Global climate change and local factors cause hydrological intermittence in Alpine rivers: what are the impacts on biological communities?

Le changement climatique global et les facteurs locaux entraînent l'intermittence hydrologique dans les rivières alpines : quels impacts sur les communautés biologiques ?

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RÉSUMÉ

Les rivières alpines sont considérées particulièrement sensibles aux effets du changement climatique, en raison de leur sensibilité aux altérations hydrologiques et thermiques et de leurs communautés biologiques très spécialisées. Un aspect intéressant mais presque négligé de ce problème est que les rivières alpines, naturellement pérennes, ont été affectées au cours des dernières décennies par un accroissement de la fréquence et l'intensité des sécheresses. Nous présentons ici les résultats de la première année d'échantillonnage du projet PRIN NOACQUA. Dans 15 rivières alpines, nous avons identifié un tronçon « pérenne » (appelé M) qui maintient en permanence l'eau courante de surface et une section « intermittente » (appelée V), où l'eau de surface disparaît. Dans ces stations, nous avons réalisé des échantillonnages analysant les communautés benthiques (diatomées et macroinvertébrés), les apports énergétiques allochtones et autochtones et d'autres paramètres environnementaux. Nous ne présentons ici que les résultats préliminaires des analyses de la communauté des macroinvertébrés benthiques. Les résultats des modèles statistiques ont montré que les sections intermittentes sont fonctionnellement différentes et caractérisées par des valeurs significatives plus faibles de richesse taxonomique par rapport aux sites pérennes et ceci est principalement dû à l'épuisement des taxons les plus sensibles (taxons EPT), indiquant un effet homogénéisant sur les communautés benthiques. Améliorer nos connaissances sur l'évolution possible des écosystèmes lotiques alpins est crucial, car ces environnements seront soumis à une pression humaine croissante dans le scénario climatique actuel.

ABSTRACT

Alpine rivers are considered especially sensitive to climate change effects, because of their sensitivity to hydrological/thermal alterations and their specialised biological communities. In particular, a dramatic but almost neglected aspect of this problem is that Alpine rivers, naturally perennial, have been affected over the last decades by a conspicuous increase in frequency and intensity of droughts. We present here the results of the first sampling year of the PRIN NOACQUA project. In 15 Alpine rivers, we have identified a 'perennial' reach (called M) that permanently maintains the surface running water and an 'intermittent' section (called V), where surface water disappears. In these stations, we investigated benthic communities (diatoms and macroinvertebrates), allochthonous and autochthonous energy inputs and other environmental parameters. We report here only preliminary results for the benthic macroinvertebrate community analyses. Results of statistical models showed that intermittent reaches are functionally different and characterized by significant lower values of taxonomic richness compared to perennial sites and this is mainly due to the depletion of the most sensitive taxa (EPT taxa), indicating a homogenizing effect on benthic communities. Improving our knowledge on the possible evolution of Alpine lotic ecosystems is crucial, because these environments will be subject to an increasing human pressure under the current climatic scenario.

KEYWORDS

Alpine rivers, benthic macroinvertebrates, droughts, global climate change, PRIN NOACQUA project

1 INTRODUCTION

There are numerous evidences that climate is rapidly changing at global scale, especially regarding temperature and precipitation patterns. The consequences of this rapid environmental change on freshwater biota are still not clear but, undoubtedly, they can be severe. A dramatic consequence of climate change is the alteration of hydrologic cycles, with increasing intensity and frequency of extreme events such as droughts, especially in Southern Europe. In this area, Alpine aquatic environments are considered especially sensitive to climate change, as warming events reduce snowpack and ice cover and changes in the precipitation amount and distribution alter hydrological cycles (Brown et al., 2003). Moreover, it is likely that climate change will represent a main driver of future biodiversity loss, because Alpine lotic environments are mostly inhabited by cold stenothermal, medium to large sized and long-living organisms. Italian Alpine rivers have always been typically perennial systems, in which the water presence was continuous along the year (Fenoglio et al., 2010). However, over the last decades they have been affected by a conspicuous increase in frequency and intensity of drought periods, mainly caused by global climate change and human impacts (agricultural and hydroelectric uses). In Mediterranean intermittent lotic environments, benthic communities have evolved adaptations and strategies to survive the dry period. Biological and ecological recovery after seasonal droughts is here relatively rapid, because aquatic organisms have adopted over-summering refuges and their life-cycles are coupled with drought periods. For these reasons, communities in intermittent streams show high resistance and strong resilience to seasonal droughts, but very little knowledge exists on the biotic responses to droughts in previously perennial Alpine streams.
Aim of this study is to explore the impact of intermittence in previously perennial Alpine stream reaches, considering biodiversity, taxonomic and functional aspects.

