean of all species
- bryophytes in coniferous forest
- bryophytes in northern hardwoods
- leaves - 57 species
- stems and branches - 57 species
- litter
- bryophyte maximum (*Thuidium*)
- bryophytes in alpine (from Bliss 1962)
 - roots - 57 species
 - *Pinus sylvestris* stand
 - alpine *Juncus* dwarf heath
 - seeds - 57 species

2000 3500 4000 4500 5000 5500 6000

cal / gdw

Forman 1968

Ochotona princeps

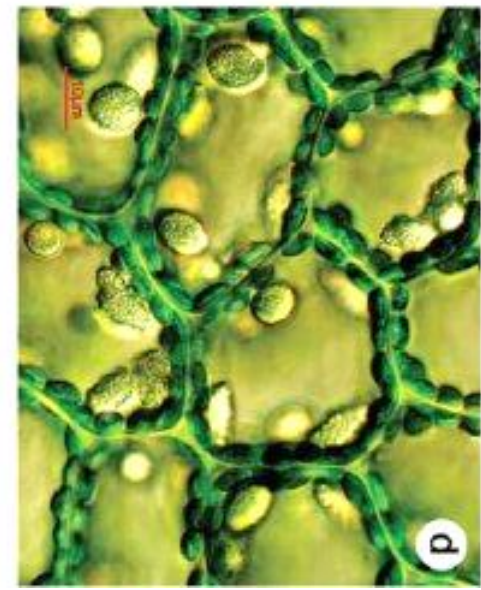
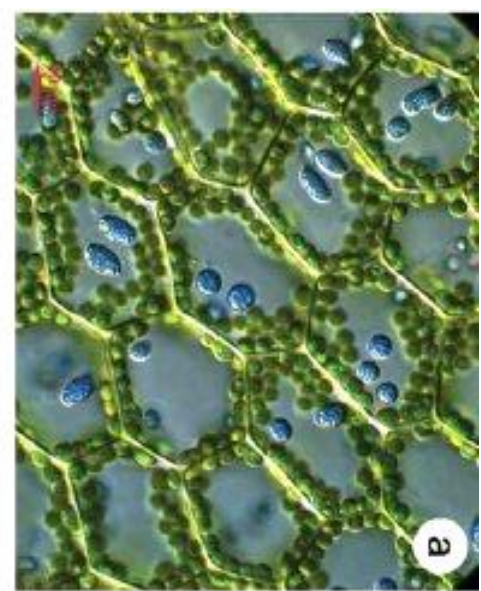
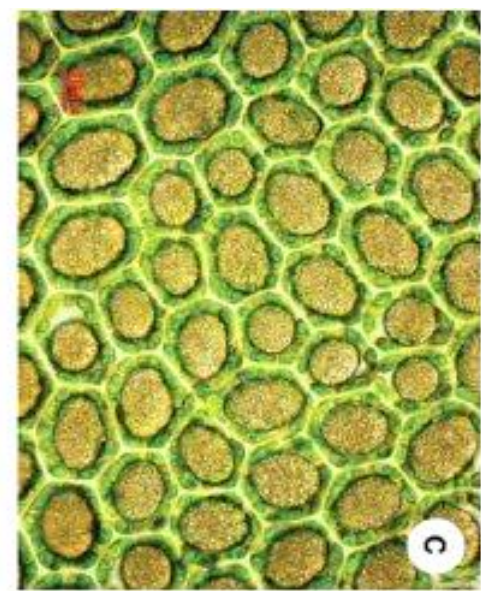


