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Editorial

Lichen Diversity and Biomonitoring: A Special Issue

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Abstract: Lichens are symbiotic organisms susceptible to environmental alteration due to their morphological and physiological features. For this reason, researchers and decision-makers are extensively using lichen biomonitoring for assessing the effects of various anthropogenic disturbances. The Special Issue was launched to fulfil some knowledge gaps in this field, such as the development of procedures to interpret and compare results. The SI includes three reviews that explore the application of lichen biomonitoring for detecting the effects of climate change. Three articles and one review paper examined the use at a decision level of biomonitoring of air pollution employing lichens, including the application in environmental forensic. Finally, six research articles are illustrative examples of lichen biomonitoring in poorly known habitats, providing data from the physiological to the community level of observation, and pose the basis for extending comparable approaches on a global scale.

Keywords: air pollution; climate change; functional traits; environmental forensic

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Lichens are symbiotic associations between a fungus and one or more photosynthetic partners. These organisms lack protective tissues, so they readily absorb water, nutritive substances, and gases directly from the atmosphere [1]. Due to these physiological peculiarities, lichens are sensitive to a suite of anthropogenic disturbances, such as atmospheric pollution, climate change, or forest management.

Although researchers extensively used lichens for biomonitoring anthropic impacts [2], there are still several controversial issues that deserve more investigation. This special issue comprises nine articles and four review papers addressing specific perspectives of lichen biomonitoring. For example, many aspects related to the interpretation of the lichen diversity data have not yet encountered a standard agreement between researchers, and new tools are currently developing in this field. For example, Rocha et al. [3], going beyond the traditional approaches for evaluating lichen diversity, adopted disturbance-tolerant lichen functional groups as an ecological indicator of the combined effects of environmental disturbances.

A recognized weak argument in lichen biomonitoring is the feasibility of applying methods on a global scale. Most of the biomonitoring applications in the recent past have been carried out in Europe and North America, whereas fewer reports came from other regions of the world. This SI contributes to filling this gap, presenting articles from poorly known habitats, such as Andean tropical ecosystems [4,5] and Turkish black pine forests [6]. Noteworthy, Aragòn et al. [7] pose the basis for developing a rapid diversity assessment method, likely applicable throughout the world. By correlating lichen growth forms and total epiphytic abundance across forests in Europe and Central-South America, the authors successfully employed lichen growth forms as a proxy of whole lichen diversity.

Other contributions explored the use of lichen diversity reports at a decision level. Brunialti et al. [8] warned about the consequences of non-sampling errors in lichen diversity assessments, attesting that the composition of the monitoring teams significantly affected data comparability, especially in long-term monitoring programs. A review paper by Loppi [9] revealed the excellent potential for using lichen biomonitoring data in environmental forensics, but stressed the relevance of delivering a formal expression of the overall uncertainty of the results. Increasing consideration has recently been devoted to the link between atmospheric pollution and ecosystem functions. In a pivotal paper, Geiser et al. [10] summarized the outcomes achieved in a large scale monitoring of atmospheric deposition of nitrogen and sulfur to US forests. As an original procedure, authors established deposition critical load in terms of an alteration of lichen functional groups, directly joining air pollution to the ecological risk for ecosystems.

Among other drivers of modification of lichen diversity, climate change is lately receiving more and more recognition. Three review papers in this SI illustrated the state of the art of research in this field, examining works carried out in different ecosystems and exploring the potential for further applications. Notably, Ellis provided a general overview and explored additional challenges to the use of bioclimatic models applied to lichen species [11]. Sancho et al. [12] evaluated the suitability of saxicolous lichens for monitoring environmental changes in Antarctic regions, where they are among the dominating organisms. Moreover, Nascimbene et al. [13] found support for the practical use of hair-lichens to detect the impact of climate change and nitrogen pollution in high-elevation forest habitats.

In connection with these reviews, Paukov et al. [14] published a research article that offered novel insights from the examination of lichen traits at species levels. Investigating saxicolous lichen communities in the Ural Mountains (Russia), the authors revealed a range of possible relationships among lichen acids, rocks, and climatic parameters. The authors suggested that secondary metabolites may be involved in some functions, such as the accumulation of metals and the stress tolerance under unfavorable conditions.

The research on lichen diversity cannot disregard the fact that many lichen species are obligate epiphytes, and that lichen diversity depends on the features of the surrounding vegetation. In their paper, Bacaro et al. [15] examined cross-taxon congruence among vascular plants and lichens in freshwater ecosystems. The authors observed that the more diverse and structurally complex the vegetation is, the more diverse are the lichen communities it hosts, enlightening new chances for a more comprehensive conservation strategy.

As a closing note, I hope readers may be inspired by the papers included in this collection and find useful material for their research. Much work remains to be achieved, with particular regards to the investigation of the diversity of lichens at distinct biological levels, including the exploration of phylogenetic and functional diversity, and the inter- and intraspecific variation of lichen functional traits, as a response to environmental drivers.

Finally, I would like to thank all the authors for their remarkable contribution to this SI. I also wish to thank the staff members at the MDPI editorial office (in particular Ms. Wei Zhang) for their support.

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