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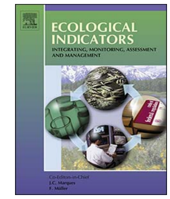

Original Articles

Snails (Mollusca: Gastropoda) as potential surrogates of overall aquatic invertebrate assemblage in wetlands of Northeastern China

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ABSTRACT

Aquatic invertebrates constitute a large proportion of biological diversity in wetlands and can be useful indicators of wetland environmental conditions; however, their assessment can be time consuming and requires special expertise. So it may be useful to screen for potential surrogates to represent overall aquatic invertebrate assemblages and make bioassessments more feasible. The composition of aquatic invertebrate communities were studied in 15 floodplain wetlands of the Wusuli River and 14 non-floodplain wetlands, all located in Northeastern China's Sanjiang Plain. Our study showed that aquatic invertebrate assemblages in non-floodplain wetlands differed from floodplain wetlands. Then the potential surrogates were identified for 11 aquatic invertebrate groups across all 29 wetlands. Gastropoda proved to be potential surrogates of overall aquatic invertebrate species density, species richness and community similarity, and could be used to classify floodplain and non-floodplain wetlands. Nine Gastropoda species were indicators for specific wetland types. Using snail assemblages as surrogates for overall aquatic invertebrate communities may make rapid assessments of wetland condition using aquatic invertebrates simple yet effective.

1. Introduction

Bioindicators, as taxa or functional groups, are widely used (1) as indicators of environmental change, (2) to identify ecological stressors, and (3) to reflect taxonomic diversity (Hodkinson, 2005; Heino et al., 2009; Gerlach et al., 2013). Although indicator taxa may sometimes be unreliable as broad indicators of biodiversity (Gerlach et al., 2013; Gleason and Rooney, 2017), they may serve a useful function in identifying ecological characteristics and for monitoring the effects of habitat management (Frédéric, 2017; Guan et al., 2017; Wu et al., 2017).

Wetlands are among the most widely distributed biological habitats worldwide, occurring from tropical to polar areas, and from deserts to rainforests. Aquatic invertebrates are important biological components of wetland, and play especially crucial ecological roles in wetland ecosystems (Batzer, 2013; Batzer et al., 2016). They typically comprise a portion of the macrobiotic diversity (i.e., plants and animals), and are the primary trophic link between plant productivity (macrophytes, algae) and higher wetland animals (fish, birds) (Batzer and Wissinger, 1996). Although species-level is considered the most suitable taxonomic level for reliable information on aquatic invertebrates, species identification is intensive laborious activity that requires time, money, and considerable expertise to reliably classify and enumerate individuals from diverse taxonomic groups (Lovell et al., 2007; Guareschi et al., 2015; Machado et al., 2015). Moreover, species-specific data or taxonomic keys are not often available for some geographical areas or some invertebrate groups (Doretto et al., 2018). Owing to the large number of aquatic invertebrate species, it would therefore be useful to identify surrogates that can be used to classify overall aquatic invertebrate communities to make conservation and environmental monitoring efforts more cost effective (Lovell et al., 2007; Siqueira et al., 2012).

Surrogacy is a relation between a particular taxon or indicator variable, and a target variable (Sarkar and Margules, 2002). Some early studies examined cross-taxon congruence in species richness (Panzer and Schwartz, 1998; Bilton et al., 2006). But mounting evidence suggested that the correlation of species richness between pairs of taxa is highly variable, both taxonomically and geographically, and thus the cross-taxon congruence in community similarity may be the more relevant measure of species diversity in the context of coarse-filter conservation strategies (Jeffery et al., 2004). Ultimately, many studies suggested that species assemblage patterns should be used in conjunction with measures of species density for conservation planning, in

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particular, when an ecosystem consists of diverse habitats and with high species turnover (e.g., Bilton et al., 2006; Lovell et al., 2007; Heino et al., 2009).

Among freshwater ecosystems, the utility of aquatic macroinvertebrates as indicators of ecological conditions has been particularly well-established for streams and rivers (e.g., Rosenberg et al., 2008; Southerland et al., 2008). Meanwhile macroinvertebrates in wetlands share some of the attributes that make macroinvertebrates in streams/rivers useful (Rosenberg and Resh, 1993), wetland macroinvertebrates have many other attributes that reduce their ability to reflect environmental quality (e.g. strong responses to weather and seasonality, frequent dispersal into and out of habitats, and a lack of adequate taxonomic keys for many groups; Rosenberg et al., 2008). Insects in the orders Ephemeroptera, Plecoptera, and Trichoptera (collectively the EPT taxa) are considered particularly useful instream/river bioassessment because so many of these taxa are environmentally sensitive (Rosenberg et al., 2008). Recent work has started to explore invertebrate alternatives to the insects for wetland bioassessment, and some support is now emerging for the Mollusca (snails: Gastropoda; clams/mussels: Bivalvia). Gastropoda assemblages have proved to be useful surrogates for overall macroinvertebrate taxon richness in 381 wetlands across the Nearctic and Western Palearctic geographic regions (Ruhí and Batzer, 2014). Wu et al. (2017) and Guan et al. (2017) found that snail assemblages can be efficaciously used to indicate condition of wetlands in Northeastern China, and the approach may have broad application.