Mniophila muscorum



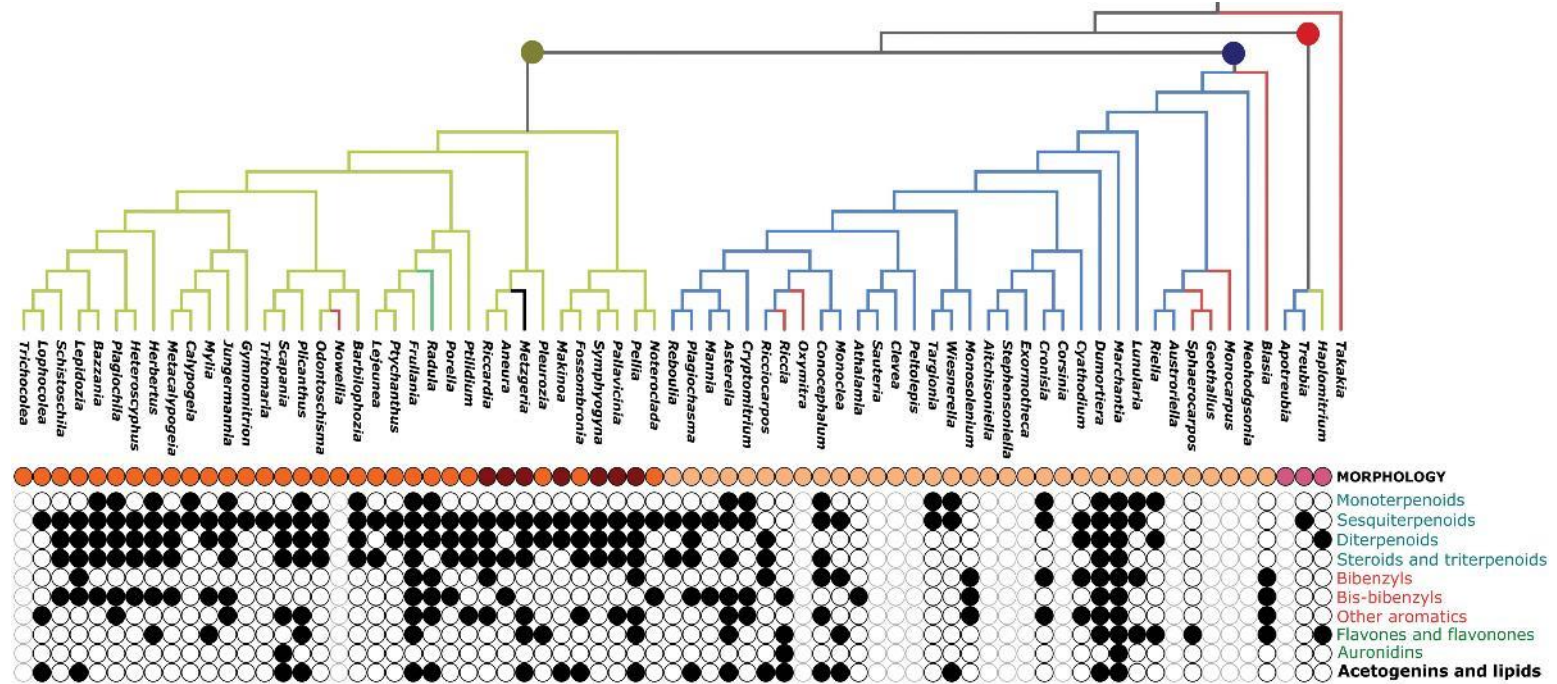
© H. Bouyon

Ochrana před herbivory – siličná tělíska

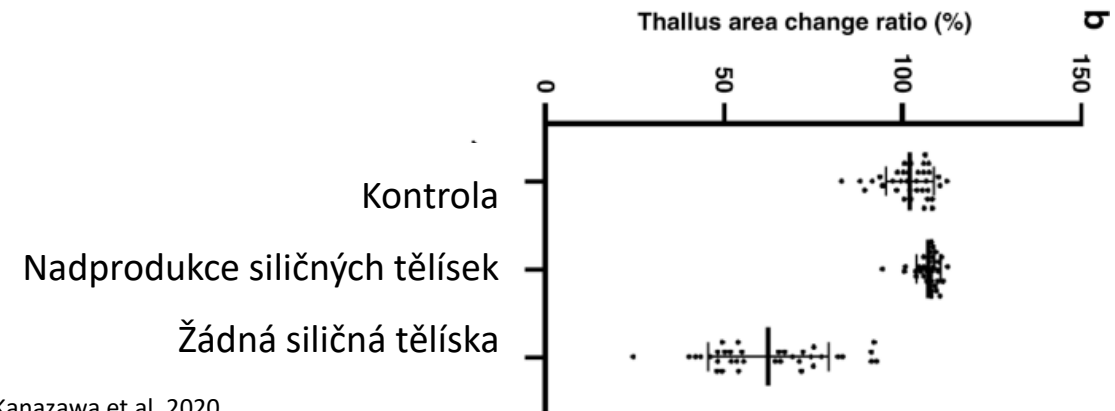


Ochrana před herbivory – siličná tělíska

- Liverwort class**
 - Haplomitriopsida
 - Marchantiopsida
 - Jungermanniopsida
- OB type**
 - Many in all cells
 - In idioblastic cells
 - Absent
 - One in all cells
 - Polymorphic genus
- Morphology**
 - Leafy-like
 - Complex thalloid
 - Leafy
 - Simple thalloid
- Compound**
 - Not detected
 - Present
 - No data



