Modelling macroinvertebrate microhabitat selection: relevance, generality and link to biological traits

Modélisation de la sélection des microhabitats par les macroinvertébrés

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RÉSUMÉ

Among the multiple environmental parameters influencing freshwater species abundance, microhabitat hydraulics have received a particular attention due to their modification by river regulation and restoration. As microhabitat selection is a complex process that varies across taxa and environmental context, comparisons among rivers and seasons of microhabitat selection models are required to test their relevance and transferability. We performed microhabitat selection models for 258 macroinvertebrate taxa, with 141 species, collected during 91 surveys distributed in 11 small streams to large rivers of Germany and France. We compared microhabitat selection for 4 hydraulic variables, developed using mixed-effects models. Models based on shear stress, velocity, and Froude number showed comparable results and were stronger than models for water depth. For these velocity-related variables, 61-78% of models were significant and revealed variable response forms among taxa. The explanatory power of "average" microhabitat selection models (common response forms) was 78-83% of the explanatory power of more detailed models with variable response forms. Significant associations with biological traits such as locomotion, relation to substrate or food types suggested that microhabitat selection results from general biological processes. Our results indicate a high degree of transferability and can be useful in many basic and applied ecological studies.

ABSTRACT

Parmi les multiples paramètres environnementaux qui influencent l'abondance des espèces d'eau douce, l'hydraulique des microhabitats a reçu une attention particulière en raison de sa modification par les régulations et restaurations des rivières. La sélection des microhabitats est un processus complexe qui varie selon les taxons et l'environnement. Ainsi la comparaison inter-rivières et -saisons des modèles de sélection de microhabitats est nécessaire pour tester leur pertinence et leur transférabilité. Nous avons réalisé des modèles de sélection de microhabitats pour 258 taxons de macroinvertébrés (141 espèces) collectés au cours de 91 suivis réparties dans 11 rivières (Allemagne et France). Nous avons comparé la sélection des microhabitats pour 4 variables hydrauliques, développée à l'aide de modèles à effets mixtes. Les modèles basés sur la contrainte de cisaillement, la vitesse et le nombre de Froude ont montré des résultats similaires, plus pertinents que les modèles pour la hauteur d'eau. Pour ces variables liées à la vitesse, 61-78% des modèles étaient significatifs, avec des formes de réponse variables parmi les taxons. Le pouvoir explicatif des modèles "moyens" (forme commune à tous les suivis) représentait 78-83% du pouvoir explicatif des modèles plus détaillés (forme variable). Le Lien avec des traits biologiques (locomotion, alimentation) suggèrent que la sélection des microhabitats résulte de processus biologiques généraux.

KEYWORDS

Courbes de préférence, Macroinvertébrés des cours d'eau, Microhabitat hydrauliques, Traits biologiques, modèles à effets mixtes

MODELLING MACROINVERTEBRATE MICROHABITAT SELECTION: RELEVANCE, GENERALITY AND LINK TO BIOLOGICAL TRAITS

Among the multiple environmental parameters influencing freshwater species abundance, microhabitat hydraulics have received a particular attention due to their modification by river regulation (water abstraction, channelization) and/or restoration (morphological restoration, environmental flow implementation; Nestler et al. 2019). Microhabitat selection is a complex process that varies across taxa and individuals, along the life cycle and according to the environmental context. Consequently, the relevance and transferability of microhabitat selection models has often been debated. Therefore, regular updates on microhabitat selection models and comparisons among rivers and seasons are required for improving management decisions; Chen and Olden 2018).

In this study, we analysed a unique database of 2156 invertebrate microhabitats collected (using surber or Hess samplers) during 91 surveys (rivers x dates) distributed in 10 small streams to large rivers of Germany and France. This database included 259 invertebrate taxa, among which 141 were identified at the species level. Microhabitats were characterized by four hydraulic variables: water depth, water column velocity, bottom shear stress and Froude number. We examined the impact of each hydraulic variable on invertebrate abundance using mixed-effect models, and compared their relative performance for explaining microhabitat selection. Our modelling approach accounted for the over dispersion of observed abundance (e.g. due to spatial aggregation), and quantified the variability in microhabitat selection across rivers and seasons.

Models based on velocity, Froude number and shear stress showed comparable results and were stronger than models based on water depth. We obtained significant relationships with hydraulics, significant habitat selection, for 61-78% of taxa with velocity-related variables. Thus, most taxa had significant responses to hydraulics, but the response forms varied among taxa. In particular, we observed significant functional links of microhabitat selection with biological traits. For example, passive filter-feeders (e.g. Simuliidae, Hydropsychidae) and taxa with attachment abilities occurred preferentially in fast-flowing microhabitats (Lamouroux et al. 2004).

We found that the median explanatory power of “average” taxa models is 72%-80% of the explanatory power of more flexible models (with varying shapes across surveys), i.e. that average microhabitat selection models with a response form common to all surveys explained around 70% of the variability explained by more flexible models that allowed variations between surveys. This result suggested a high transferability of the habitat selection models among rivers.

As our data cover a wide range of taxa with variable biological traits, our synthesis on microhabitat selection patterns can be useful for a wide variety of applied ecological studies (e.g., habitat modeling, environmental flow determination) as well as more basic research on the complexity and the diversity of microhabitat selection processes.

LIST OF REFERENCES

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