In this paper, Aquatic invertebrate community characteristics were quantified and assessed whether the aquatic invertebrate community varied across the 15 river floodplain wetlands and 14 non-floodplain wetlands in Northeastern China's Sanjiang Plain. 11 taxon groups were investigated as potential surrogates to represent overall aquatic invertebrate diversity, assessing both species richness and community similarity across taxonomic groups. Finally, the utility of Gastropoda as surrogates to indicate environmental variation of freshwater wetland habitats of Northeastern China's Sanjiang Plain was assessed.

2. Materials and methods

2.1. Study sites

Our study was carried out at 29 wetland sites between 45°15′and 48°12′N of the Sanjiang Plain, in Heilongjiang Province of Northeast China (Fig. 1). The Sanjiang Plain formed by the Heilong, Songhua and Wusuli Rivers, has a total area of 10.9 million ha (Liu and Ma, 2002) and supports one of the largest freshwater wetland complexes in China. 14 non-floodplain wetlands were sampled in Honghe National Nature Reserve, Sanjiang National Nature Reserve, and the Sanjiang Mire Wetland Experimental Station of the Chinese Academy of Sciences. 15 river floodplain wetlands were sampled along the Wusuli River, which forms a border between China and Russia. All sites were in the same geographical area, but varied substantially in water sources, hydrologic permanence (i.e. hydroperiod) and plant communities. All supported extensive marsh vegetation, dominated by *Carex pseudocuraica* F. Schmidt., *C. lasiocarpa* Ehrh., *C. meyeriana* Kunth., *C. appendiculata* (Trautv.) Kük., and *C. schmidtii* Meinsh (Wu et al., 2013).

The study area experiences a temperate moist monsoon climate with a mean annual temperature of 1.9–2.7°C and a mean annual precipitation of 550–600 mm. The average monthly temperatures range from −21 °C in January to 22 °C in July. More than 60% of the annual precipitation falls between July and September. The study area lies in a seasonally frozen zone, and the frost-free period is 125 days. More than 60% of the annual precipitation falls between July and September. The altitude of the study area averaged 55 m.

2.2. Field collections and sample processing

We sampled for macroinvertebrates twice of the course of the study, in May 2013 (Spring) and October 2013 (Autumn). We sampled assemblages of aquatic invertebrates using a D-shaped sweep net (35-cm diameter, 1-mm mesh). Sweep nets sample a rich array of invertebrates and are considered useful for aquatic invertebrate community studies (Batzer et al., 2001). Four 1-m-long horizontal sweeps were collected at randomly selected locations in each wetland. As the nets sieved the water column, scraped the bottom, and swept submersed and emergent plant surfaces, a fairly complete sample of the aquatic invertebrate community was collected (Batzer et al., 2001; Meyer et al., 2013). The four 0.35 m × 1 m sub-samples per wetland per date were pooled and stored in labeled plastic bags, and preserved in 95% ethanol. In the laboratory, aquatic invertebrates were hand sorted from sediments and plant debris under a dissecting microscope, and then re-preserved in 95% ethanol. Aquatic invertebrates were identified to the lowest taxonomic level practical using standard references, keys, and guides (Liu et al., 1979; Qi et al., 1985; Clifford, 1991; Liang, 1996; Duan et al., 2010). Mollusca were classified to species or genus, while Insecta, Crustacea, and Annelida were classified to species, genus, or family.

2.3. Statistical analyses

Variation in overall community compositions among the 29 study wetlands was assessed using aquatic invertebrate taxon abundance and composition. Analysis of variance (ANOVA) was used to assess whether total aquatic invertebrates varied between floodplains and non-floodplain wetlands. In order to visualize the variation in aquatic invertebrate community structure and to identify groupings among the different wetlands, non-metric multidimensional scaling ordination (NMDS) were used based upon relative abundances of the aquatic invertebrate taxa. Bray–Curtis similarity was used as the distance measure. To test for significance, we contrasted groupings using a SIMPROF test (Clarke et al., 2014). Cluster analysis was also carried out, using group-average clustering from the Bray-Curtis similarities. Data were square-root transformed to reduce impacts of the most abundant taxa, and to ensure rarer taxa remained influential.

Then standard datasets were created and Spearman rank correlations were used to test cross-taxon species abundance and species richness correlations. The congruence in taxonomic assesmblage similarities were assessed using one-way analysis of similarity (ANOSIM) tests, with Bray-Curtis coefficients of square-root-transformed counts. 'Second-stage' similarity matrix generated from the *p*-values of ANOSIM tests between each pair of taxa. Second-stage cluster analysis using group average clustering from the 'Second-stage' similarity matrices was then carried out to visualize the relatedness of each taxon (Lovell et al., 2007).

Potential surrogates were identified using the congruencies of species density, species richness and community similarity. Then variation of surrogate assemblages was tested using non-metric multidimensional scaling ordination (NMDS), and verified whether the same groupings of aquatic invertebrates existed in floodplain and non-floodplain wetlands. Finally, indicator species analysis was used to identify potential representative indicator species among the surrogate taxonomic groups for wetlands with different conditions. This test uses both abundance and frequency of taxa across designated groups to generate indicator value (IV) from 0 (no indicator value) to 100 (perfect indicator) for every taxon (5000 random permutations were used for the Monte Carlo analysis to test for significance, with only significant species being reported). Cluster, NMDS and ANOSIM analyses were conducted using the PRIMER 7 software package (Clarke and Gorley, 2015), Indicator Analyses were conducted in PC-ORD 5, and ANOVA analyses in SPSS 21.0.

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