

Drought effects on freshwater macroinvertebrate community in the Mediterranean: ecological network analysis as an innovative tool for bioassessment

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Freshwater ecosystems in the Mediterranean region are under high pressure. Predictions point to an increase in water scarcity with negative implications to the sustainability of freshwater resources. Models at the local and regional level forecast that water stress may become particularly acute in the south-west USA, the Mediterranean Basin and the Middle East. On the other hand, at the global scale, water demand has doubled over the last fifty years due to increased demography and water intensive use. It is therefore essential to develop tools able to quickly detect environmental drought effects and establish measures that minimize their associated socio-economic impacts.

From an ecological perspective, droughts are considered to be a ‘ramp disturbance’, whose effects on biological communities is influenced by factors such as timing, duration, intensity and the presence of refuges. As flows decrease, habitat space is generally reduced; organisms respond to these conditions by continuous colonisation–extinction processes that often lead to a reduction in their density or even extirpation. Network analysis can be a powerful tool to obtain useful information about the pattern of species incidence and/or species co-occurrence, revealing complex direct and indirect effects of stressors on biotic communities, beyond the simple loss or gain of species.

Here, we tested how drought dynamics in rivers influence the modular partitioning of macroinvertebrates co-occurrence networks using different datasets within the Mediterranean region, covering different spatial and temporal drought surveys. We postulate that under severe drought events the contraction of available habitats/resources leads to an increasing modularity. The higher modular partitioning of networks clearly indicate that the pattern of species co-occurrence is influenced in a non-trivial way by the drought period, influencing how each species aggregate or segregate in space and time. Our findings suggest that network modularity is a key tool for biomonitoring, able to discriminate the role of drought in different datasets and giving us better information than metrics from standard methods, with the advantage of requiring the same sampling efforts as current monitoring procedures. We advocate the use of such tool to improve our capacity to quickly detect environmental drought effects and accurately assess the ecological status of Mediterranean streams under multiple stressors.