Analysis of Ephemeroptera, Plecoptera and Trichoptera (EPT) richness and diversity of Guilford Creek, Guilford, NY

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ABSTRACT

Analysis of a single kick sample from a 2nd order stream in Guilford, NY of known water quality showed slight variation among three 100 fixed-count subsamples in calculating EPT Richness at family and genus level of taxonomic resolution. EPT (Ephemeroptera, Plecoptera and Trichoptera) richness of one subsample varied enough to assign the site to a water quality level below other subsamples when compared at both the family level, but not when compared at the genus level of resolution. Comparing EPT richness to subsample size revealed 100 organisms are less than adequate in defining true EPT assemblages of Guilford Creek; however, smaller subsample size had no effect on the assigned water quality value of the site.

INTRODUCTION

Biological assessments of human and environmental impacts on water quality and aquatic organisms have been used since the early 1900s (Wallace et al. 1996). Since the Clean Water Act of 1972, many local and national government agencies have been developing various techniques to measure the health of the country's waterways (Bode and Novak 1995; Southerland and Stribling 1995). Of these techniques the use of macroinvertebrates to assess water quality has become a standard addition to many State and Federal environmental bureaus (Bode and Novak 1995; Barbour et al. 1999), and has been used by citizen science organizations and schools for education purposes and environmental watchdogging efforts (Bode et al. 1997; Lathrop and Markowitz 1995). Macroinvertebrates are ideal indicator organisms as various taxa are associated with different levels of water quality. Macroinvertebrates also inhabit a vital position in the food chain of aquatic systems and therefore can be used to make estimates of ecosystem health (Bode and Novak 1995). Analysis of macroinvertebrate assemblages is also time and cost efficient compared to chemical and physical assessments of water quality (Bode et al. 1996), which provide little insight into temporal variation in conditions.

The simultaneous development of ecological monitoring techniques throughout various parts of the country has resulted in the creation of different indices (Barbour et al. 1999; Southerland and Stribling 1995). The variation and use of these indices also depends on the goal of the researchers and the type of impact that is being measured (Barbour et al. 1999; Bode et al.1995; Southerland et al. 1995; Wallace et al. 1996). Among the various methods of water quality assessment is the need for cost and time efficient methods that would produce rapid turn-around of results, and could assess a wide range of water qualities. This prompted the use of rapid-bioassessment protocols (Barbour et al. 1999).

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Rapid bioassessment protocols using macroinvertebrates generally consist of kick sampling methods of collection, fixed-count subsamples (100 organisms is standard), reduced taxonomic resolution and the use of multiple metrics to calculate water quality values (Resh 1995; Smith and Bode unpubl.; Wallace et al. 1996). Subsample size and level of taxonomic resolution have become topics of debate among professionals in the field, and have subsequently become the topic of numerous studies since the 1970s (Resh and Unzicker 1975; Bailey et al. 2001; Somers et al. 1998; Vinson and Hawkins 1996).

Greater taxonomic resolution is needed for various indices of biological assessment dealing with toxicology and to evaluate the specific ecology and conservation needs of different organisms. However, species level identification is neither time nor cost efficient and can even require the identification of several life stages of a single species as many keys to aquatic orders are not available throughout the country (Resh and Unzicker 1975; Bailey et al. 2001). While species level resolution is useful in determining types of water quality impact, the goal of rapid bioassessment criteria is only to determine if impairment exists (Smith and Bode, unpubl.).

The necessary resolution of sample size also depends on the type of indices used and the goal of the research. Larger enumerations will provide better information of rare organisms in the sample and the true richness of the assemblage; however smaller sample sizes are often efficient when estimating abundances of more common taxa (Somers et al, 1998; Vinson and Hawkins 1996). Most rapid-bioassessment indices are only useful in determining relative differences in biotic richness (Smith and Bode unpubl.). Therefore standard count subsamples of 100 organisms are often adequate and the loss of rare taxa may be an expected trade-off when comparing relative abundances and richness of indicator organisms (Vinson and Hawkins 1996).

This study evaluates the factors of subsample size and taxonomic resolution in assessing the water quality and family and genus richness of EPTs by a single kick sample from Guilford Creek in Guilford, NY.

METHODS

Samples were collected on November 15, 2003 from Guilford creek in Guilford, NY 10 m downstream from the Chenango County Rte. 8 bridge. This stream is a second order stream of non-impacted water quality according to the New York State biological water quality assessment criteria (Bode, pers. comm.). An average velocity of 40 cm/sec was determined from three float tests by timing a leaf floating 1m downstream. Average stream depth was estimated to be 40 cm.