Romani et al. 2022



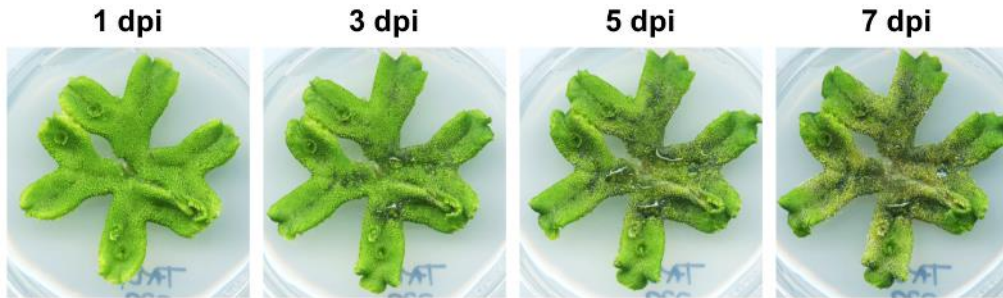
Kanazawa et al. 2020

Hostitelé širokého spektra patogenů

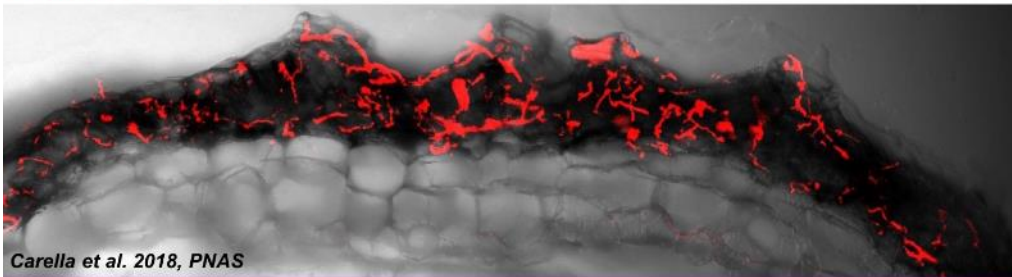
- Bakterie (některé ale asi i mutualisti)
- Oomycety
- ale hlavně houby

