



## Using genomics to solve taxonomic puzzles in the genus *Cladonia* Final report

### 1. Team

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### 2. Project focus

The initiative lasted from July 1<sup>st</sup> to December 31<sup>st</sup> 2025. The project thematically built on and extended previous projects supported by AKTION Initiative, which were realised in 2023 and 2024 in cooperation between Charles University and the University of Graz. In both previous projects, we focused on the lichen-mite interactions and studied *Cladonia norvegica*, a lichen species characterised (apart from other characters) by red spots on the thallus. These red spots are caused by rhodocladonic acid (otherwise known from the fruiting bodies of red-fruited *Cladonia* species), and it is thought that the lichen produces this substance in response to mite infection and feeding.

In 2025, we extended our cooperation to start covering a new topic: genomics in the genus *Cladonia*, which connects the know-how of both involved institutions. Furthermore, we (including team members from previous projects) focused on the preparation of manuscripts that resulted from our results obtained during previous years. This resulted in two published scientific papers (described in bigger detail below).

### 3. Objectives and aims

In the project proposal, we defined the following goals:

1. Provide high-quality genome annotations of *Cladonia bellidiflora*, *C. polydactyla* and *C. umbri-cola*.
2. Combine genome sequencing data with reduced representation data (RADSeq) from a previous population genomic project to identify variable genomic areas.
3. Crosslink functional annotation data with data on the genetic variation in specific genomic regions to identify candidate regions which could explain phenotypic differences between the taxa
4. Extend an already existing genome-based phylogeny of the genus *Cladonia* to reevaluate the elusive evolutionary history of the three studied *Cladonia* species.
5. Obtain high-quality genomes of members from another taxonomically problematic group (*Cladonia coccifera* group) to lay the foundation for continued collaboration in the following year.

Here we describe how we managed to achieve them:

We successfully accomplished points 1, 4, and 5. Points 2 and 3 are currently in progress and are expected to be completed in spring 2026. The delay was caused by organisational and personnel changes during the project period, which temporarily limited the capacity for data integration and functional analyses.



In addition to the originally proposed objectives, we devoted substantial effort to the preparation and publication of joint manuscripts. Two papers have been published during the project period: (i) the description of the new lichen species *Cladonia rubrotincta*, and (ii) a study on the diversity and ecological associations of mites associated with this lichen. Furthermore, a third manuscript is currently in preparation. All three manuscripts include an acknowledgment of support from the AKTION project.

#### 4. Outcomes and results

We successfully strengthened and deepened the collaboration between the lichenology and acarology research groups at Charles University and the University of Graz. As part of this collaboration, two peer-reviewed papers were published in 2025:

- Vtípilová V., Timdal E., Stodůlková E., Semerád J., Resl P., Steinová J. (2025): *Cladonia rubrotincta*, a new species distinct from *C. norvegica*. *The Lichenologist*, 57(6), 304-316.
- Pfingstl, T., Vtípilová, V., Ghlimová, H., Mourek, J., Steinová, J., Hessinger, T. P., Schäffer S., Resl, P. (2025). Oribatid mite fauna of three members of the lichen genus *Cladonia* in Europe—observations on species richness, endophagous juveniles and their morphology. *Acarologia*, 65(4), 1092-1123.

A third manuscript, focusing on feeding preferences of oribatid mites, is currently in preparation and is planned for submission to *Oecologia* in February 2026.

Additionally, two contributions based on project results were submitted to the International Association for Lichenology 10th Symposium (Trieste, 2026):

- “From red spots to a new species: integrating phylogeny, chemistry, and oribatid mite ecology in the *Cladonia norvegica* complex” (Vtípilová V., Pfingstl T., Ghlimová H., Mourek J., Resl P., Steinová J.)
- “Investigating phenotypic differences in the *Cladonia bellidiflora* group within the context of a phylogenomic analysis of Cladoniaceae” (Resl P., Grewe F., Konečná E., Steinová J.)

In July 2026, Dr Resl visited Prague, during which the teams discussed results to date and planned future collaborative activities. A joint field trip to Prokopské údolí was conducted with other Czech lichenologists, during which lichen samples were collected.

In November 2025, Jana Steinová visited Graz to focus on data analysis and the progress of joint publications, while also discussing additional research directions to strengthen ongoing collaboration. To support continued cooperation, we applied for another AKTION bilateral cooperation grant for 2026.

Furthermore, Heda Ghlimová, a Czech PhD student, collaborated with Dr Resl during a one-month research stay at the University of Graz (financed by an AKTION scholarship), contributing to manuscript preparation and collecting lichen material for her PhD thesis on serpentine rock outcrops near Kirchdorf. The inventory of this locality is planned for publication in 2026.

Regular online meetings of the team ensured coordination and discussion of future plans. The planned research stay of Mgr. Eliška Konečná was postponed due to institutional constraints at the University of Graz.

Overall, the project has expanded the thematic scope of future collaboration, particularly in lichen (phylo)genomics and lichen-mite interactions. The work completed and the publications produced demonstrate strong scientific impact and provide a foundation for further research with significant publication potential and relevance to the lichenological and acarological communities.