Forest bryophytes and microclimate

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Abstract

Bryophytes, often overlooked yet crucial and sensitive components of terrestrial ecosystems, play essential roles in forest understories by providing ecosystem services such as moisture retention and nutrient cycling. Their high sensitivity to environmental conditions makes them ideal model organisms for studying ecological processes under forest canopies. Forests cover a significant portion of terrestrial ecosystems and possess unique microclimate that buffer climatic extremes, differing substantially from open land. However, most climate data originate from meteorological stations outside forests, creating a potential blind spot in understanding climate change effects within forest interiors. Despite the potential for advancing forest understory ecology by combining bryophyte records with microclimate time-series, such data have rarely been available together until recently. The advent of affordable microclimate loggers has increased data availability but introduced new challenges, such as the lack of standardized measurement guidelines and common practices for calculating microclimate variables. Consequently, significant gaps remain in our understanding of microclimate effects on forest understory organisms.

To address the gap in bryophyte data availability, we established the Database of lichens and bryophytes of the Czech Republic (DaLiBor), which compiles and harmonizes all available digital data, resolves different taxonomic concepts, and validates metadata, including partial validation of occurrences themselves (Paper 4). To standardize microclimate time-series data handling, we developed myClim, an R package that provides reproducible methods for handling microclimate time-series data from loggers (Paper 3). A key question in microclimate ecology is whether in-situ measurements, which are expensive and demanding, are necessary or if cheaper proxies suffice. Our research demonstrates that no proxy fully captures the microclimate effects on forest understory bryophytes. The most critical drivers shaping bryophyte communities are growing degree days, maximum air temperature, and mean soil moisture (Paper 1). We also found that vapor pressure deficit, particularly its temperature component, significantly influences bryophyte communities at the landscape scale (Paper 2).

In conclusion, we found that near-ground microclimate is a crucial driver of temperate forest bryophytes. Specifically, we identified vapor pressure deficit, growing degree days, maximum air temperature, and mean soil moisture as the most important factors. Our findings are novel because they are based on field studies with in-situ measured variables, contrasting with existing knowledge primarily derived from physiological and manipulative experiments. Our results fill a gap in understanding the processes in forest understories affected by climate change and disturbances, traditionally based on macroclimatic data from weather stations, which are largely irrelevant for forested areas.