Trebouxia - a key player in the formation of many different lichen species

[1,2,3]I. Valentin Petrescu-Mag

[1] Department of Environmental Engineering and Protection, Faculty of Agriculture, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania; [2] Bioflux SRL, Cluj-Napoca, Romania; [3] University of Oradea, Oradea, Romania.
Corresponding author: I. V. Petrescu-Mag, zoobiomag2004@yahoo.com

Key Words: association, evolution, fungus, green algae, symbiosis.

Introduction. There were approximately 15,000-20,000 known species of lichens in the world (Bhagarathi et al 2022). Lichens are the result of symbiosis between an alga (photobiont) and a fungus (mycobiont). A species of alga can create a relation with one or more species of fungi. Each species of lichen is the result of a unique combination between one alga and one fungus.

The plastic and versatile group of algae. Among the algae that form symbiotic relationships in lichens, the most versatile and widely associated genus is *Trebouxia. Trebouxia* is a genus of green algae that is known to form associations with a diverse range of fungal partners, particularly in the lichenized ascomycetes. This adaptability makes *Trebouxia* a key player in the formation of many different lichen species.

Trebouxia algae are found in a wide range of lichens, contributing to the diversity of lichen species worldwide. Their ability to associate with various fungi allows for the creation of a multitude of unique lichen species, each with its own specific ecological niche and habitat. Within the genus *Trebouxia*, there are many species that have been identified as lichen photobionts (the photosynthetic partner in the lichen symbiosis). Estimates suggest that there are over 70 recognized species of *Trebouxia* associated with lichens, but this number may vary as new research is conducted and more detailed molecular studies are performed.

Some lichens can form symbiotic relationships involving more than two species. These are known as "tripartite lichens" (García-Breijo et al 2023). In addition to the fungus and a primary photosynthetic partner (usually a green alga or a cyanobacterium), they may also include a third microorganism, often a yeast or another type of alga, which can contribute to the lichen's overall biology. One example is the *Lobaria pulmonaria* lichen, which forms a symbiotic relationship with both a green alga from the genus *Trebouxia* and a cyanobacterium. This makes it a tripartite lichen. It is worth noting that while these tripartite associations exist, they are less common compared to the more typical lichen symbiosis involving just a fungus and a single photosynthetic partner. The study of multipartite lichen associations is an interesting area of research within lichenology.

***Trebouxia* in terms of evolution**. *Trebouxia* is a genus of green algae that is commonly found in lichens. In lichens, *Trebouxia* forms a mutualistic relationship with a fungus, where the *Trebouxia* provides photosynthetic capabilities to the lichen, while the fungus offers structural support and protection. This mutualistic relationship is crucial for

the survival and growth of the lichen. While *Trebouxia* is typically associated with lichens, it is possible for some species of *Trebouxia* to exist independently in certain environmental conditions. In these cases, the algae may be found growing on surfaces like rocks, soil, or trees without an associated mycobiont (fungus). However, it's important to note that the biology of *Trebouxia* is diverse, and not all species may be capable of independent growth (Ahmadjian 2001). We suppose that some species of *Trebouxia* can live independently without a mycobiont, but this is not their typical mode of existence. Their primary ecological role is within the symbiotic relationship of lichens. There are some other interesting aspects about *Trebouxia*, wich makes the genus susceptible to evolution and/or suggest that it is currently in full evolutionary process.

High genetic diversity. *Trebouxia* exhibits a high degree of genetic diversity (Nyati et al 2013). This diversity has been attributed to various factors, including geographic isolation, host specificity, and ecological conditions. Different species of *Trebouxia* may have specialized adaptations that allow them to thrive in specific environments or with particular fungal partners.

Horizontal gene transfer. Studies have suggested that horizontal gene transfer (the transfer of genetic material between unrelated organisms) may have played a role in the evolution of *Trebouxia*. This phenomenon could have contributed to the genetic diversity observed in this genus (Beck et al 2015).

