4.2. Changes in composition and abundance of benthic invertebrate communities

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Abstract

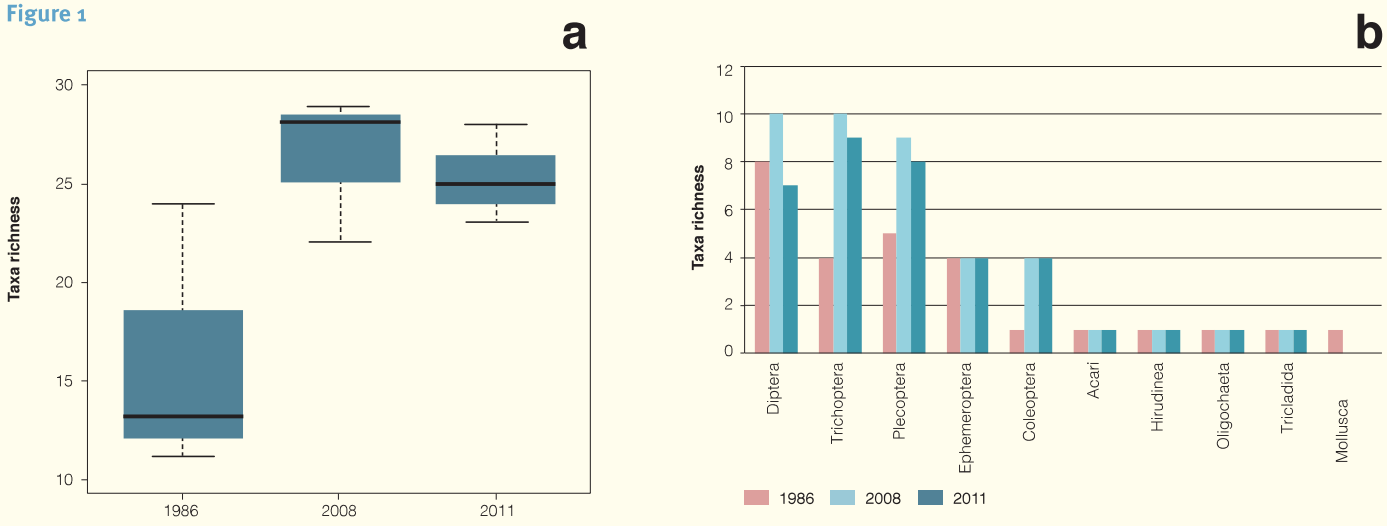
Aquatic ecosystems and the communities of benthic invertebrates that inhabit them are clearly vulnerable to the effects of environmental changes. In the present study spatial and temporal changes were detected in communities of the Sierra Nevada rivers. Local short-term alterations on the invertebrate community in relation to heavy precipitations during 2010 in the Andarax river were detected. However, long-term faunistic changes were the most noticeable when comparing recent data with those from 80's. An increase in species richness in relation to altitude was observed because species from mid-lowland reaches moved upstream. Moreover, foreign species from nearby mountain chains colonized the Sierra Nevada in the last 20 years.

Aims and methodology

The long-term changes in species richness were studied in species of the order Trichoptera, comparing current data with those from the 1980s in the Sierra Nevada. The sampling was conducted seasonally (spring, summer, autumn) at 19 sites in 16 rivers and lakes, following the sampling and laboratory protocols to assess the ecological status of the rivers [4].

In addition, data from 2 sites (Monachil at 2150 m.a.s.l. and Monachil at 1450 m.a.s.l.) selected from 23 localties (distributed along 8 rivers) seasonally sampled since 2008 were

Figure 1



Changes in total taxa richness (p-value = 0.04) (a) and changes in taxa richness at order level in three diferent years (b) for the high-mountain site (2150 m.a.s.l.) of the Monachil River.

compared with published data in the 1990s to detect changes in benthic community [5]. Similarly, to detect short-term structural changes at community level, data from a locality of the Andarax River (1050 m.a.s.l.) were selected. In both studies, the sampling and laboratory protocols for benthic fauna in fordable rivers was followed as laid out by the General Water Authority (MAGRAMA). Moreover, adult Plecoptera and Trichoptera were collected for their species determination, using these data to detect possible changes in the spatial distribution of the order Plecoptera, given its sensitivity to environmental changes.

