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Comparison Of Mean %EPT, Mean FBIBI, And Functional Feeding Groups Of Aquatic Macroinvertebrates From Disturbed And Undisturbed Sites Within The Flat Brook Watershed In Northern New Jersey

Kelly Norris
Environmental Studies Department
University of North Carolina Asheville
Asheville, North Carolina, 28804

Faculty Advisor: David Gillette

Abstract

There is growing concern for the health of the world's freshwaters, and bioassessment is often used as a water quality monitoring tool under the Clean Water Act. I used the Surber sampler method to collect aquatic macroinvertebrates from disturbed and undisturbed locations within the Flat Brook watershed in northern New Jersey, USA. Percent EPT, FBIBI, and functional feeding groups were compared to suggest the overall water quality of each location. Differences were not statistically significant; but overall high %EPT and excellent FBIBI values suggest high quality waters within the Flat Brook watershed. These positive ecological results indicate the need to preserve the pristine state of the Flat Brook watershed.

1. Introduction

Freshwater systems have long been exploited by humans for various societal activities. Fortunately, there is growing recognition of the innate value of freshwater systems and their biological complexity[2]. Aquatic macroinvertebrates are key organisms to many aquatic systems, and they have been extensively used in monitoring efforts as bioindicators of water quality[12, 19, 3]. For many aquatic macroinvertebrates, the beginning stage of their life cycle is spent with limited mobility in the water, thus making them especially susceptible to the harmful effects of water pollutants. Community characteristics such as high taxa richness and diversity indicate a generally healthy stream [4]. Degraded waters due to organic pollution often result in decreased presence of macroinvertebrates within the ecosystem [11]. A high percent of organisms within the orders Ephemeroptera, Plecoptera, and Trichoptera (%EPT), indicates good quality waters[10]. The Family Based Index of Biotic Integrity (FBIBI) similarly assigns tolerance values to aquatic macroinvertebrate based on taxonomic grouping[8]. The use of functional feeding groups (FFGs) is a less developed field of water quality assessment; but is an important ecological component to explore.

The Flat Brook watershed is largely protected from development and pollution and is considered to be one of the highest quality surface waters in the state of New Jersey[18]. The watershed drains roughly 65 square miles, starting at the confluence of the Little Flat Brook and the Big Flat Brook, eventually flowing into the Delaware River near Flatbrookville, New Jersey[18.] Under the provisions of the Clean Water Act of 1972, states have the legal authority to use bioassessment in their water quality programs. Both %EPT and FBIBI are legitimate tools for bioassessment of water quality. In the state of New Jersey, macroinvertebrate bioassessment measures for the Flat Brook Watershed were last taken in 2008[14] .

I performed bioassessment of undisturbed and disturbed sites within the Flat Brook watershed, specifically comparing 1) %EPT, 2) FBIBI, and 3) functional feeding groups. I formed three alternative hypotheses: 1) %EPT would be greater in undisturbed sites, 2) FBIBI would be closer to zero in undisturbed sites, and 3) the total abundance and diversity of functional feeding groups would be higher in undisturbed sites; with the null hypotheses that there are no differences in %EPT, FBIBI, and functional feeding groups between disturbed and undisturbed sites.

2. Materials and Methods

2.1 Field methods

2.1.1 Sampling sites

I compared five sites within the Flat Brook Watershed in northern New Jersey. I classified sites as either undisturbed or disturbed based on visual notes of each location. I chose three disturbed sites for their clear proximity to anthropogenic influences. At disturbed site 1 (D1; Lat N41.207115°, Long E-74.803178°), the Big Flat brook flowed directly beneath a high-traffic, paved roadway bridge on Route 206 in Branchville, New Jersey. Disturbed site 2 (D2; Lat N41.157351°, Long E-74.877541°), was a site near a lower traffic National Park Service Road in the Delaware National Recreation Area, where the Big Flat brook flowed directly beneath an open grate roadway bridge. Disturbed site 3 (D3; Lat N41.224958°, Long E-74.761985°) was a section of the Little Flat Brook flowing directly adjacent to a busy camping and day use area within Stokes State Forest, New Jersey. I chose undisturbed sites based on their apparent absence of any moderate anthropogenic disturbance relative to the disturbed sites. Undisturbed site 1 (U1; Lat N41.212029°, Long E-74.798652°) and undisturbed site 2 (U2; Lat N41.184738°, Long E-74.84994°) were more difficult to access, far from obvious anthropogenic influence such as roadways, bridges, and recreational areas, had well developed riparian zones, good flow, and clear water.