One 15minute traveling kick sample was taken using a triangle net with an opening of 356 cm^2 (55 in^2), across a 15 m transect starting at the top of a riffle. Kick sample protocol was adjusted from Smith and Bode (unpubl.), who used a net opening of 1045 cm^2 (162in^2). Large rocks and sticks were removed from the sample after brushing off any macroinvertebrates into a wash pan. The sample was strained through a sieve with a mesh size of 1mm and frozen for 48 hours. The sample was then preserved in 70% ethanol, and later drained and preserved in 90% ethanol as residual water diluted the weaker solution and slight decomposition occurred.

In the laboratory the sample was poured into a large watch glass. Approximately 1 teaspoon of material was removed from the sample at a time and processed in a white enamel pan. Macroinvertebrates were removed randomly from the detritus and gravel and placed in a smaller watch glass for identification under a dissecting microscope. Organisms in the orders Ephemeroptera, Plecoptera, and Trichoptera were identified to the genus level using Peckarsky et al. (1990). Other organisms were identified to order or family. Each organism was numbered in chronological order of identification for further sub-sample analysis.

Species dominance, trophic diversity of functional feeding groups, and organic pollution tolerance level diversity (Bode et al, 1996) were calculated for Ephemeroptera, Plecoptera and Trichoptera within the sample. Family and genus richness within EPTs were also measured at 25 organism intervals for cost-benefit comparison of taxa richness and sample size (Horvath pers. comm.). Water quality assessments were calculated according to Bode et al. (1997). They included Community Parameters I (EPT Richness), II (Biotic Index), and III (Percent Model Affinity) for three separate 100 organism subsamples (1-100, 101-200, and 201-300). Water quality values for Community Parameter I EPT Richness are as follows: <2 = poor water quality (severely impacted), 2-5 = fair (moderate impact), 6-10 = good (slight impact) and >10 = excellent quality (no impact) (Bode et al. 1996; 1997). EPT Richness was calculated at the family and genus levels for comparison of taxonomic resolution. Community Parameters I-III were developed as rapid-bioasessment protocol for use by schools and citizen science organizations and are normally viewed as the "first step in the screening process" of water quality. More precise protocol and variations on these indices are used in definitive bio-assessment profiles by the NYS DEC in combination with physical and chemical stream parameters (Bode et al. 1997).

RESULTS

In the sample, 325 organisms were identified to at least the level of order. The Ephemeroptera, Plecoptera and Trichoptera made up 92% (299) of the total sample. The three most dominant genera were the Ephemeropterans *Leptophlebiidae; Paraleptophlebia* (n = 128, 39% of sample), *Ephemerellidae; Ephemerella* (n = 37, 11%) and *Drunella* sp. (n = 30, 9%). Together, Ephemeroptera comprised about 60% of the sample.

Trophic diversity of the EPTs suggests collector-gatherers as the most abundant feeding group in Guilford Creek, followed by scrapers, shredders, predators, and filterers respectively (Table 1). Tolerance levels were based on mean tolerance level for species within each genus (from Bode et al. 1996). Table 2 summarizes the abundances of EPT genera having those tolerances. Low tolerances were exhibited by the majority of EPTs present in the sample of Guilford Creek.

Comparisons of EPT family richness showed slight variation among subsamples (Table 3). The largest amount of variation was seen in the Trichoptera, from 6 families in subsample 1 to 2 families in subsample 3. Water quality values were affected slightly by this variation as subsample 1 and 2 were assigned values of “excellent” water quality, while subsample 3 was assigned a water quality value of “good-excellent”.

Comparisons of EPT genus richness also showed variation among subsamples (Table 4). Variation between subsamples ranged from 4 genera among Ephemeroptera to 5 genera in the Trichoptera and Plecoptera between subsamples. However, variation had no effect on the assigned excellent water quality value for all three subsamples.

	Functional Feeding Groups				
	Collector-filterers	**Collector-gatherers**	**Scrapers**	**Shredders**	**Predators**
Ephemeroptera	**0**	**186 (7)**	**55 (3)**	**0**	**0**
Plecoptera	**0**	**0**	**0**	**19 (6)**	**18 (18)**
Trichoptera	**14 (4)**	**0**	**1 (1)**	**4 (2)**	**2 (1)**
Total	**14 (4)**	**187 (7)**	**56 (4)**	**23 (8)**	**20 (19)**
% Trophic level	**4.67**	**62.33**	**18.67**	**7.67**	**6.67**

Table 1. Trophic Diversity Among Ephemeroptera, Plecoptera and Trichoptera from a single kick sample of Guilford Creek, showing the abundance of various feeding groups of the EPT orders found. Genus richness for each feeding group is shown in parenthesis.

Community Parameter II Biotic Index assigns water quality values as follows: < 40 = poor water quality, 40-59 = fair, 60-79 = good, and >79 = excellent water quality (Bode et al. 1997). Comparisons of the three subsamples revealed little variation in Biotic Index values (Subsample 1 = 96.5, Subsample 2 = 97.8, and Subsample 3 = 98.6), with no variation from the assigned “excellent” water quality value.