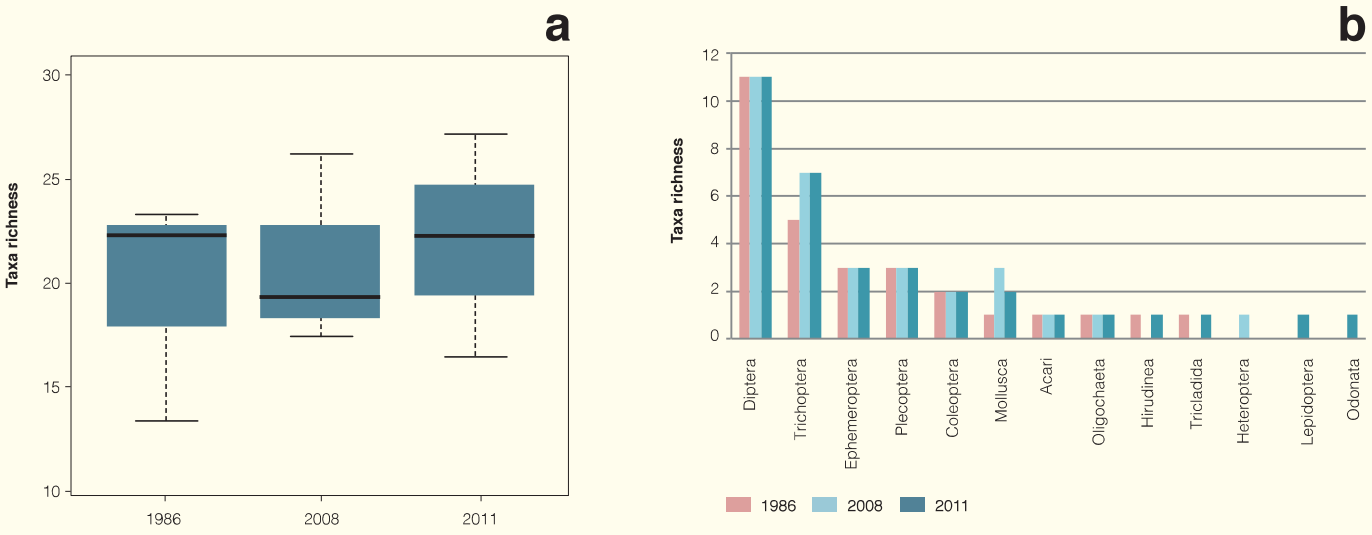
Results

In the comparative study made in the river Monachil, greater richness at the family level was found among macroinvertebrates in high-mountain elevations (2150 m.a.s.l.; Figure 1). Several taxa considered exclusive of mid-altitude mountain in Monachil River in the 1980s (*Serratella ignita* (Ephemeroptera), *Perla marginata* (Plecoptera), and *Micrasema moestum* (Trichoptera)) were captured above 2000 m.a.s.l. in current samplings. Similar results were observed in several families belonging to the orders Diptera and Coleoptera, some of which had not been captured previously in this river. In contrast, no changes in taxa richness was detected at mid-high altitude in Monachil River (1450 m.a.s.l.) (Figure 2).

Similar results were found when analysing the species richness of Trichoptera at sites situated all along the protected area of Sierra Nevada. An increase in caddisfly species richness was detected in the last 20 years (Figure 3), especially at sites situated at an intermediate altitude (1800-2000 m.a.s.l.) within the studied altitudinal range (800-3050 m.a.s.l.). Thus, most of the Trichoptera species enlarged their distribution ranges in elevation (*Rhyacophila meridionalis, Rhyacophila nevada, Hydroptila vectis, Philopotamus montanus, Hydropsyche infernalis, Micrasema moestum, Halesus tessellatus, Athripsodes* sp., and *Sericostoma vittatum*) (Figure 4) or were captured for the first time in the most recent studied period (*Agapetus* sp., *A. fuscipes, Hydropsyche pellucidula, Wormaldia occipitalis, Brachycentrus maculatum, Limnephilus obsoletus, Annitella iglesiasi, Mesophylax aspersus,* and *Athripsodes albifrons*). The species that have enlarged their distribution range are characterized by having good dispersal abilities and also inhabit mountains near the Sierra Nevada.

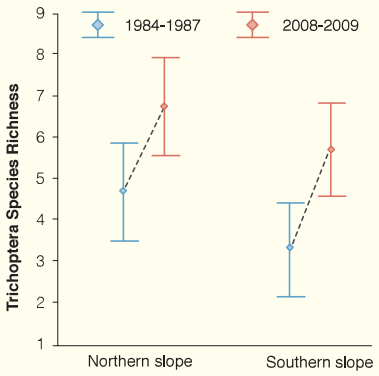
In the Andarax river, short-term changes in community composition were detected (2008-2012).