2.1.2 Sampling method

I sampled the sites on warm days with good overall weather, beginning the first collection at noon. The sampling dates for sites D1, D2, D3, U1, and U2 are respectively as follows: July 2, 2016, July 6, 2016, July 18, 2016, July 2, 2016, and July 18, 2016. I used the standard Surber sampler method to collect aquatic macroinvertebrates, replicating the collection four times at each of the sites for a total of twenty samples. I preserved each collection in its own labeled jar containing 70% ethanol. I identified each insect to family under a dissecting light microscope in the laboratory.

2.2 Laboratory methods

2.2.1 Determining %EPT

For each of the twenty samples, I summed the total number of Ephemeroptera, Plecoptera, and Trichoptera individuals and divided that by the total number of insects in the sample. I multiplied that number by 100 to get a percentage:

$$\%EPT = \frac{n_i}{N} \times 100$$

where n_i equals the total number of EPT specimens and N equals the total number of specimens in the sample. I calculated the average %EPT for disturbed and undisturbed sites.

Determining FBIBI

I used Hilsenhoff's family based index of biotic integrity. Assigned tolerance values for each family can be found in Appendix 1 of Hilsenhoff's (1988) publication.

$$FBIBI = \frac{\Sigma n_i x t_i}{N}$$

where n_i equals the number of specimens within a family, t_i equals the assigned tolerance value for that family, and N equals the total number of specimens in the sample. I calculated the average FBIBI for disturbed and undisturbed sites.

2.2.2 Classifying functional feeding groups

I classified each macroinvertebrate family based on its functional feeding group, categorizing specimens as predator, shredder, collector, or grazer, for each of the five sites[13].

2.2.3 Statistical analysis

I conducted a t-test in Microsoft Excel to evaluate significant differences ($p<0.05$) in %EPT and FBIBI between disturbed and undisturbed sites, as well as t-tests to evaluate significant differences ($p<0.05$) in total abundance and abundance within each functional feeding group between disturbed and undisturbed sites.

3. Results

Percent EPT and FBIBI did not differ significantly ($p>0.05$) between disturbed and undisturbed sites (Figure 1, Figure 2). The number of grazers and the total abundance of aquatic macroinvertebrates were significantly greater for undisturbed sites (Table 1, Figure 3).

3.1 Mean %EPT

Disturbed site 2 had the highest %EPT, 74.4% (Table 1). Undisturbed site 1 had the lowest %EPT, 59.3% (Table 1). Overall mean %EPT was higher in disturbed sites compared to undisturbed sites (D=67.7±7.56%; U=66.7±10.5%, Figure 1); however, the difference was not statistically significant ($p=0.909$). Percent EPT taxa richness values greater than 41, 31, and 27% indicate excellent quality water in mountain, piedmont, and coastal streams, respectively (Lenat 1988).

Table 1. %EPT for individual sites.

Site	%EPT
Disturbed 1	69.2%
Disturbed 2	74.4%
Disturbed 3	59.5%
Undisturbed 1	59.3%
Undisturbed 2	74.2%

