Are family-level biotic indices a useful measure of human influence in moderately disturbed tropical streams? An assessment from Belize.

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Bio-assessment based on macroinvertebrates is being increasingly used for tropical stream management and many practitioners rely on family-level indices extrapolated from temperate regions. Many of these indices were originally designed to rapidly assess gross organic pollution effects, but with improvements in stream water quality limitations in their ability to detect more subtle effects were revealed. Family-level indices present a valuable assessment tool in many tropical parts of the developing world where urbanization is rapidly increasing and sanitation and sewerage systems are poor. However, many tropical regions are still considered to be only moderately disturbed. Given concerns about the efficacy with which family-level indices discriminate subtle impacts in the regions for which they were intended, there is a need to assess their ability to discriminate low-level effects in tropical streams.

The Hugh Cary Gilson Award allowed me to investigate this question in four catchments in southern Belize, where less than 30% of the forest has been cleared. Macroinvertebrate communities vary with geology in the studied catchments, so I sampled calcareous and silicate streams separately in areas of forest and human activity assumed to provide a gradient of environmental change. Variance in physico-chemical information and macroinvertebrate metrics was tested among i) forest ii) subsistence/non mechanised farming
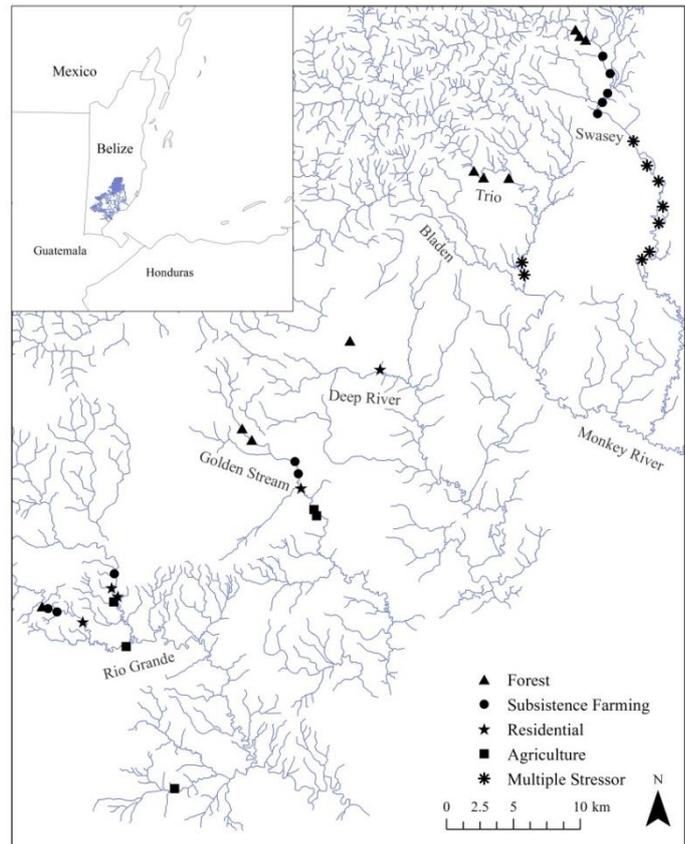

Figure 1. Sites sampled for macroinvertebrates and physico-chemical information within each treatment category. Rio Grande, Golden Stream and Deep River are calcareous catchments. The inset map shows the location of Belize in Central America and the location of the studied catchments in Belize.

iii) rural settlements and iv) commercial agriculture (mainly citrus and cattle) sites in calcareous streams and i) forest ii) subsistence/non mechanised farming and iii) multiple stressor (intensive agriculture, residential activities, sand and gravel extraction) sites in silicate streams.

Figure 2. Examples of treatment group sites: a) forest, b) non-mechanised farming, c) residential and d) multiple stressor.

Did family-level information detect anthropogenic environmental change?