Figure 2



Changes in taxonomical richness for the medium mountain site (1450 m.a.s.l.) of the river Monachil (p-value = 0.795). Left: Total taxa richness. Right: Taxa richness at order level.

Figure 3



Average (± 95% CI) of Trichoptera species richness in 1984–1987 and 2008–2009 studied periods of sampling sites located at the northern and southern slopes of the Sierra Nevada streams and rivers.

Discussion and conclusions

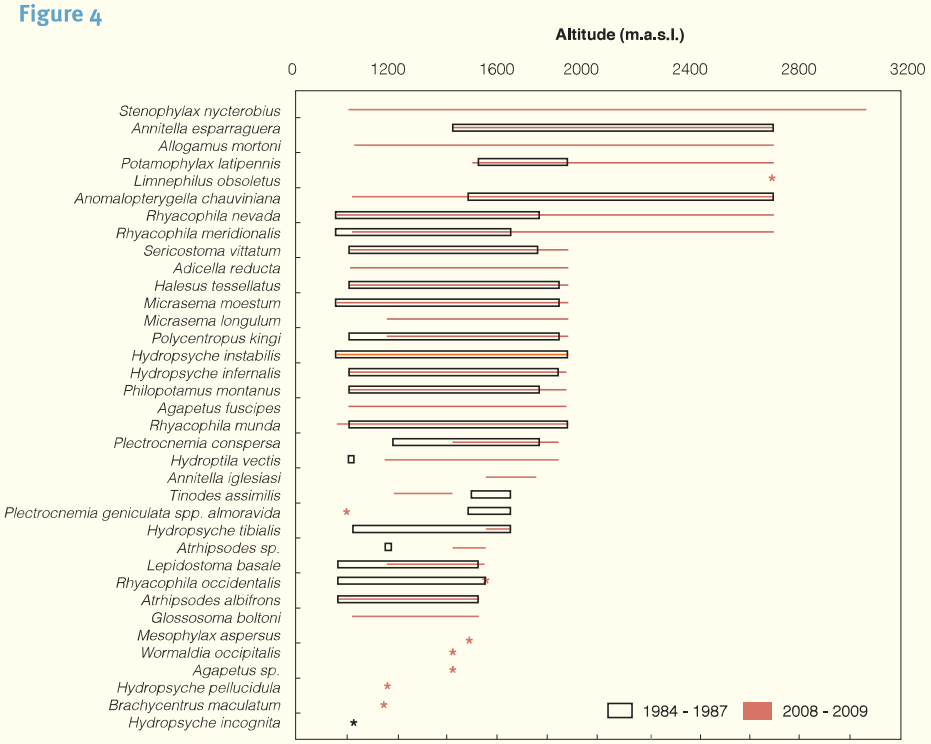
The detected relationship between altitude and change in species richness along the studied periods may be explained by the hypothesis that mountains of considerable altitudinal gradient act as refuges for species in a scenario of climate warming [6]. Species with enough dispersive ability would track thermally suitable habitats [7]. Besides sites of middle to high mountain could be suitable not only for species with narrow ecological requirements but also for generalist species. Endemic species appear to be more vulnerable as a consequence of their low dispersal capacity as well as for their strict requirements for very particular ecological conditions [8]. These species will also be threatened by more generalist species that are able to migrate in altitude and compete for resources.

These results may be relevant when considering possible conservation measures of river ecosystems from climate change. Special effort should be directed to protect conditions of lakes, headwaters, and upper reaches of streams and rivers, but also low altitude sites where human influence may be stronger. Twenty years is a short period of time to detect the effects of climate change on the overall group of species. Therefore it might be early to assess the risk to which they are subjected especially endemic species linked to the headwaters. Due to detrimet of river flow and the rise of temperatures are unavoidable, it would be necessary better control of aquatic systems in the high mountains in order to protect the species inhabiting headwaters and prevent the destruction of their habitats.

Torrential rainfall directly affect the composition and richness of the benthic community, requiring several years for some of the taxa to be collected again in the affected area. The increase in torrentiality, as a consequence of climate change, will be an additional risk factor for these communities.

