A novel approach of fish and macroinvertebrates micro-habitat selection models: how to deal with spatial and temporal variations of overdispersed abundance data

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A NOVEL APPROACH OF FISH AND MACROINVERTEBRATES MICRO-HABITAT SELECTION MODELS: HOW TO DEAL WITH SPATIAL AND TEMPORAL VARIATIONS OF OVERDISPERSED DATA.

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The Habitat concept is one of the main concepts in ecology. The understanding of the process in which organisms select a habitat to live, i.e. the habitat selection, is crucial to better understand the response of organisms to habitat natural and anthropogenic modifications. Linked with hydraulic models, habitat selection models in rivers, as micro-habitat models, allow predicting fish and macroinvertebrates tendencies to abundance increasing or decreasing in function of water discharge. However, many fish and macroinvertebrates habitat models are built with low temporal and spatial replicates which limit their transferability from a river to another river and consequently their predictive performance. With current statistical developments, we developed habitat selection models for 34 fish species and 206 macroinvertebrates taxa using data sets, respectively, from 10 rivers (34 sites, 145 surveys) and 11 rivers (22 sites, 90 surveys). We linked abundances to hydraulic key variables (e.g. water depth, current velocity for fish, shear stress for macroinvertebrates) using negative binomial distribution to account for overdispersion of the abundance, and generalized linear mixed effects models to deal with the spatial and temporal variability of the abundance and habitat selection between surveys. Finally we tested the transferability of the models between rivers.

1 INTRODUCTION

The Habitat concept is one of the main concepts in ecology [1]. The understanding of the process in which organisms select a habitat to live, i.e. the habitat selection, is crucial to better understand the response of organisms to habitat natural and anthropogenic modifications. These modifications are frequently observed in rivers, due to hydraulic buildings as dams or weirs. Linked with hydraulic models [2, 3], habitat selection models, as micro-habitat models, allow predicting fish and macroinvertebrates tendencies to abundance increasing or decreasing in function of water discharge. These models have shown their efficiency to predict the responses of aquatic organisms to flow modifications. However, many fish and macroinvertebrates habitat models are built with low temporal and spatial replicates which limit their transferability from a river to another river and consequently their predictive performance. In our study, we proposed a novel methodological strategy to developed habitat selection models for 34 fish species and 206 macroinvertebrates taxa using data sets, respectively, from 10 rivers (34 sites, 145 surveys) and 11 rivers (22 sites, 90 surveys). The data were collected using electrofishing technique for fish and surber and Hess sampler technique for macroinvertebrates.

2 METHODOLOGICAL KEY POINTS

We linked abundances to hydraulic key variables (e.g. water depth, current velocity for fish, shear stress for macroinvertebrates) using negative binomial distribution to account for overdispersion of the abundance [4], and generalized linear mixed effects models to deal with the spatial and temporal variability of the abundance and habitat selection between surveys [5, 6]. We developed four nested models of increasing complexity from a constant model (i.e. the abundance is independent to the hydraulic key variables, so no habitat selection was observed) to the most parametrized model (i.e. the abundance is link to hydraulic key condition and the habitat selection differ for each survey). All models included a variance at the survey level, so they allowed differences in mean abundance between each survey. Because the habitat selection is a non-linear process, we introduced b-splines for the hydraulic key variables, which decomposed these variables into piecewise of cubic regression at fixed knots. Finally, models were compared using AIC criterion and simulations techniques.