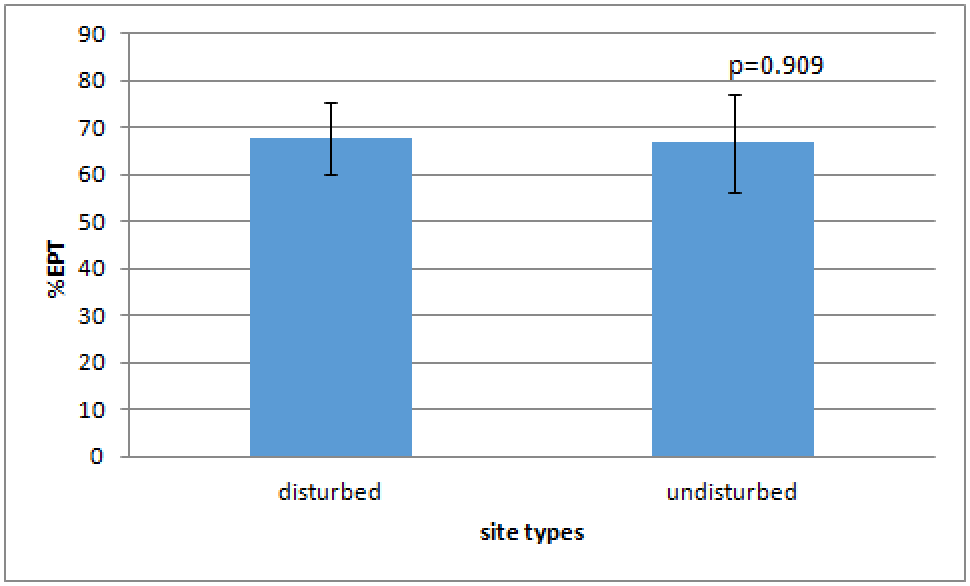

Figure 1. Mean %EPT for disturbed and undisturbed site types with standard deviation. Difference between disturbed and undisturbed sites was not statistically significant.

3.2 Mean FBIBI

The lowest FBIBI, meaning the site with the most pollution intolerant families, was 2.37 at Undisturbed site 1 (Table 3). The highest FBIBI was 3.15 in Undisturbed site 2 (Table 3). The mean FBIBI value for undisturbed sites was lower relative to disturbed sites (D=2.83±0.275%; U=2.76±0.548%, Figure 2); however, the difference was not significant ($p=0.854$). FBIBI values of 0.0-3.75 suggest excellent water quality; 3.76-4.25 very good; and 4.26-5.00 good water quality. All disturbed and undisturbed sites fell within the excellent water quality parameter described in Hilsenhoff's publication[9].

Table 2. Aquatic macroinvertebrate families found in all site types.

Perlidae	Polycentropodidae
Hydropsychidae	Potamanthidae
Tipulidae	Grynidae
Psephenidae	Empididae
Hemiphlebioidae	Ephemeridae
Tabanidae	Potamanthidae
Gomphidae	Psychidae
Phrydaneidae	Chironomidae
Tricorythidae	Chloroperlidae
Corydalidae	Nemouridae
Isoperla	Dryopidae
Brachycentridae	Oligoneuriidae
Astacoidae	Brachyptera
Peltoperlidae	Leuctra
Coptomomus	Pteronarcyidae

Table 3. FBIBI for individual sites.

Site	FBIBI
Disturbed 1	2.85
Disturbed 2	3.10
Disturbed 3	2.55
Undisturbed 1	2.37
Undisturbed 2	3.15

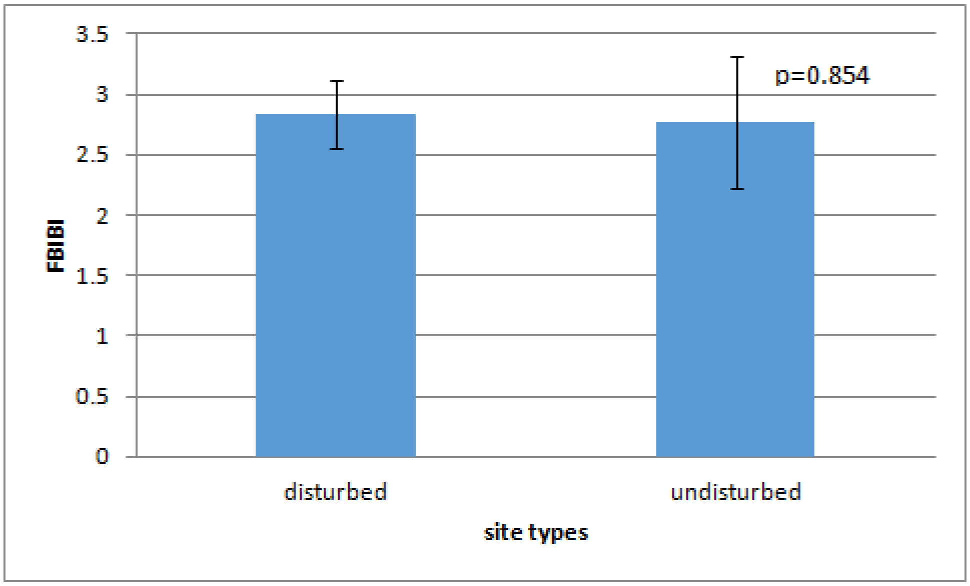

Figure 2. Mean FBIBI for disturbed and undisturbed sites with standard deviation. Difference between disturbed and undisturbed sites was not significant.