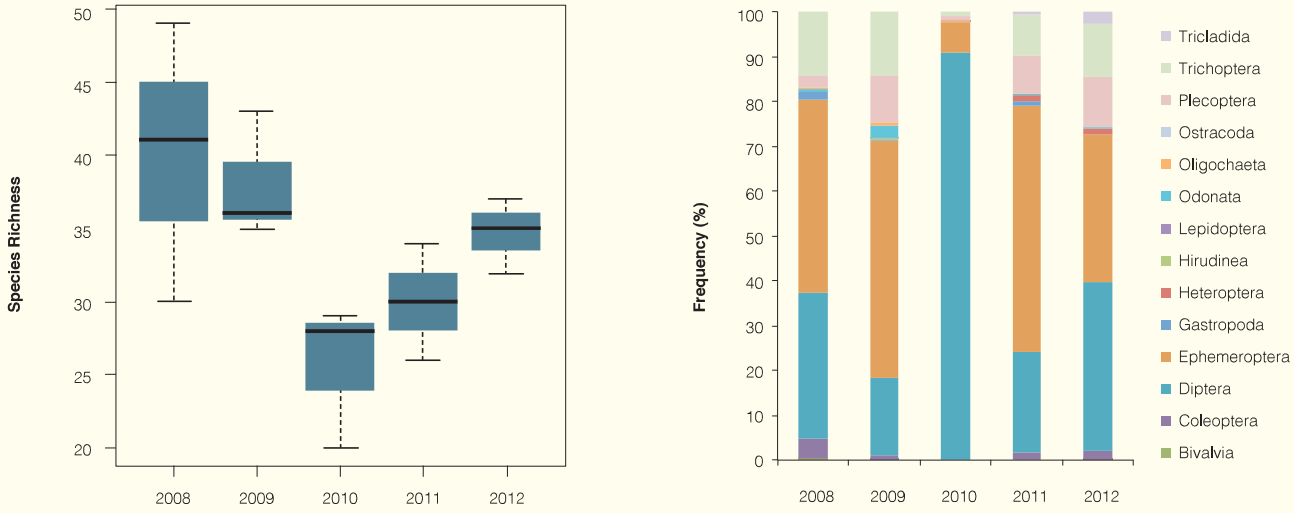
In this period, taxonomic richness diminished from 63 families captured during 2008 and 2009 to 38 in 2010. this reduction mainly affected orders Coleoptera, Odonata, Heteroptera, and Trichoptera, as well as those of the class Gastropoda. The first taxa that colonized the area belonged to the order Diptera, representing more than 90% of the individuals captured in the sampling campaign (spring) after the heavy rains. During the 2011 samplings, the number of taxa continued to be lower than in previous years (Figure 6). In the particular case of the order Plecoptera, the altitudinal comparison between benthic community current samplings and those made in 1979 and 1986, shows that several species have become rare or have disappeared at their lower distributional ranges (Figure 7). However, at high altitude, changes are hardly detected.

Figure 4



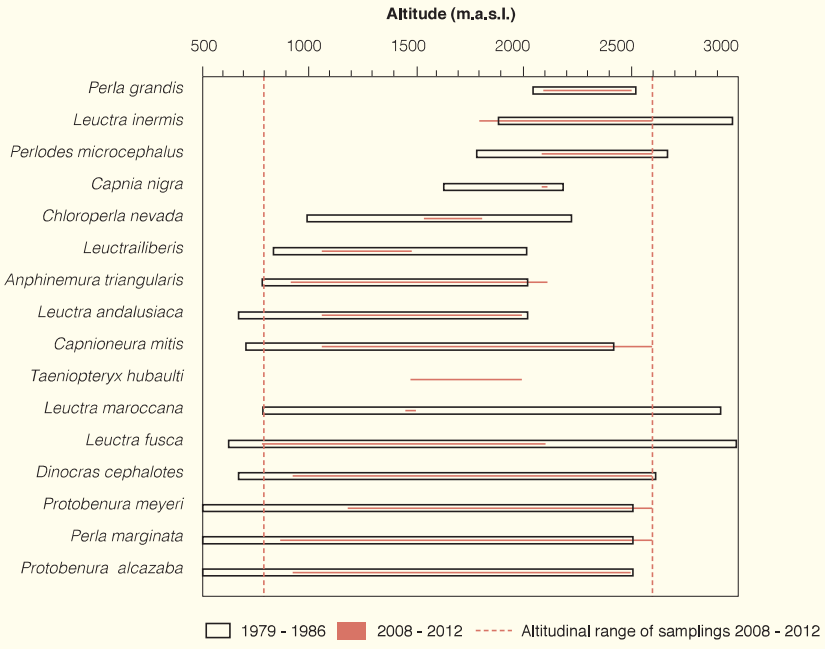
Comparative altitudinal distribution of Trichoptera species between the two studied periods (1984–1987 and 2008–2009).

Figure 5



Changes in taxonomic richness (left) and relative abundance (right) of the benthic invertebrate community after torrential rainfall at the beginning of 2010 in the Andarax River.

Figure 6



Differences in the distribution of Plecoptera in the Sierra Nevada between 1979-1986 and 2008-2012.