Adaptation to environmental conditions. Different species or lineages of *Trebouxia* may show adaptations to specific environmental conditions, such as drought tolerance, resistance to pollutants, or the ability to thrive in nutrient-poor substrates. These adaptations likely evolved in response to the diverse range of habitats where lichens containing *Trebouxia* can be found (De Carolis et al 2022).

Co-evolution with fungal partners. *Trebouxia* has likely co-evolved with its fungal partners over millions of years. This co-evolution has likely involved reciprocal adaptations that allow both the alga and the fungus to thrive in their symbiotic relationship (Ahmadjian 1987).

Ancient origins. *Trebouxia*, like other green algae, has ancient origins, dating back hundreds of millions of years. The association between green algae and fungi in lichens is thought to have evolved early in Earth's history (Beck et al 2015).

Flexibility in symbiotic partnerships. Species of *Trebouxia* can form symbiotic associations with a wide range of fungal species (Muggia et al 2013). This adaptability to different fungal partners may have contributed to the success and ubiquity of *Trebouxia*-containing lichens in various ecosystems.

Potential for hybridization. Some studies have suggested that hybridization events between different species or lineages of *Trebouxia* may occur under certain circumstances (Ahmadjian 2001). These events could potentially lead to the formation of new genetic variants with unique ecological characteristics.

Conclusions. Due to the fact that *Trebouxia* is a highly versatile and evolutionarily active genus it is a key player in the formation of many different lichen species. Our understanding of *Trebouxia*'s evolution is based on ongoing scientific research, and new discoveries may provide further insights into the fascinating evolutionary history of this genus.

Conflict of interest. The author declares that there is no conflict of interest.

References

Ahmadjian V., 1987 Coevolution in lichens. Annals of the New York Academy of Sciences 503(1):307-315.

Ahmadjian V., 2001 *Trebouxia*: reflections on a perplexing and controversial lichen photobiont. In: Symbiosis: mechanisms and model systems. Dordrecht: Springer Netherlands, pp. 373-383.

Beck A., Divakar P. K., Zhang N., Molina M. C., Struwe L., 2015 Evidence of ancient horizontal gene transfer between fungi and the terrestrial alga *Trebouxia*. Organisms Diversity and Evolution 15(2):235-248.

Bhagarathi L. K., Maharaj G., DaSilva P. N. B., Subramanian G., 2022 A review of the diversity of lichens and what factors affect their distribution in the neotropics. GSC Biological and Pharmaceutical Sciences 20(3):27-63.

De Carolis R., Cometto A., Moya P., Barreno E., Grube M., Tretiach M., Leavitt S. D., Muggia L., 2022 Photobiont diversity in lichen symbioses from extreme environments. Frontiers in Microbiology 13:809804.

García-Breijo F. J., Molins A., Reig-Armiñana J., Barreno E., 2023 The tripartite lichen *Ricasolia virens*: involvement of Cyanobacteria and Bacteria in its morphogenesis. Microorganisms 11(6):1517.

Muggia L., Vancurova L., Škaloud P., Peksa O., Wedin M., Grube M., 2013 The symbiotic playground of lichen thalli - a highly flexible photobiont association in rock-inhabiting lichens. FEMS Microbiology Ecology 85(2):313-323.

Nyati S., Werth S., Honegger R., 2013 Genetic diversity of sterile cultured *Trebouxia* photobionts associated with the lichen-forming fungus *Xanthoria parietina* visualized with RAPD-PCR fingerprinting techniques. The Lichenologist 45(6):825-840.

Received: 02 June 2023. Accepted: 22 June 2023. Published online: 30 June 2023.

Author:
Ioan Valentin Petrescu-Mag, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Agriculture, Calea Mănăştur 3-5, 400372, Cluj-Napoca, Romania, European Union, e-mail: zoobiomag2004@yahoo.com

How to cite this article:
Petrescu-Mag I. V., 2023 *Trebouxia* - a key player in the formation of many different lichen species. AES Bioflux 15(1):47-49.