Oomycete

Phytophthora palmivora causes disease in *Marchantia*

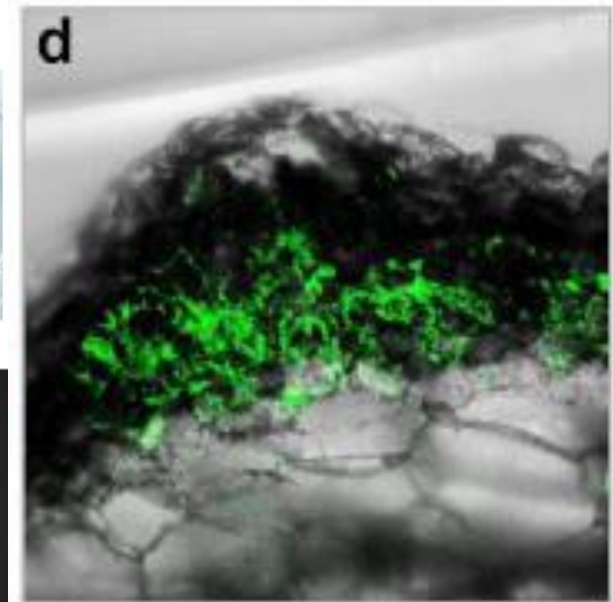


P. palmivora – ARI-td: All tested isolates are infectious



Bacteria

Pseudomonas syringae



Jeong et al. 2023

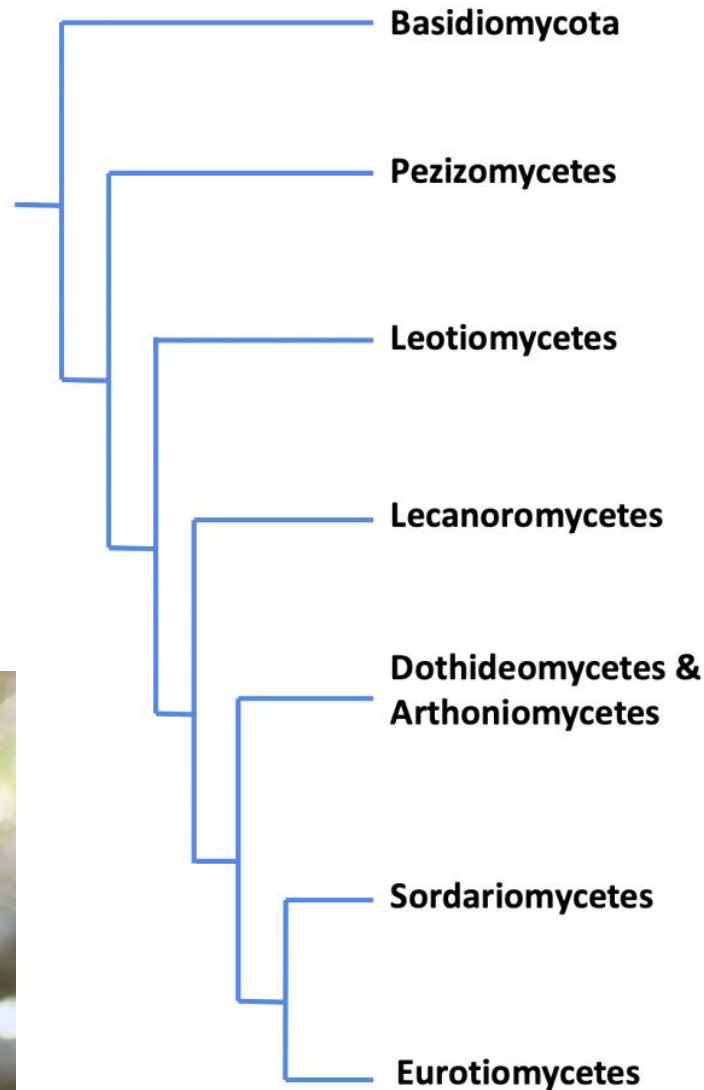
Bryoparazitické houby

- především zástupci Ascomycota a Basidiomycota
- vznik této strategie alespoň 20x nezávisle na sobě
- popsáno přibližně 500 druhů bryoparazitických hub
- skutečná diverzita ale řádově vyšší – „microscopic El Dorado“
- výrazné rozdíly v efektu na hostitele (biotrof/nekrotrof)

Acrospermum aleanum



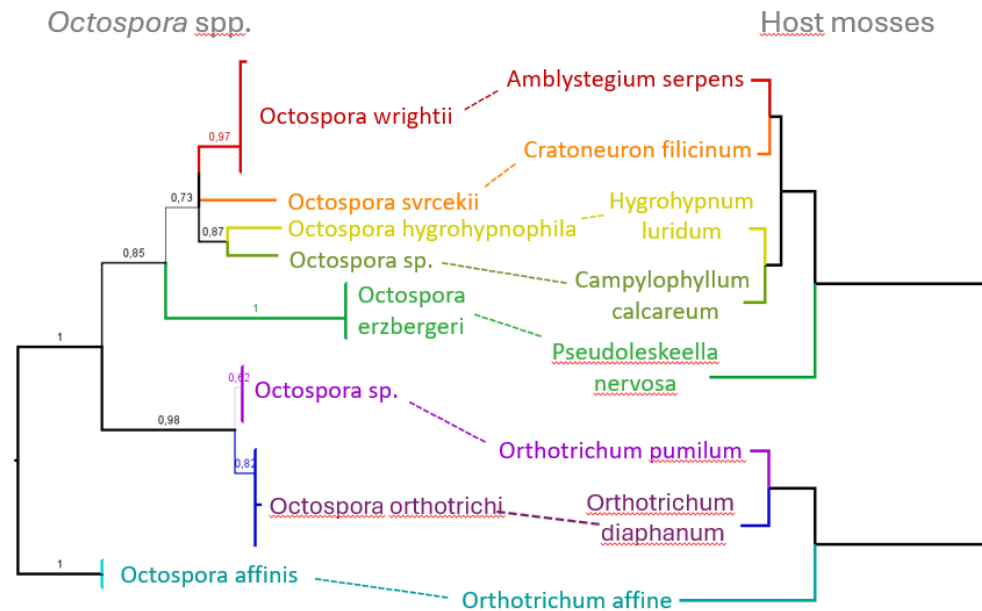
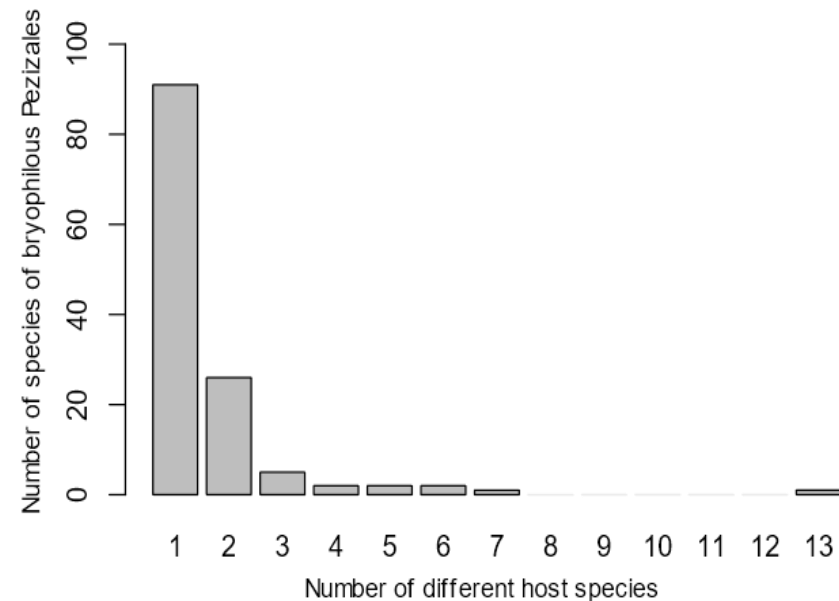
G. Greiff