3.2 Functional feeding groups

Total abundance and number of grazers were both significantly higher in undisturbed sites relative to disturbed sites (Table 1, Figure 3).

Table 1. Mean total abundance and mean abundance within functional feeding groups for disturbed and undisturbed sites with *t*-test. P values >0.05 not statistically significant.

Site Type	# predators	# shredders	# collectors	# grazers	Total abundance
Disturbed	62	50	30	21	160
Undisturbed	74	11	92	39	216
T-test p value	0.354	0.355	0.317	0.040	0.013

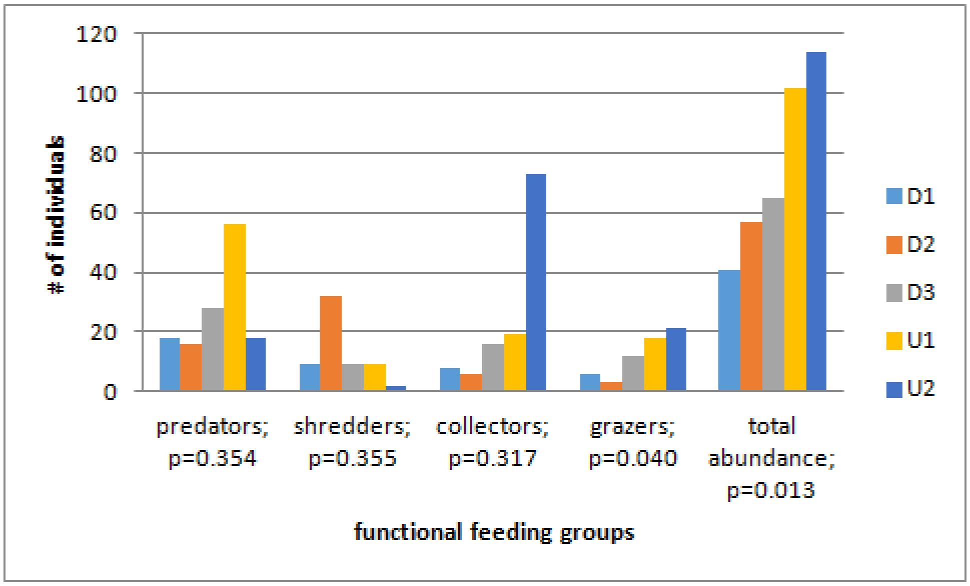

Figure 3. Number of specimens within each functional feeding group per site. T-tests show significant difference ($p<0.05$) in total abundance and number of grazers between disturbed and undisturbed locations.

4. Discussion

Using bioassessment as an indicator of water quality, the results of this experiment suggest overall excellent quality waters within the Flat Brook watershed, even in areas with moderate anthropogenic disturbance. The pristine state of these surface waters based on bioassessment represent positive ecological impacts of the Flat Brook watershed's protections. The Flat Brook watershed is exemplary of the Clean Water Act's success and the importance of its enactment.

4.1 %EPT and FBIBI

These results fail to reject null hypotheses 1 and 2 for %EPT and FBIBI. The site types both fell within Lenat's[10] excellent water quality class designation, and %EPT did not significantly differ between disturbed and undisturbed sites ($p=0.909$, Figure 1). Both undisturbed and disturbed sites had excellent biotic index ranges and did not significantly differ ($p=0.854$, Figure 2).