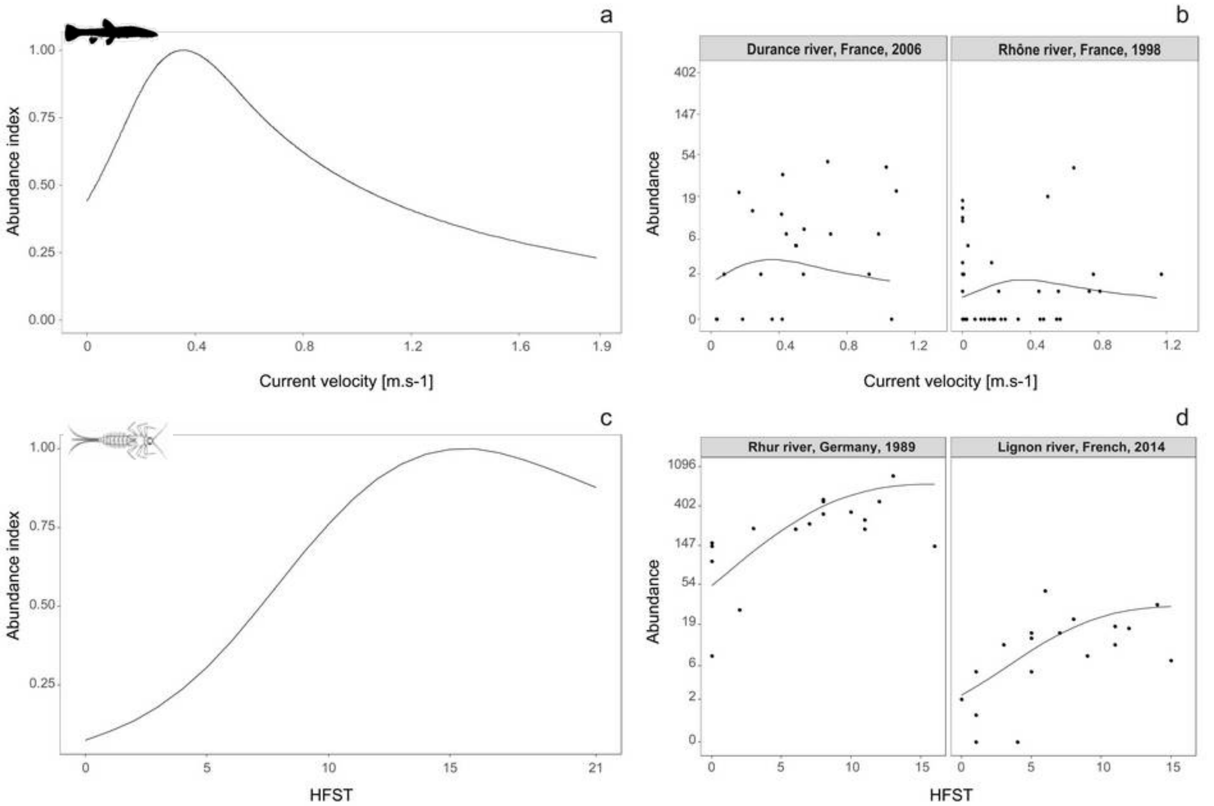

Figure 1: Model number 2, linking the abundance of (a, b) Stone loach *Barbatula barbatula* or (c, d) Ephemeroptera *Baetis rhodani*, to a non-linear hydraulic key variable (a, b) current velocity, (c, d) HFST (estimation of shear stress [7]), including a variance intercept at the survey level. Marginal predictions (a, c), divided by the maximum abundance value, represent the average habitat selection model and conditionnal predictions (b, d; examples for two surveys) represent the marginal predictions adjusted by surveys which illustrate the variance intercept translating the predictions for each surveys.

3 ACKNOWLEDGMENTS

For financial support, thanks to Agence Française pour la Biodiversité, Compagnie Nationale du Rhône, Agence de l'eau Rhône-Méditerranée-Corse, Electricité De France, Région Rhône-Alpes, Région Provence-Alpes-Côte d'Azur.

For fish data sets, thanks to Irstea Villeurbanne, Irstea Aix-en-Provence, University of Marseille, Ecotec, and special thanks to all contributors who helped for numerous sampling surveys.

For macroinvertebrates data sets, thanks to Ulricke Fuchs et al (Arbeitsgemeinschaft Landschaftsökologie (ALAND) Boeckhstr, Karlsruhe, Deutschland), Barbara L. Peckarsky (Rocky Mountain Biological Laboratory, Crested Butte, CO 81224, U.S.A.), Sylvie Mérigoux et al (UMR 5023, CNRS, Ecologie des Hydrosystèmes Fluviaux, Universite´ Lyon 1, Villeurbanne, F–69622, France) , and special thanks to all contributors who helped for numerous sampling surveys.

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