Deriving life traits from habitat characteristics :
an initial application for neotropical invertebrates

Traits de vie et caractéristiques mésologiques□
une première application aux invertébrés néotropicaux

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Abstract
Using invertebrate life trait□patterns as a biomonitoring tool for the assessment of human impact in rivers is a rising research field. Yet in tropical regions, the lack of detailed biological or ecological information results in great difficulties to document such traits. Herein, we propose an approach to infer ecological traits from habitat characteristics, using ecological profiles. The method was tested on river invertebrates from the Bolivian Amazon Basin, as a preliminary step prior to adapting this tool to the context of tropical rivers.

Key-words
Macroinvertebrates, Method, South America, Stream

Résumé
L’étude des traits de vie des organismes constitue une approche pertinente des perturbations auxquelles sont soumises les communautés aquatiques. Or, dans les régions tropicales en général, le manque de connaissances préalables sur l’écologie et la biologie des espèces constitue le plus souvent un obstacle à l’étude de ces traits. Dans cet article, nous posons les bases d’une approche permettant de déduire certains traits écologiques à partir des caractéristiques du milieu, en utilisant des profils écologiques. Cette méthode a été testée sur les invertébrés de rivières du bassin amazonien bolivien et constitue un premier pas vers l’adaptation de cette approche au contexte des zones tropicales.

Key-words
Amérique du Sud, Cours d'eau, Macroinvertébrés, Méthode

Introduction

Assessing changes in biological communities in relation to environmental variations is a major issue in both theoretical and applied ecology, whatever the organisms or systems considered. For running waters, a great variety of approaches was thus developed to monitor species or community responses as bioindicators of ecosystem disturbance. Approaches are based on indicators species, taxonomic composition, community structure or a combination of these methods (see a review in Cairns & Pratt, 1993 for freshwater invertebrates). In addition to traditional methods based on taxonomic structure of biocenoses, alternative approaches focusing on life traits patterns emerged in the last decade, providing a more functional image of aquatic communities (e.g. the "River Habitat Templet" concept, Townsend & Hildrew, 1994, developed from the idea of Southwood, 1977). They relate functional groups derived from life history or other biological or ecological traits of species to spatial or temporal gradients of environmental variability. For freshwater macroinvertebrates, recent tests at various geographical and temporal scales provided encouraging results in temperate streams as trends in species traits along environmental gradients were often significant (Charvet *et al.*, 1998, Townsend *et al.*, 1997, Dolédec *et al.*, 1999, Usseglio-Polatera *et al.*, 2000).

Although some studies have shown that genus and even family levels may be sufficient to explore the functional diversity of freshwater invertebrates (Bournaud *et al.*, 1996, Dolédec *et al.*, 1998), great difficulties still remain when biological features of taxa are poorly documented. In tropical regions, the knowledge of invertebrates traits is often limited by a crucial lack of specialistes and published data. This is why we looked for a field-based coding method, that would enable us to posterior fuzzy coding and multifactorial analysis comparable to those performed in Europe (e.g. Usseglio-Polatera *et al.*, 2000).

Our aim is to explore the validity of a field-based, practical approach to document ecological traits of benthic macroinvertebrates. The macroinvertebrate fauna and the associated microhabitat variables were studied in non-impacted sites from the Bolivian Amazon Basin.

Methods

For each taxon, ecological traits were derived from the ecological profiles (Godron, 1968, Guillerm 1971) and coded using an "affinity scale" to constitute a reference matrix.

Field sampling

Benthic macroinvertebrates were sampled with a 0.1 m^2 surber net in 22 non-impacted rivers located in the Yungas region of the Bolivian Amazon Basin that constitute an homogeneous entity in terms of faunal and ecological characteristics (Wasson & Barrère, 1999). Fauna was identified to the family level. Thirty two taxa were collected in 125 samples (scarce taxa were omitted). At each site, six characteristics of mesohabitats (elementary units of a patch mosaic sampled by surber net) were investigated to document hydraulic characteristics (flow speed, water depth), sediment type (dominant superficial substrate, under-layer) and feeding resources (organic deposits, periphyton) of habitats. These parameters were separated into 21 categories (cf. Table 1). Data were collected in the context of the BIOBAB (IRD, Institut de Recherche pour le Développement - La Paz University) project.

