

Molecular phylogeny of Alpine groundwater *Niphargidae* (Crustacea, Amphipoda) reveals the effects of Quaternary climate fluctuations

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Abstract

The groundwater amphipod genus *Niphargus* comprises over 425 described species mainly distributed in the Western Palearctic. Representatives of the genus are quite rare in areas formerly occupied by Quaternary glaciers. Although a couple of species were previously discovered in high-elevation caves and karstic springs, it is only recently that the genus was found to be widely distributed along the Alpine chain (Fišer et al. 2018; Stoch et al. 2020). Using a molecular phylogeny approach, we tested the hypothesis of multiple origins of Alpine *Niphargus* species followed by dispersal versus allopatric speciation in glacial refugia. We sampled all type localities of species present in the Alps and collected at several new sites, both in formerly glaciated areas and in areas very close to the last Quaternary glacial border. All sequences of Alpine species stored in GenBank were downloaded and included in the analysis as well. Our results show that several phyletic lineages independently colonized the Alpine chain at different periods. We found examples of preglacial colonization, with species surviving as glacial relicts with a very limited range expansion, as well as of recent post-glacial dispersal allowing colonization of very large areas on the northern slope of the Alps. In the Southern Limestone Alps as well as in the Western Alps, most species have a distribution restricted to small karstic massifs south of the area occupied by glaciers during the Last Glacial Maximum (Stoch et al. 2022), except for a single putative relict. Three clades show a relict distribution with highly isolated species found also in caves more than 2,000 m above sea level. The reconstructed time-calibrated phylogeny strongly supports the hypothesis that the evolutionary history of most clades is pre-Pleistocenic on the southern slope of the Alps, while on the northern slope both phylogenetic relicts and recent dispersers co-exist.

Keywords

Pleistocenic glaciations, relict species, Alpine chain, dispersal, vicariance

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Author contributions

Alice Salussolia: laboratory work; conceiving and writing the paper

Jea-François Flot: conceiving and writing the paper

Fabio Stoch: data analysis; conceiving and writing the paper; coordination

Conflicts of interest

None

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