G. Greiff, adapted from Stenroos et al., 2010

Hostitelská specificita

- úzká vazba na jeden druh hostitele
- koevoluce?
- širší hostitelské spektrum hlavně u nekrotrofních druhů
- jeden druh mechorostu může hostit i 10-15 různých parazitických hub (často specializace na konkrétní orgány)
- celosvětově 25 000 druhů mechorostů - skutečná diverzita bryoparazitických hub?



Bryoparazitické houby - bryofilní Pezizales

- okruh rodu *Octospora* - zemnička
- druhově bohatá skupina biotrofních parazitů mechorostů rozšířená po celém světě
8 rodů, 212 popsanych + stovky nepopsanych druhů
- specializovaný infekční aparát



Octospora rustica



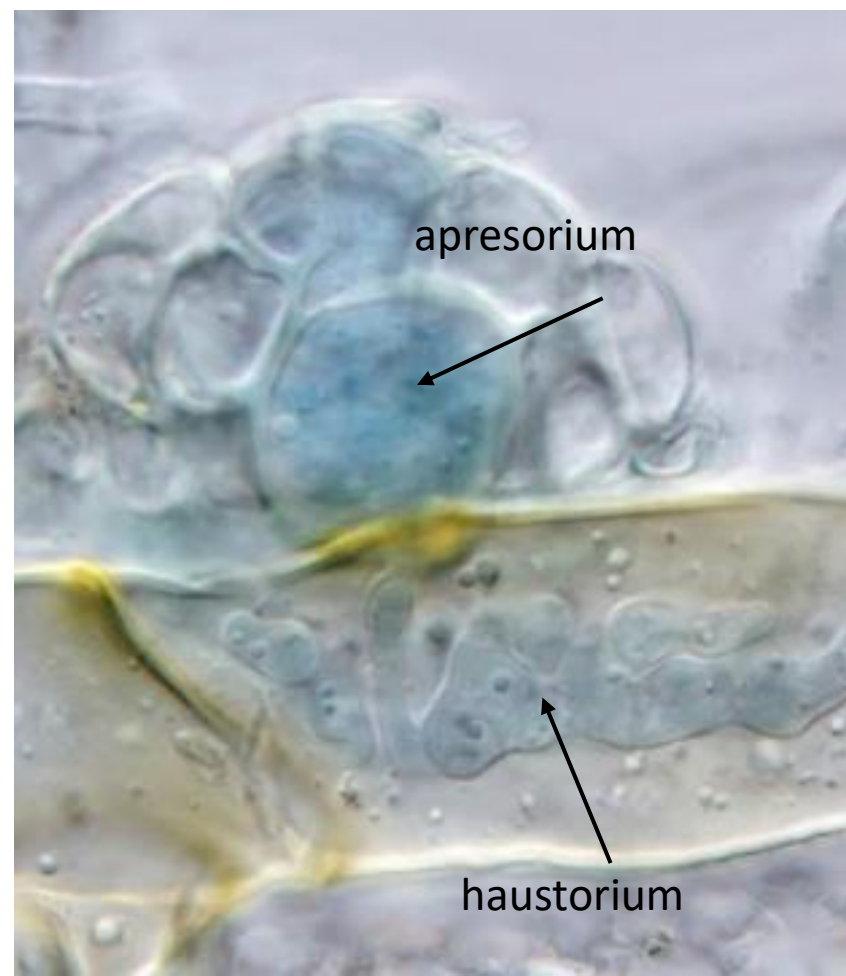
Neottiella vivida



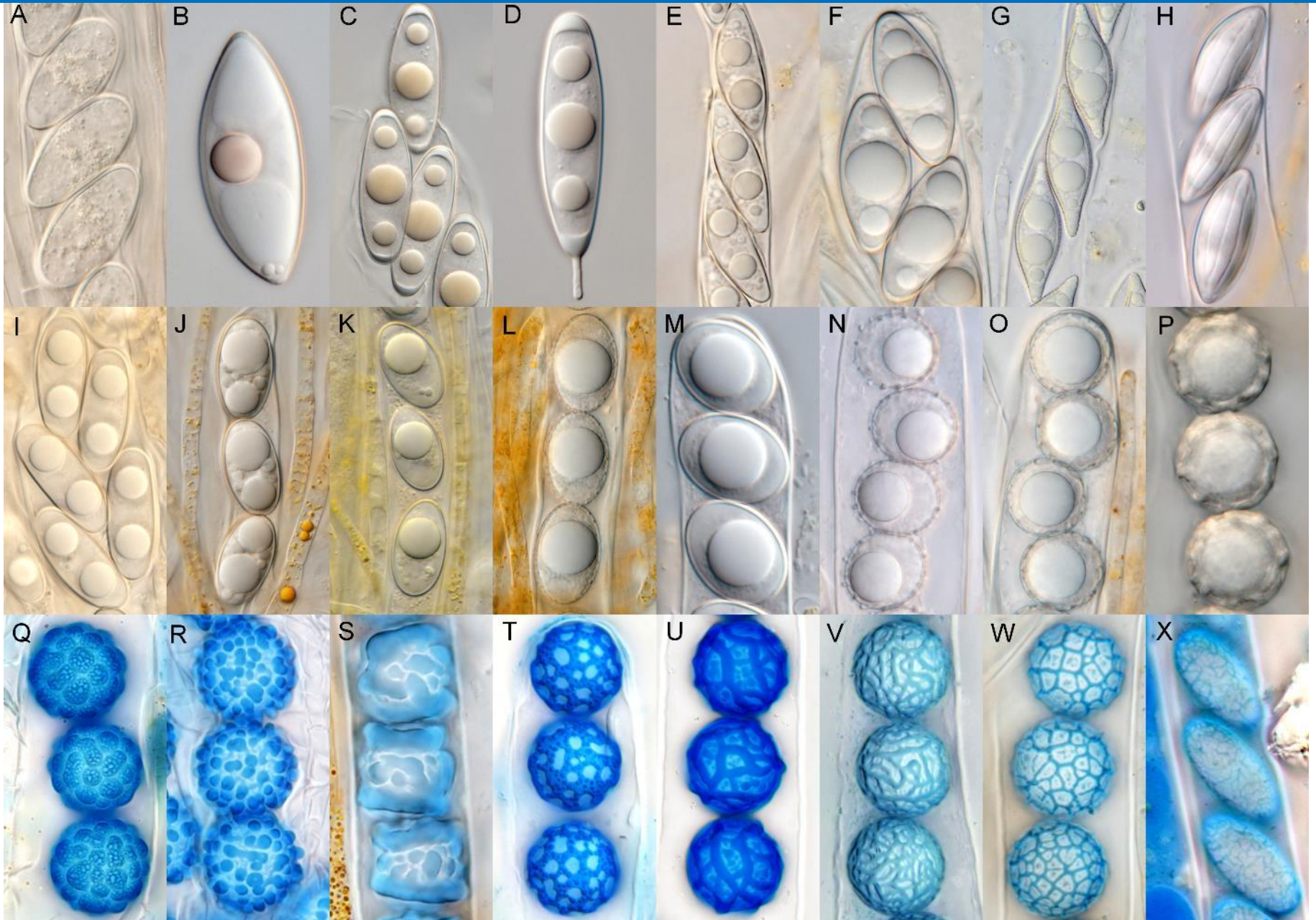
