Evolution's got a hold on stoichiometry

"Only with a leaf can I talk of the forest"
Visar Zhiti, The Condemned Apple: Selected Poetry

The ability of organisms to change their tissue stoichiometry to match their environment is in vogue as research in our field takes an evolutionary bent. One of the central tenets of ecological stoichiometry is that elemental composition and ratios can be somewhat inflexible—at least on ecological times scales—and so create barriers that define organism survival, growth, and reproduction.

The elemental composition of many organisms may not be rapidly evolving, but that does not mean it is independent of evolutionary history. In fact, the evolutionary history of organisms should be a major driver of their elemental concentration and stoichiometry. One taxon where this signal may not be strong is terrestrial plants who have famously flexible leaf stoichiometry, but also have diverse life history strategies and a well-resolved phylogenetic tree. In their recent publication, Sardans et al. gathered data on about 24,000 leaves from plants across the world and across the phylogenetic tree to analyze the influence of evolutionary history and plant environment on their elemental concentration. Their study focused on the concept of a biogeochemical niche, the idea that individual species remain viable within a restricted range of elemental concentrations in their tissues. They suspected that these tissue demands correspond to uptake demand from their environment and so they could help explain where and why each species can grow.

Sardans et al.'s efforts demonstrated a dominant effect of evolutionary history on leaf elemental concentration, which they found explains 80% of the variation in their data set. Furthermore, the variation in elemental concentrations across the phylogenetic tree was consistent with evolutionary history so that species in recently divergent genera had elemental concentrations that were more similar than those within genera that diverged further back in history.

In addition to evolutionary history, environmental conditions also played an important role. Mean annual temperature, precipitation, nitrogen deposition, and soil type together explained about 2% variation in leaf stoichiometry once phylogenetic history was considered. Environmental conditions did explain more than 3.8% of the variation in leaf stoichiometry when phylogenetic relationships were ignored. However, the limited explanatory power of environmental conditions after accounting for phylogeny is surprising given our preconception that plant leaf stoichiometry plasticity follows environmental variation.

Sardans et al. proposed a mechanism to explain why leaf stoichiometry may be more variable in some genera. Species that grow in stressful environments with non-elemental limitation (e.g., drought) appeared to have less variation in their elemental concentrations, which suggests a trade-off between optimizing elemental concentrations for the mean environment versus keeping flexible for matching emerging conditions (i.e., ruderals). For those species living in the wet, comfortable, herbivore-free ecosystems of the world, the strong effect of phylogeny on their leaf stoichiometry is a reminder that even the most malleable organisms carry the legacy of their evolutionary past.

From the Paper: "*Shared ancestry explained 60–94% of the total variance in foliar nutrient concentrations and ratios whereas current climate, atmospheric N deposition and soil type together explained 1–7%, consistent with the biogeochemical niche hypothesis which predicts that each species will have a specific need for and use of each bio-element.*"

Contributed by Robert Buchkowski, Jordi Sardans, and Josep Peñuelas

Sardans, et al. 2021. Empirical support for the biogeochemical niche hypothesis in forest trees. Nature Ecology & Evolution 5: 184–194. https://doi.org/10.1038/s41559-020-01348-1

ASLO's 2021 Hutchinson Award

Congratulations to Elena Litchman (Michigan State, USA), who recently received the 2021 G. Evelyn Hutchinson Award from the Association for the Sciences of Limnology and Oceanography (ASLO) for her work on 'trait-based' approaches in the study of plankton ecology. Most of us know Elena for her work on phytoplankton stoichiometry and trying to understand algal growth. According to ASLO, this award is given each year to "a limnologist or oceanographer who has made considerable contributions to knowledge, and whose future work promises a continued legacy of scientific excellence." Well done Elena; this is a decidedly important and well-deserved award. To learn more award this award and Elena's background, visit the ASLO page here:

https://www.aslo.org/aslo-awards/2021-aslo-award-recipients/2021-hutchinson-award-recipient/

ASLO Association for the Sciences of Limnology and Oceanography