INTRODUCTION

Fluvial networks are structured across a spatial hierarchy of environmental factors, where variables acting at higher spatial scales, such as climate and geological setting, are major species occurrence ecological determinants interacting with lower spatial scale factors such as discharge and water quality or geomorphological structure. Rivers in Mediterranean-climate regions are characterized by extremely variable annual and interannual discharge regimes, presenting seasonal and predictable floods to droughts which annual and fluvial species have adapted through their evolutionary processes. Therefore, it is assumed that fluvial communities composition between Mediterranean Rivers systems may exhibit great similarity. Nevertheless, this idea has never been tested for bryophyts' communities in the Mediterranean Europe since the assessment of compositional differences between communities from different fluvial regions should be achieved using biotic and environmental field data from standardized areas, and, until the beginning of the XXI century, this dataset was not available for bryophytic composition. Therefore, we aimed to explore the compositional segregation of bryophytes communities across three Mediterranean regions using biotic and environmental field data from standardized areas and pan-European surveys available after the implementation and intercalibration processes of the EU Water Framework Directive.

METHODS AND RESULTS

We first, used floristic data collected for intercalibration purposes under the European Union Water Framework Directive and data from River Habitat Survey of 474 Mediterranean stream sites in Mediterranean Europe Climatic Areas, namely, (i) 99 sites from Mediterranean South, (ii) 246 sites from Mediterranean North, and (iii) 129 sites from Mediterranean Mountains (fig 1 and fig 2); in order to compare bryophytic assemblages between Mediterranean-climate regions and identify indicator (core) taxa we performed: a Two-way Indicator Species Analysis (TWINSAN classification; CA(3.1)), a One-way Analysis of Similarity (ANOSIM) between groups obtained in the TWINSAN classification, and a Similarity Percentage Analyses (SIMPER; WINSER 5).

To study the influence of environmental factors on bryophytic assemblages we performed a canonical correspondence analysis (CCA; CANOCO 5) with forward selection of environmental variables to explore the influence of environmental factors on bryophytic assemblages.

Each TWINSAN group corresponds to a distinct community dominated by a different assemblage of bryophytic species, presenting different and recognizably ecological preferences. The CCA ordination supports the segregation of TWINSAN groups and the heterogeneity of the climatic groups (Fig. 4). The first axis reflects a climatic and stream water pH gradient, represented by bryophytes communities from more alkaline streams in drier conditions to those characterizing more acidic watercourses with greater rainfall. The second axis is mainly related with an altitudinal gradient.

Bryophytic communities from Mediterranean Mountain sites are usually found in the climatic area corresponding to the Mediterranean Mountains (fig 5a), in watercourses with moderate alkalinity (fig 5b), while communities B and C are more common in the Mediterranean North and South (fig 5a), in more acidic watercourses (fig 5c).

To better understand the distribution of the TWINSAN groups we used a "ensemble first, predict later" community level modelling approach. We used the site groups obtained in the TWINSAN analysis and Species Distribution Modelling techniques to model the distribution of the main Mediterranean fluvial bryophytic assemblages found.

We modelled the distribution of the groups using biomod2 ensemble forecasting package in r environment. The environmental predictors used in the modelling procedure were selected from the topmost important variables influencing bryophytic assemblages identified in the CCA analysis. We used the following modelling algorithms Random forest, Artificial Neural Networks Multiple Adaptive Regression Splines, MAXENT and Classification Tree Analysis. Only models with an AUC evaluation score > 0.7 were included in the ensemble forecast.

The ensemble predictions were obtained using the weighted mean of probability, which means that models with greater AUC scores had more importance in the ensemble. The maps shown correspond to modelled probability of occurrence of each group for Mediterranean Europe.