Calculation of ecological profiles and coding

For a given taxon, ecological preferences related to a given environmental variable were expressed using the frequency distribution of this taxon among the categories describing the trait (Figure 1). As a result, ecological profiles were calculated as distributions of occurrence per category (i.e. percentages) in the samples. The resulting matrix of percentages was then transformed to obtain a final “affinity matrix” per taxon and per category on a narrower scale. Within each variable, percentages different from 0 were ranked and an affinity score of 1 was given to the lowest percentage above null. The affinity score of the next category was incremented by 1 point if the percentage difference with the previous category was greater than 5 % or by 2 points if the difference was more than 30 % (empirical thresholds).

Results and discussion

The final matrix provided, for each taxon, an affinity score per category from 0 (indicating “no affinity”) to 5 (indicating “very high affinity” - Table 2). A first interpretation of the matrix can be found in the observation of the taxa with high affinity for some modality (codes 3 to 5 in Table 1). A quarter of the taxa had a high affinity with the absence of organic deposit; 38 % prefered more than 50 % in periphyton cover; 62 % in total had high affinity with cobbles or fine stones in surface while the affinities with the sublayer classes were weaker; 41 % of the taxa had a stronger affinity with 30 - 49 cm.s^{-1} flow speed; high affinities with water depths were always noted for less than 10 % of the taxa (Figure 2). Flow speed, dominant substrate and periphyton were the more discriminating parameters at mesohabitat scale.

Information about invertebrate taxa preferences for the six environmental variables considered can be derived from this matrix. In this preliminary work, ecological traits derived from field data were globally consistent with our ecological knowledge for the taxa. For examples, Simuliidae were clearly rheophilic and Oligochateta prefered finer substrates.

The first tests using this matrix as a reference for various impacted sites from the same ecoregion (rivers from the Bolivian or the Argentinean Yungas) provided encouraging results. Contrasted patterns in species traits were observed among sites, and could be related in some cases to contrasted disturbance intensities. As an example, invertebrates known, in the same area of Bolivia, to be sensitive to suspended solids (Fossati *et al.*, 2001) had higher affinities with abundant periphyton, which is limited by suspended solids (Fossati *et al.* publication in preparation).

In further studies, all the availble data for non-impacted sites will be used to code all the possible traits, in order to find which traits are really important. Moreover, we will better explore relationships between traits patterns and disturbance characteristics in order to better validate the reference matrix of taxa affinities for environmental features of habitats, and improve the coding process if possible.

When using the species trait approach in a biomonitoring context, a major disadvantage is that affinities of taxa for various traits have first to be documented. As a result, this approach is strongly dependent on the availability of biological information for taxa. Inferring ecological information (e.g. taxa “□preferendum□ for environmental variables) exclusively from field data has some bias. It may however represent a practical and valuable strategy to document species traits when other sources of information are lacking, in complement with bibliographic data already available on the biology and ecology of taxa. We assume that many ecological traits can be derived from characteristics of habitats. In contrast, the same approach may be problematic for biological traits (e.g. traits related to life history, behaviour, reproduction, nutrition…). Various approaches are thus clearly necessary. Despite these limitations, we believe that our approach and initial data set could contribute to identify ecological responses of invertebrate communities of tropical streams to natural and anthropic pertubations.

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Tables and figure

Table 1. Habitat variables used to define the ecological traits (6 variables, 21 categories).

Table 2. Ecological traits for 32 neotropical taxa from the Yungas Bolivian rivers (matrix for 21 categories of 6 traits). Affinity scale : 0 – "no affinity"; 4 – "high affinity".

Figure 1. Strategy to derive the affinity matrix per taxon for the 21 categories of the 6 ecological traits. Illustration for Hydropsychidae and the 3rd ecological trait (dominating substrate) with 4 categories.

Figure 2. Percentages of taxa with high affinities (code 3 to 5) with the considered parameter modality.

Fossati, Dumas et al. Tab. 1

Fossati, Dumas et al. Tab. 2

Fossati, Dumas et al. Fig. 1

Fossati, Dumas et al. Fig. 2