Octospora erzbergeri



Octosporella jungermanniarum



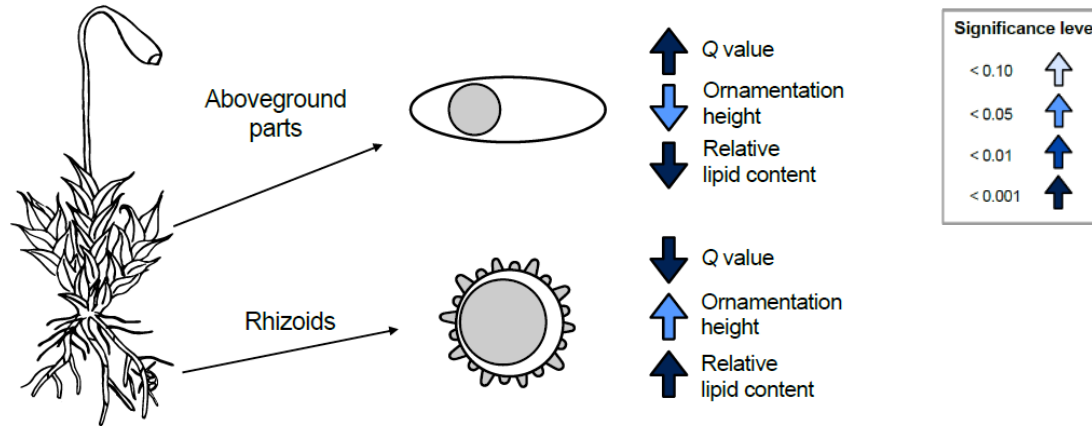
Octospora - morfologie askospor



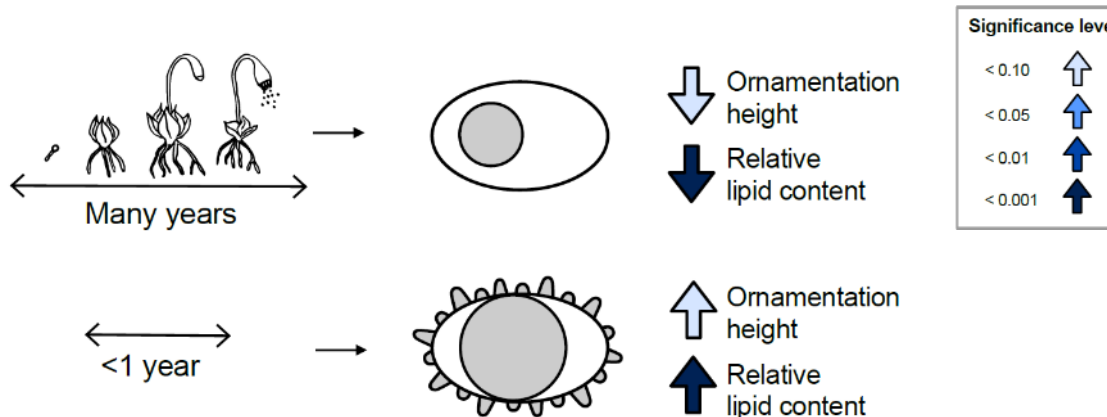
Octospora - morfologie askospor

- korelace morfologie askospor s ekologií hostitele a místem infekce

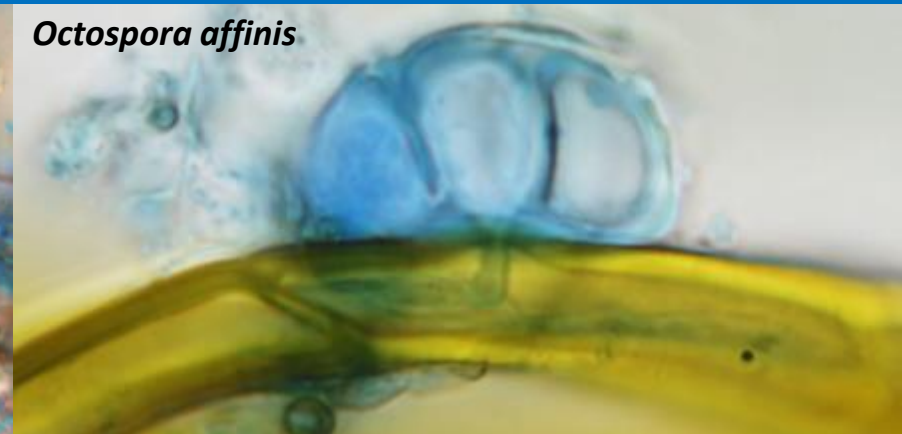
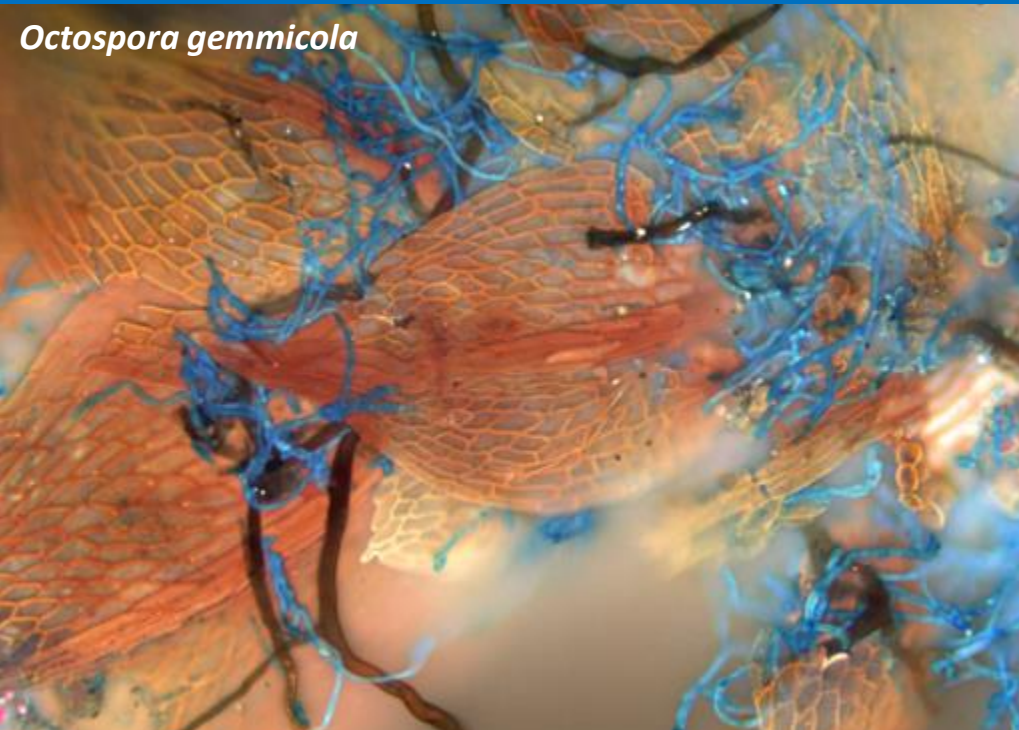
Dominant place of infection



