A study explores the hidden chemistry of moss and the factors influencing its emissions

- **A study led by IDAEA-CSIC and CREAF reveals that mosses and liverworts emit different types of volatile chemical compounds.**
- **The study, which analyzed 26 different species, found that some species emit more compounds than others.**
- **These volatile compounds may serve to communicate with each other and defend against environmental stress, as they fulfill similar roles in other higher plants.**

Bryophytes communicate through volatile organic compounds (VOCs), molecules released into the air by plants to "talk" to each other.

Barcelona, December 9, 2024. When we think of plants, it's easy to imagine towering trees or plants with various shapes and colors, but mosses and other bryophytes often go unnoticed. These small and modest plants have inhabited Earth for millions of years and harbor a fascinating secret: they emit volatile chemical compounds that could help them defend against

environmental stress. A recent study led by Ana María Yáñez-Serrano, associate researcher at CREAF and Institute of Environmental Assessment and Water Research (IDAEA-CSIC), suggests that this ability could help them survive and adapt to climate change, much like other higher plants. The study shows that bryophytes emit volatile organic compounds (VOCs), molecules that allow many plants to "communicate" with each other and their surrounding ecosystems. While communication through VOCs has been documented in other plant species, bryophytes' case remains a mystery. This research, although it does not fully decode the functions of these compounds in bryophytes, opens new lines of inquiry to better understand their chemical language and the essential role they may play in the balance of terrestrial ecosystems.

Many of the study areas are mountain spring sources. One of the major risks is that drought is increasingly affecting these microhabitats, causing them to dry up. Location: Font de Bufaganyes (Paratges de la Moixina, Olot). Credits: Marcos Fernández-Martínez.

These chemical messages have a dual function in plants, and with further studies in bryophytes, we may observe these mechanisms in them as well. On one hand, these compounds could activate growth maturation, and on the other, help species coordinate to face challenges such as heat, drought, light competition, or predation. A fascinating example is isoprene, which is considered a volatile hormone that triggers an immediate reaction to defend against thermal stress within minutes. Another example is limonene, which acts as a direct repellent against potential predators.

"Most of the bryophyte species we analyzed in the study had not been measured before. What we have discovered will help us better understand how they communicate and what triggers the emission of volatile organic compounds by bryophytes," said Yáñez-Serrano.

Communicating to acclimate to climate change

In the face of global warming, plants develop strategies to withstand thermal stress, and bryophytes are no exception. Yáñez-Serrano's study reveals that mosses' volatile emissions increase when temperatures rise, suggesting a possible natural protective mechanism. Isoprenoids, in particular, help reduce free radicals inside leaves, protecting plants from excessive heat and desiccation. Additionally, in boreal and tropical regions, where these plants cover vast areas of soil, their volatile emissions can influence atmospheric chemistry, as these compounds are precursors to aerosols that affect radiation and cloud formation.

Not all "speak" the same way

An interesting finding revealed by this research is that not all bryophyte species "express themselves" in the same way. Some, considered high emitters, release generous amounts of volatile compounds when they show higher productivity—that is, a higher level of photosynthesis. Others are classified as low emitters, producing much more modest amounts. What does this imply? The species that release more volatile compounds could have a competitive advantage, such as more effectively repelling predators. Ana Yáñez-Serrano explains that this difference could be important not only for the individual survival of each species but also for the health and balance of the ecosystem. Another case that highlights this dynamic is explained by an international study led by Eliška Vicherová, where it was shown that the moss *Hamatocaulis vernicosus* can detect volatile compounds emitted by another species, *Sphagnum flexuosum*, and affect not only its own growth but also the composition of its emissions.

In the study led by Ana María Yáñez-Serrano, the species *Oxyrrhynchium speciosum*, found in Catalonia, is one of the highest emitters of volatile organic compounds. Credits: Jordi Corbera (ICHN).

The methodology employed for this study was rigorous and complex, as measuring volatile emissions in such small and delicate plants as bryophytes presents a technical challenge. Photosynthesis measurement chambers were used to study 26 bryophyte species that inhabit mountain spring ecosystems in northeastern Spain. "Bryophytes are small and extremely sensitive plants, and measuring their volatile emissions has been a challenge. Even the slightest change in their environment can alter the quantity or type of compound they emit," says Ana Yáñez-Serrano.

"With this new perspective on mosses and liverworts and their surprising ability to communicate and adapt, a wealth of knowledge opens up," explains the researcher. In a context where climate change threatens global biodiversity, these tiny but extraordinary organisms remind us that nothing in nature is insignificant. What else could these pioneering plants, the first to colonize land, reveal to us? Perhaps within their invisible chemical secrets lie answers to other mysteries, but it is undeniable that their role in the planet's balance is just beginning to be understood. They still have much to tell us.

This study was led by Ana María Yáñez-Serrano from IDAEA-CSIC and CREAF, with contributions from Joan Llusià, Iolanda Filella, Josep Peñuelas, and Marcos Fernández-Martínez from CREAF, Jordi Corbera from ICHN, Miguel Portillo-Estrada and Ivan Janssens from PLECO, Catherine Preece from IRTA, and Francesc Sabater from BEECA-UB.

A.M. Yáñez-Serrano, J. Corbera, M. Portillo-Estrada, I.A. Janssens, J. Llusià, I. Filella, J. Peñuelas, C. Preece, F. Sabater, M. Fernández-Martínez (2024) *Drivers of biogenic volatile organic compound emissions in hygrophytic bryophytes.* Science of The Total Environment, Volume 946. ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2024.174293

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