Environmental data confirmed expectations that the study streams were only moderately disturbed. Dissolved oxygen, pH and turbidity for example were similar to measurements made in moderately disturbed streams across a number of tropical regions. Nevertheless, variation in riparian and depositional characteristics was evident among all treatment categories in silicate streams, and among calcareous forested and agricultural sites. Despite anthropogenic environmental change, variation in macroinvertebrate families was most pronounced among geological stream types.
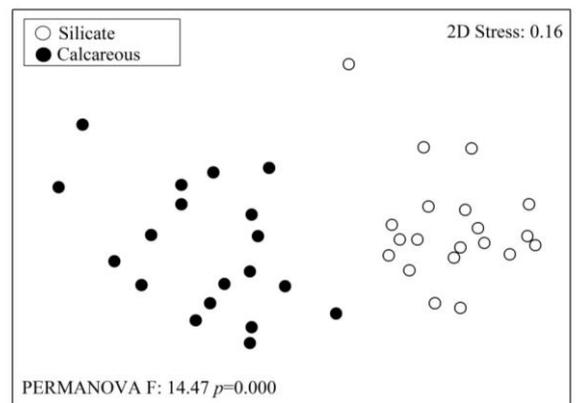

Figure 3. Non-metric dimensional scaling revealed variation in the composition of macroinvertebrate families was most pronounced among calcareous and silicate sites.

Controlling for stream type, there was little evidence to suggest family-level metrics or community composition responded consistently to environmental change associated with low-levels of human activity. A significant response was observed only in assemblage attributes measured at multiple stressor sites.

There is widespread support for the use of family resolution in rapid bio-assessment studies, particularly in developing tropical countries where taxonomic and ecological information can be scarce for many of the species and genera that comprise the families typically used to classify impairment in streams. Overall, this study indicates that family-level indices can detect coarse environmental change in moderately disturbed tropical streams, but that alternative approaches are needed to detect more subtle effects.

What's Next?

This study forms part of a wider project that seeks to facilitate the development of stream assessment in Belize. Next steps include selecting metrics that are responsive to change resulting from the range and magnitude of human activities occurring at a national scale. For areas that are influenced by low-levels of environmental stress this will include resolving family-level data to a finer taxonomic resolution. Recent advances in the availability of taxonomic and environmental information will help this effort, but please get in touch if you have been working with macroinvertebrates in Belizean or other Central American streams.
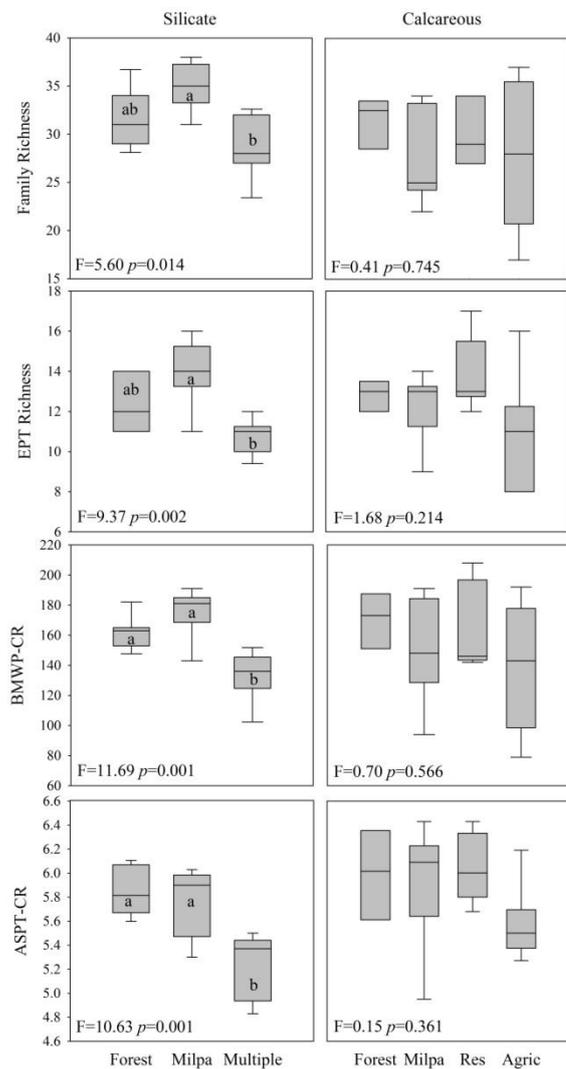

Figure 4. Variation in selected metrics among treatment groups. Different letters reflect significant differences ($p=<0.05$). BMWP-CR and ASPT-CR are based on a Costa Rican adaptation of the original BMWP score.