ABSTRACT

Native fish are indicators of the health of aquatic ecosystems, and they have become a key quality element to assess the ecological status of rivers. The understanding of factors affecting native fish species is important for the management and conservation of aquatic ecosystems. The general objective of this thesis are to analyse the relationships between biological and habitat variables (including connectivity) across a range of spatial scales in Mediterranean rivers, with the development of modelling tools to support the decision-making in river restoration.

This thesis is composed by four articles. The first aims to model the relationship between a set of environmental variables and native species richness (NFSR), and to evaluate the potential effectiveness of river restoration actions to improve NFSR in the Júcar river basin. In order to solve these questions, an artificial neural network (ANN) modelling approach was carried out, using the Levenberg–Marquardt learning algorithm in the model training phase. The partial derivatives method was applied to determine the relative importance of input environmental variables. According to the results, ANN model combined variables describing riparian quality, water quality, and physical habitat and helped to identify the primary drivers of the NFSR patterns in Mediterranean rivers. In the second part of the study, the model was used to evaluate the effectiveness of two restoration actions in the Júcar River: the removal of two abandoned weirs and the consequent increase in the proportion of riffles. These simulations indicated that richness increases with the augmentation of channel length without artificial barriers and riffle proportion, and demonstrated the utility of ANN as a powerful tool to support decisions in the management and ecological restoration of Mediterranean rivers.

The second paper aims to determine the relative importance of the two main factors controlling the reduction of native fish species richness (NFSR), i.e. the interactions between aquatic species, habitat (including river connectivity) and biological variables (including invasive species) in the Júcar, Cabriel and Turia rivers. To this end, three ANN models were analysed: the first one built only with biological variables, the second one only built with habitat variables and the third one was made with the combination of both groups of variables. The results show that habitat variables are the most important drivers for the distribution of NFSR, and demonstrate the ecological relevance of the developed models. The findings of this study highlight the need to propose mitigation measures related to improve the habitat as a means to conserve and restore these Mediterranean rivers.

The third paper seeks to compare the reliability and ecological relevance of two predictive models of fish species richness, based on artificial neural networks (ANNs) and random forests (RF). The relevance of the selected input variables of each model was evaluated based on ecological knowledge and supported by other researches. Both models were developed using a *k*-fold cross validation procedure and their performance were evaluated by three metrics: the determination coefficient (R^2), the Mean Square Error (MSE) and the adjusted determination coefficient (R^2adj). According to the results, RF obtained the best performance in training. But, the cross-validation procedure revealed that both techniques gave similar results (R^2=68% for

RF and R^2=66% for ANN). The comparison of different ML methods is very helpful for the critical analysis of the results obtained from the models.

The fourth paper has the following purpose: to evaluate the ability of ANN to identify local stress factors affecting density and presence/absence of *Luciobarbus guiraonis* in the Júcar river basin district. We used multilayer feed-forward artificial neural networks (ANN) to represent nonlinear relationships between *L. guiraonis* descriptors and biological and habitat variables. The models predictive power was evaluated based on the Kappa statistic (*k)*, the correctly classified instances (CCI), and the area under the curve (AUC) of a receiver operator characteristic (ROC) plots. According to the results, the presence/absence of *L. guiraonis* is well predicted by the ANN model (CCI= 87%, AUC= 0.85 and *k*= 0.66). The prediction of density was moderate (CCI = 62%, AUC=0.71 and *k*= 0.43). The most significant variables that described the presence/absence were: solar radiation, drainage area and proportion of exotic fish species with a relative importance of 27.8%, 24.53% and 13.60%, respectively. In the density model, the most important variables were coefficient of variation of mean annual flows with a relative importance of 50.5% and proportion of exotic fish species with 24.4%. The models provides important information about the relation of *L. guiraonis* with biotic and habitat variables, this new knowledge could be used to support future studies and practical decisions for the management and conservation of this species in the Júcar River Basin District.