2 MATERIAL AND METHODS

We present here the results of the first sampling year of the PRIN NOACQUA project. In this MIUR (Ministry of Education, Universities and Research) project, we are in charge of the Alpine area, the University of Parma investigate the Apenninic systems and the University of Ferrara lowland rivers. In 15 alpine rivers, we have identified a 'perennial' reach (called M) that permanently maintains the surface running water and an 'intermittent' section (called V), characterized by a drying phase. Quantitative samplings of benthic communities (diatoms and macroinvertebrates) were performed in each of these sections. In addition, both allochthonous (CPOM amounts) and autochthonous (benthic chlorophyll-a estimated with the Benthotorch) energy inputs were estimated. We report here only the preliminary results of the benthic macroinvertebrate community analyses. A partial-RDA was performed to understand which environmental and spatial factors mainly affect benthic invertebrate communities. To investigate how water intermittency shapes the diversity of benthic communities, we partitioned total diversity (gamma diversity) into alpha (local diversity) and beta (turnover) diversity components in both permanent and intermittent sites, while an indicator species analysis (ISA) was performed to identify which taxa are indicators of perennial and intermittent sites. The response of several parameters of benthic communities, i.e. taxa richness, EPT richness and the abundance of functional groups (FFG, biological groups and ecological groups) to water scarcity and environmental parameters was tested by means of statistical models.

3 RESULTS AND DISCUSSION

Although we have only analysed the first partial results of a project that will last until 2020, it is interesting to note that hydrological intermittence has right now a clear influence on benthic communities.
Results of partial-RDA showed that benthic macroinvertebrate composition is driven by both environmental factors and spatial limitation in alpine streams. In particular, dispersal of organisms is limited among streams, probably because adults cannot overcome mountain barriers. Their composition is also driven by several environmental factors, acting at different spatial scales: flow velocity (local scale), intermittency (reach scale) and physical-chemical parameters (stream scale).
The partitioning of total diversity (γ-diversity) of the entire sampling area into local diversity (α-diversity) and variation among streams (β-diversity) showed a balanced contribute of both alpha and beta diversity in perennial sites, while intermittent reaches are characterized by lower values of local diversity, indicating a depletion of taxa. These patterns were confirmed by the results of the indicator species analysis, which showed that EPT taxa are indicators of perennial sites (*Epeorus*, *Amphinemoura*, *Ecdyonurus*, *Isoperla*, *Leuctra* and *Sericostomatidae*), while there are no indicator taxa for intermittent reaches.

Results of statistical models showed that intermittent reaches are characterized by significant lower values of taxonomic richness compared to perennial sites and this is mainly due to the depletion of the most sensitive taxa (EPT taxa), indicating a homogenizing effect on benthic communities. From a functional point of view, reaches with permanent water are characterized by significantly higher abundances of shredders, as well as higher abundances of taxa belonging to the biological group f and the ecological group A, compared to intermittent reaches (Usseglio-Polatera et al., 2000).
In fact, we found that M-communities are on average richer and more diversified than V-communities. Moreover, while M-communities are highly heterogeneous, V communities are much less differentiated. We suppose that hydrological intermittence act as a filter that selects, also from different communities, species sharing the same life-history traits adapted to overcome the drought periods. Improving our knowledge on the possible evolution of Alpine lotic ecosystems is crucial, because these environments will be subject to an increasing human pressure under the current climatic scenario.

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