These results could suggest that the moderate levels of anthropogenic disturbance observed in the disturbed sites do not have a significant harmful effect on water quality. Disturbed sites 1 and 2 were disturbed by bridges crossing over the water. Bridges can cause increased instantaneous discharge, increased turbulent flow by excess sediment, and heightened bank erosion in streams[17]. However, a well-developed riparian zone can effectively reduce the entrance of upslope pollution into waterways[16]. Both disturbed sites 1 and 2 had diverse, well-developed riparian zones, which could have mitigated the effects of pollution caused by the bridges.

Disturbed site 3 was directly adjacent to a popular day-use and camping area, putting the location at risk for moderate anthropogenic disturbance and pollution such as litter, oil, and sedimentation. However, the excellent %EPT and FBIBI designations for this site suggest minimal degradative effects of camping on water quality. Similar to disturbed sites 1 and 2, a well-developed riparian zone could mitigate the entrance of pollution into the stream; however, several of the campsites are situated directly on the stream, where a riparian zone is completely absent. The maintenance of excellent quality water in this location, then, is due to other factors like minimal levels of or benign types of anthropogenic disturbance.

4.2 Functional feeding groups

The total abundance of aquatic macroinvertebrates was significantly greater in undisturbed locations ($p=0.013$, Figure 3). In addition, the number of grazers was significantly greater in undisturbed locations ($p=0.040$, Figure 3). Because both disturbed and undisturbed sites had excellent %EPT and FBIBI designations, factors not directly related to anthropogenic disturbance are likely to account for the significant difference in functional feeding groups. Separation by functional feeding guilds reflects the different feeding niches filled by aquatic macroinvertebrate families; thus, the higher abundance of aquatic macroinvertebrates in undisturbed locations could be attributed to greater resource availability relative to the disturbed locations.

Shredders, including crane flies, some caddisflies, and stoneflies utilize coarse organic matter (CPOM) and convert it to fine particulate organic matter (FPOM) and dissolved organic matter (DOM). CPOM is comprised mostly of vascular plant tissue or leaves[7,1]. The higher abundance of shredders in disturbed sites (50, Figure 3) relative to undisturbed sites (11, Figure 3), might suggest the disturbed locations receive more allochthonous input. However, the difference is not statistically significant ($p=0.355$), so this is a loose assumption.

Cummins et al. [5] observed an increased abundance of collectors when shredders were in high abundance, due to the increase in FPOM availability as shredders convert CPOM. Collectors, which include black flies, spinning caddisflies, some mayflies, and midges collect dead organisms, detritus, and suspended food particles. Undisturbed sites had higher abundance of collectors (92, Figure 3) relative to disturbed sites (30, Figure 3). This might suggest greater availability of FPOM in disturbed sites for collectors to utilize, though the difference in abundance was not statistically significant ($p=0.317$).

Predators collected in this study included dobson flies and dragon flies, and they may reduce CPOM processing by predating upon other aquatic macroinvertebrates that utilize CPOM[15]. Predators were in high abundance in undisturbed sites (74, Figure 3), where a low abundance of shredders was also observed (11, Figure 3). The difference in abundance of predators between disturbed (62, Figure 3) and undisturbed locations (11, Figure 3) was not statistically significant ($p=0.354$).

The number of grazers collected from undisturbed locations (21, Figure 3) was significantly greater ($p=0.040$) than the number collected from disturbed locations (39, Figure 3). Grazers, which include water pennies, some caddisflies, midges, and mayflies scrape algal film from substrate. Grazer food resources are proliferated by algal production; thus food availability is driven and limited by light penetration and nutrients in the water[6]. The undisturbed locations might be more highly productive than the disturbed locations due to higher light penetration and more highly nutrified water. These conditions would create more algae to be utilized by grazers, accounting for their significantly greater abundance in undisturbed locations.. Overall, the significantly higher abundance of total aquatic macroinvertebrates in the undisturbed locations suggest greater and more diverse resource availability to be utilized by the members of the different functional feeding groups.

4.3 Future research

Each of the sites in this study were classified as having excellent quality waters, despite the disturbed locations having some amount of anthropogenic influence. Studies assessing the effects of different levels and types of anthropogenic disturbance on water quality would be beneficial. The Flat Brook watershed is apparently in pristine condition; and managers should strive to avoid excessive anthropogenic disturbances which could deteriorate the watershed's quality.

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