Community Parameter III Percent Model Affinity water quality values are as follows: <35 = poor quality, 35-49 = fair, 50-64 = good, and >64 = excellent water quality (Bode et al. 1997). Little variation occurred among the PMA values among the three subsamples (Subsample 1 = 64, Subsample 2 = 58, and Subsample 3 = 57) and water quality was determined as “good” for each subsample.

Figure 1 shows the relationship between sample size and EPT family richness in 25 organism increments throughout a 325 organism subsample. All families of Ephemeroptera were represented by the first 75 organism identified. However, families of Trichoptera and Plecoptera were not fully represented until the 150th and 200th organisms were identified, respectively. By the 100th organism, 6 of the total of 7 families of Trichoptera were found; only 4 of the total of 7 families of Plecoptera had been identified at that point. This implies that a 100 organism subsample is insufficient to evaluate richness at the family level.

Diversity of Organic Pollutant Tolerance Level Among EPTs

Tolerance Level	Ephemeroptera Abundance	Plecoptera Abundance	Trichoptera Abundance	Total	% of Total EPT
0	53	5	2	60	20.13
1	165	3	5	173	58.05
2	13	28	0	41	13.76
3	0	1	0	1	0.34
4	3	0	10	13	4.36
5	7	0	2	9	3.02
6	0	0	1	1	0.34
7	0	0	0	0	0.00
8	0	0	0	0	0.00
9	0	0	0	0	0.00
10	0	0	0	0	0.00

Table 2. Diversity of organic pollutant tolerances of Ephemeroptera, Plecoptera and Trichoptera of Guilford Creek. Tolerance levels defined in Bode et al. (1996) range from 0 (intolerant of organic pollutants) to 10 (very tolerant of organic pollutants). EPTs from Guilford creek are relatively intolerant to organic pollutants with values ranging from 0-6.

	Family Richness		
EPT Groups	**Subsample 1**	**Subsample 2**	**Subsample 3**
Ephemeroptera	5	4	5
Plecoptera	4	5	3
Trichoptera	6	4	2
Total	15	13	10
Water Quality	excellent	excellent	good-excellent

Table 3. EPT family richness comparisons among three 100-organism subsamples of a single kick sample. The greatest variation in richness occurred in the order Trichoptera resulting in varying values of water quality among samples.

	Genus Richness		
EPT Groups	**Subsample 1**	**Subsample 2**	**Subsample 3**
Ephemeroptera	**10**	**6**	**8**
Plecoptera	**5**	**8**	**3**
Trichoptera	**7**	**5**	**2**
Total	**22**	**19**	**13**
Water Quality	**excellent**	**excellent**	**excellent**

Table 4. EPT genus richness comparisons among three 100-organism subsamples of a single kick sample. Variation in Genus richness had no effect on assigned water quality values.

Genus richness comparisons were also made to sample size (Figure 2). A 100 organism subsample at the genus level proved to be even less adequate than at the family level, particularly with plecopterans. Only 4 genera were identified at that interval, while ultimately 10 genera were identified. By the 200th organism, all genera of EPTs present were identified, with the exception of 1 genus of Plecoptera.

DISCUSSION

Comparisons of EPT Family Richness among three 100-count subsamples (Table 3) showed that variation among EPT Richness does exist among the three subsamples. This variation resulted in assigning a lesser water quality value to the third subsample, although the average of the three subsamples would still produce a water quality value of excellent. This finding suggests that use of a single fixed count subsample of 100 organisms may provide incorrect water quality values when using Community Parameter rapid bioassessment techniques outlined in Bode et al. (1997). Variations among EPT genus richness (Table 4) showed no impact on assigned water quality values, and therefore may be a better indicator of water quality than resolution only to family. Statistical comparisons were not available due to the processing of only one sample. Comparisons of subsample size and taxonomic resolution among various streams of different water quality is needed to fully address the limitations of sample size on EPT Richness and other metrics designed for assessing water quality impact.

Comparison of both genus richness and family richness of the EPTs to subsample size (Figures 1 and 2) showed that more than 100 organisms are needed to fully assess the richness of these three orders in Guilford Creek. However, family and genus richness within the first 25 organisms (11 families and 13 genera) would have validated a water quality level of excellent without completing the standard 100-organism subsample.

The value of identifying rare taxa from a particular site depends on the scope of the research and the goal of the observer (Vinson and Hawkins, 1996). When using the EPTs, and other aquatic organisms, to evaluate water quality, rapid bioassessment indices only measure the relative health of the water from the relative abundance of taxa and diversity of the community (Vinson and Hawkins 1996; Smith and Bode unpubl.). Researchers and work focusing on the ecology or assemblage of EPTs of a given stream should consider using more than 100 or 200 organisms in a subsample to truly assess the community of the stream (Vinson and Hawkins 1996), but this level of analysis is exhaustive and not cost effective for communities or environmental and natural resource managers to conduct for relative stream health indices.

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