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Techniques of Fisheries Management: Water Quality Assessment with Stream Insects

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Nutrient enrichment of streams is a long-standing problem that continues to have substantial local and regional consequences. For example, water quality of streams in the southern Appalachian Mountains of the U.S. can be seriously degraded by organic nutrients leached from animal wastes if cattle or other livestock are allowed to graze in the riparian zone. Local efforts to recover native brook trout *(Salvelinus fontinalis)* and improve habitat for coldwater fishes are often undermined by poor livestock management practices. At a regional scale, the cumulative effects of nutrient-enriched streams have resulted in eutrophication of important Atlantic Coast estuaries such as Chesapeake Bay in Virginia and the Albemarle-Pamlico system in North Carolina. Recent outbreaks of a toxic estuarine dinoflagellate *(Pfiesteria piscicida),* which caused massive fish kills and affected human health, have been attributed to nutrient enrichment.

Natural resource managers need to be able to precisely evaluate nutrient enrichment for two reasons: (1) to measure the extent and severity of detrimental effects on aquatic life; and (2) to monitor the success of efforts to reduce nutrient impacts - i.e., to determine if best management practices result in measurable improvements. With regard to streams, one of the basic tools that investigators in the U.S. use to evaluate biological conditions is the EPA Rapid Bioassessment Protocol (RBP) for macroinvertebrates. Although this method reveals impaired benthic communities, it has an important weakness - it does not identify cause-effect linkages, i.e., whether the impairment is due to chemical pollutants, sedimentation, nutrient enrichment, or other perturbations.

Recognizing the inherent weakness of RBP for nutrient assessment, I have devised a method by which growth of filamentous bacteria *(Sphaerotilus* sp., *Leptothrix* sp.) on aquatic insects can be used as a bioindicator of detrimental nutrient levels in streams. I have found that simple visual assessment of benthic samples using a hand lens (10-l5X magnification) is sufficient to identify sites where nutrient impacts are likely to be occurring. Laboratory studies have determined that bacterial growth reduces insect survival, providing evidence of a cause-effect linkage between bacterial growth and impaired insect communities found in the field. My presentation in the PASS Workshop will describe the technique of using aquatic insects as a bioindicator of detrimental nutrient enrichment in streams.

Diagnostic Capability

The occurrence of epizoic bacterial colonization of aquatic insects can be a useful, quick indicator of detrimental point- or non-point-source nutrient enrichment. The degree of bacterial growth associated with the mortality threshold can be used as a diagnostic endpoint. When mortality data from the laboratory experiments is examined in combination with relationships between insect density and bacterial infestation in the field, 25% body coverage emerges as the diagnostic endpoint for the bioindicator. Survival of insects with 10-25% coverage can be good but above 25%, survival is unlikely. Thus, the metric used to signify harmful impacts of nutrients on stream insect populations is 25% body coverage by filamentous bacteria. This level of infestation can be easily detected in the laboratory or field with a hand lens (10-15X magnification; see photos).

Reliability and Simplicity

Bacterial infestation of insects has practical application as a bioindicator of detrimental nutrient enrichment in a field setting. Intensive quantitative benthic sampling is not necessary; qualitative kick samples of insects are adequate and they can be viewed on-site, allowing a screening-level field assessment to be conducted within minutes.

Preservation of insects in ethanol or formalin, or manipulation of insects with collection equipment such as brushes and forceps, do not dislodge the bacteria. Consequently, severity of infestation can be confirmed in the laboratory without loss of data. Archived samples collected as part of a long-term monitoring program or other research purposes can also be evaluated. Immersing individual insects into water or preservative suspends bacterial filaments attached to the lateral edges of the body for easy recognition, particularly on the caudal filaments of heavily infested mayflies (Ephemeroptera) and stoneflies (Plecoptera). Individuals whose bodies are >25% covered by bacteria (i.e., the indicator level for impact assessment) can be rapidly detected in the field or laboratory.

Application to Rapid Bioassessment

The bioindicator can be easily applied to fresh or preserved benthic samples collected using the EPA Rapid Bioassessment Protocol RBP), which is used by fishery biologists throughout the USA. The RBP was developed for application to streams and rivers, and focuses on numerical relationships between Ephemeroptera, Plecoptera, and Trichoptera (caddisflies) to assess whether a benthic macroinvertebrate community is healthy or impaired. These 3 orders of insects are also among the best to use in detecting growths of filamentous bacteria. Positive diagnosis of bacterial growth can strengthen RBP analyses by identifying a probable cause for impaired macroinvertebrate communities, and it can help to focus subsequent investigations because nutrient enrichment is indicated as a major contributing factor. The simplicity and speed of the method allow it to be incorporated into the EPA RBP with little additional effort by those conducting stream surveys.

Conclusions

My field and laboratory studies indicate that the insect-bacteria bioindicator is valid for application to nutrient assessment in streams (see handout publication). Bacterial growth on insects is a practical tool for identifying the existence of detrimental non-point-source nutrient inputs, as well as evaluating the severity of biological impacts from known sources. Rapid field or laboratory screening of benthic samples is possible. A discovery of insects whose bodies are ≥ 25% covered by filamentous bacteria is all that is necessary to reliably diagnose harmful impacts of nutrients on stream macroinvertebrate communities. The information provided by this bioindicator will be useful for detecting nutrient problems as well as monitoring the success of management actions to improve water quality.