



Dissecting copepod diversity at different spatial scales in Southern European ground water

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It is widely recognized that species diversity is scale-dependent, and this empirical observation led most researchers to evaluate scale-effects in determining community composition. Copepod diversity in Southern European ground water at different spatial scales has been examined. A nested spatial hierarchy was defined and a stratified sampling strategy adopted at four spatial scales: (1) the region, (2) the hydrogeographic basin, (3) the aquifer type (karstic *versus* porous), (4) the habitat type (unsaturated and saturated zones in karstic aquifers, hyporheic and phreatic zones in porous aquifers). A total of 681 sites were sampled in four regions, namely: the Cantabria (Spain), the Jura Massif (France), the Lessinian mountains (Italy), and the Krim Massif (Slovenia). Our research was aimed at evaluating the spatial scale sensitivity of stygoxenic, stygophilic and stigobiotic copepods and at assessing differences in assemblage composition along the spatial scales analysed. The multivariate statistical analyses performed (MDS, clustering, and ANOSIM) returned marked differences in assemblage composition at the largest regional spatial scale. Although regions displayed approximately the same diversity, measured as Taxonomic Distinctness, in the hierarchical multivariate analysis of variance based on stigobiotic species, regions accounted for 51% of the overall variation. Statistically significant differences were also found at the same spatial scale in mean relative endemism, which returned high values in all regions, except the Jura Massif, suggesting that historical factors are the major determinants in shaping copepod assemblages at this scale. Aquifer type accounted for 13% of variation, although the observed differences were not statistically significant. The smallest spatial scale analysed, i.e. the habitat type, accounted for 10% of variation, while residual, unexplained variation was 26%. Habitat specialization was higher in unsaturated karstic habitats, which showed a higher relative endemism accompanied by lower taxonomic uniqueness; both historical and ecological factors seemed to have operated together in shaping copepod assemblages among habitat types. A negligible effect on copepod assemblages was observed at the hydrogeographic basin scale. Moreover, stygoxenic and stygophilic species did not affect the observed patterns, due to their random distribution along the spatial hierarchy analysed: stigobiotic copepods were, by far, the most sensitive to spatial scale-effects.