Freshwater biodiversity patterns across a gradient in environmental degradation associated with the production of sugarcane

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Introduction

The dawn of a new paradigm in energy supply – biofuels – points to the continued expansion of agriculture in Brazil in the near future. The country is in a favorable position to assume the global leadership in biofuel production for possessing both ideal geographic and environmental conditions and the already most efficient ethanol industry worldwide. Not surprisingly however, agriculture involves both benefits and costs to society. Industrial agriculture is one of the most environmentally harmful human activities, being directly involved in habitat destruction and in the contamination of water resources.

This study proposed to test the hypothesis that the expansion of sugarcane is associated with significant changes in freshwater community composition, diversity and structure, and that these changes are consistent with agrochemical contamination in the environment. The study system consisted of algae as producers, anuran larvae as consumers, and predatory aquatic insects.

We conducted sampling surveys early in the rainy season of 2009/2010 in 33 water bodies distributed across a gradient of environmental degradation, i.e., that comprised of a reference, native habitat (cerrado forest/semi-deciduous seasonal Atlantic Forest), pastures, and sugarcane plantations. Although native habitats offer the appropriate reference sites for assessing the impacts of agricultural expansion overall, a comparison between pastures and plantations offers stronger insights in the assessment of eventual impacts of agrochemicals, as both are structurally degraded but plantations are, in addition, subject to agrochemical contamination. Fieldwork was conducted in the Estação Ecológica do Jataí and surroundings, in the region of Ribeirão Preto, State of São Paulo, Brazil. Quantitative and qualitative surveys for freshwater community composition and structure employed pipe sampling, dipnetting, and calling surveys. In each water body we sampled phytoplankton standing crop as an index of basal resource availability, the abundance and species identity of anuran larvae, and the abundance and family identity of their predators, which in these habitats are mainly dragonfly larvae (Odonata), larval and adult beetles (Coleoptera), larval dobsonflies (Megaloptera), nymphal and adult bugs (Heteroptera: Belostomatidae, Nepidae, Notonectidae, Corixidae, Naucoridae), and fish. Sampling was preceded by habitat characterization and analyses of basic water quality parameters.

Results and Conclusions

There was a strong signal of land use on freshwater community diversity, composition and structure. Mean amphibian species richness per pond decreased across the hypothesized gradient of environmental degradation, ranging from 4.4 species in native habitats to 2.3 species in pastures to 1.8 species in sugarcane plantations. Land use also influenced tadpole density and biomass, but not their frequency of occurrence. Ponds in pastures presented lower amphibian densities and biomass than ponds in cerrado and sugarcane plantations. Sugarcane plantations were characterized by a relatively impoverished fauna with large variation in densities and biomass; in fact, some of the highest densities and biomass of tadpoles in the whole study site were found in sugarcane plantations.

An analysis of species distributions demonstrates that certain species, including *Dendropsophus minutus, Hypsiboas faber, Trachycephalus venulosus, Odontophrynus cultripes* and *Dermatonotus muelleri* were found exclusively in the reference site. In turn, *Hypsiboas raniceps* e *Elachistocleis* sp. were found exclusively in pastures and/or sugarcane plantations. No species were found exclusively in sugarcane plantations. Judging from the standpoint of biomass, *Scinax fuscovarius, Scinax similis, Physalaemus cuvieri* and, especially, *Leptodactylus fuscus* appeared to be favored by the conversion of native habitats to pastures or plantations. *Leptodactylus fuscus* was of notable prevalence in sugarcane: the species, found in 6 of 9 ponds in cerrado and in 1 of 10 ponds in pasture, occurred in no less than 11 of 12 ponds in sugarcane plantations, where it reached densities and biomass as high as 718 inds/m2 or 118 g/m2. Actually, in half of the sugarcane ponds this species occurred alone. These observations indicate that *L. fuscus* is a species of particular interest in the experimental components of our research program, towards an understanding of the traits that are correlated with success in degraded areas.

Land use also had strong effects on predator richness, frequency of occurrence, density, and biomass. Overall, the strongest pattern was an impoverishment of the fauna of predators in sugarcane when compared to cerrrado or pastures. Whereas 100% of ponds in the cerrado or pasture contained at least one predator, only 67% of ponds in plantations contained predators. Similarly, predator richness, density and to a lesser extent biomass were lower in plantations than in cerrado or pastures. Ponds in sugarcane plantations never contained nepids, naucorids, leeches or fish. In general, larval dragonfly and larval and adult beetles were the most frequent predators. In terms of biomass, larval dragonflies were clearly the dominant predators in all forms of land use, which reinforces the adequacy of employing dragonfly larvae as model predators in the experimental components of our research project.

Land use had a strong influence on water quality; there was a trend towards higher temperature, conductivity, and dissolved oxygen moving from cerrado to pastures to sugarcane. There was also a qualitative trend towards increased turbidity and phycocyanin concentration along the same gradient. Reference ponds had lower nitrate and nitrite than pasture and plantation ponds

Overall, we found a strong signal of land use on water body structure, freshwater quality, and community diversity, composition and structure. The loss of species as

one goes from pastures to plantations is consistent with an effect for habitat contamination, and we witnessed die offs in amphibian larvae of several species in ponds in sugarcane fields that could be consistent with the timing of application of pesticides. We are currently considering to associate more closely the timing of pesticide applications and biodiversity sampling. We are also conducting analyses on residue levels in field collected tadpoles to understand to what degree amphibian species are subject to agrochemical contamination and how do these residue levels correspond to those accumulated by conspecifics exposed in the laboratory and mesocosms to commonly used pesticides.

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