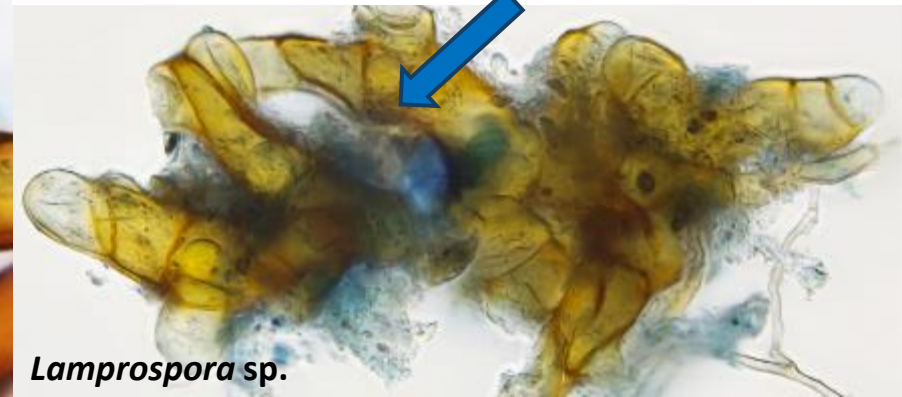
Potential host lifespan



Specializace na konkrétní orgány hostitele



tvorba hálek na rhizoidech



Lamprospora sp.

Specializace na konkrétní orgány hostitele

Epibryon interlamellare (Chaetothyriales): listy *Polytrichaceae* spp., specializace na prostory mezi asimilačními lištami



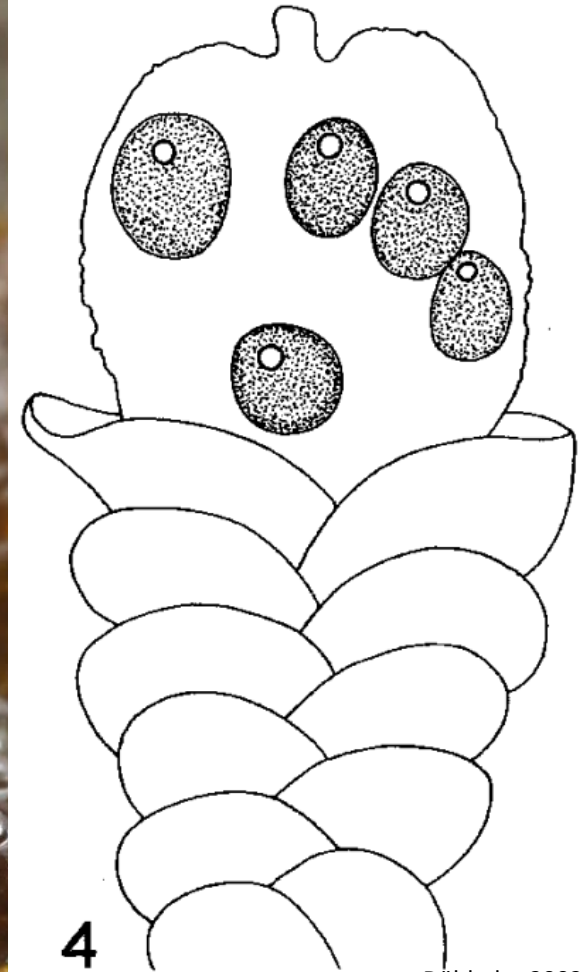
Specializace na konkrétní orgány hostitele

***Lizonia* spp.** (Pleosporales): vrchol samčích rostlin s antheridii různých
Polytrichaceae → kastrace hostitele



Specializace na konkrétní orgány hostitele

Periantria frullaniae (Hypocreales): periant a mladý sporofyt *Frullania* spp. → kastrace hostitele



Specializace na konkrétní orgány hostitele

Epibryon endocarpum (Chaetothyriales): listy *Plagiochila* spp., extrémní morfologická redukce → celá plodnice uvnitř jediné buňky hostitele



C. Halpin



G. Greiff