Do saxicolous lichen communities represent photobiont-mediated guilds?

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Introduction

More than 15 100 lichen (fungus) species have been described to date, occurring in almost all terrestrial ecosystems, colonizing a wide range of habitats. In a certain geographic space, particular habitats can host more or less unvarying lichen communities. Their composition is usually a good indicator of specific local conditions (e.g. high-metal-content in siliceous rock). Many of lichen communities were described based on the composition of lichen (fungus) species, however, we know almost nothing about the composition of their photobionts...

Some recent studies have found lichen-forming algae or cyanobacteria from different environments clustered in distinct lineages. Such environmental preferences of autotrophic partners may limit ecological niches available to lichens. Together with requirements of mycobionts they result in the existence of lichen guilds.

Hypothesis: Lichen communities function as lichen guilds, i.e. each lichen (fungus) community growing in specific environmental conditions associated with a distinct pool of photobionts.

Object: saxicolous lichen communities of central Europe...

... growing in similar climatic conditions (low altitudes) on different rock types...

... sharing Trebouxia photobionts

Results

Photobiont diversity

- In 89 lichen taxa of saxicolous communities, 24 Trebouxia lineages were found, including eight authentic Trebouxia species (additional sequences used in the analysis represent further 25 clades).
- Photobionts of saxicolous lichens of central Europe belong to three of four Trebouxia major clades – A, I, and S (see phylogenetic tree on the left).

Lichen guilds

- All individual Trebouxia lineages were shared by several fungal species (3–34); the selectivity of fungi varied from low to high.
- The photobionts exhibited rather clear habitat/community preferences – each lichen community shared a specific pool of distinct algal lineages.
- The lichen fungi and their photobionts formed obvious ecological assemblages – limestone (calcareous), volcanic and siliceous rock guilds.

- Each guild had its „core“ comprising species with narrow ecology, but the boundaries among guilds were not distinctly defined – ecologically closer communities partly shared their photobionts.
- Volcanic guild formed a natural link between limestone and siliceous guild.
- Eurycious lichen taxa often represent the intermediates between „neighbouring“ guilds (e.g. Lecanora saxicola between limestone and volcanic guild, Candelariella vitticola between volcanic and siliceous guild – see figs on the right).

Ecology of photobionts

- The adaptation to different chemical composition and pH of substrate seems to have an origin in the evolution of Trebouxia – the preferences were obvious already on the level of major clades:
  - clade A is rather basophilous (but including acidophilous subspecies as well, e.g. T. jamesii, clade A1)
  - clade I is strictly acidophilous
  - clade I does not prefer distinct pH, but their members were mainly found in lichens typical for eutrophicated environments.

- It may have a consequence in algal preferences to main substrate types: rock, soil and tree bark – T. incarnata and its close relatives from clade A were exclusively associated with saxicolous and terricolous lichens, on the other hand, the members of clades I and S represented mainly substrate generalists or preferred epiphytic lichens (see tree on the left).

Core species wanted!

- In a system of lichen guilds, vegetatively reproducing lichens (core species sensu Rikkinen et al.) may serve as propagators of photobionts within their soredia or isidia.
- We detect an interesting disproportion in numbers of vegetatively and sexually reproducing lichens associated with individual photobionts – some algae were never found in a core species (especially rock specialists from clade A), other seemed to predominantly associate with asexual, often epiphytic lichens.
- We can speculate about the role of symbiotic propagules as a common source of photobionts. The photobiont rain probably includes relatively high proportion of free-living forms of symbiotic algae (at least of some algal lineages).

Conclusions

- We found photobiont-mediated guilds in saxicolous lichen communities in central Europe.
- More than 24 photobiont species occurred in studied lichens. Four to five distinct Trebouxia lineages formed a core of each lichen guild.
- Some photobionts exhibit clear environmental preferences and participate only in one specific guild, several algae represent eurytopic taxa participating in various guilds (mainly Trebouxia species of volcanic guild).
- The most of Trebouxia species reveal chemical characters and pH of substrate rather than its „type“ – they are able to associate with saxicolous, terricolous as well as epiphytic lichens within similar range of pH.
- Trebouxia-mediated guilds have commonly a low proportion of vegetatively reproducing lichens. Moreover, some algal lineages are associated with very low number of sorediate or isidiate species. Therefore, we suppose they spend considerable part of their existence, including dispersal, as free-living algae.

Preparation: Lifebar (phylogenetic maximum likelihood analysis using GARLI v. 2.13) (Zwickl 2006), TIM1+I+G model, BLAST similarity searches (Zwickl 2006) and color coding of trebouxial taxa with bootstrap ≥90% are in bold. 

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