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A Modification of the Biotic Index of Organic Stream Pollution to Remedy Problems and Permit Its Use Throughout the Year

William L. Hilsenhoff
University of Wisconsin

A MODIFICATION OF THE BIOTIC INDEX OF ORGANIC STREAM POLLUTION TO REMEDY PROBLEMS AND PERMIT ITS USE THROUGHOUT THE YEAR[1]

William L. Hilsenhoff[2]

ABSTRACT

The biotic index of the arthropod fauna of streams is modified by limiting to ten the number of individuals in each taxon used in its calculation. This reduces detrimental effects on the index of certain fairly tolerant taxa in clean streams, effects of a few tolerant taxa in somewhat polluted streams, and the effect of our inability to identify larvae in some insect genera to species. It also greatly reduces seasonal variability, allowing use of the biotic index throughout the year with only a minimal decrease in the sensitivity of the index during the summer months. The EPT index was highly variable and exhibited seasonal variation in most of the streams.

Because previous experience suggested that stream arthropod communities can be readily recognized in the field by their dominant genera, I initiated a study in June 1972 to develop a rapid, objective method for evaluating water quality by relating it to the arthropod community structure as recognized by dominant genera (Hilsenhoff 1977). Twenty-nine Wisconsin streams that were presumed to be undisturbed by human activities were sampled in late June, early September, and November, 1972, and early May, 1973. Twenty-four streams with known sources of pollution were similarly sampled from June 1973 through May 1974. These 53 diverse streams were selected to be representative of streams throughout Wisconsin. Samples were collected with a D-frame net from riffles and with artificial substrate samplers (Hilsenhoff 1969) from runs or deep riffles. Contents of the net or sampler were placed in a shallow pan with water, and live arthropods were removed for 20 minutes; no more than 25 individuals of dominant genera were removed for inclusion in each sample, which averaged 120 arthropods. Results (Hilsenhoff 1977) revealed that classification of streams by their arthropod communities was not possible because 52 different community structures existed among the 53 study streams. Samples were therefore evaluated with a diversity index (Wilhm and Dorris 1968, Weber 1973) and with a modification of the biotic index (Chutter 1972) that used only arthropods. The diversity index was ineffective and rejected because it evaluated many pristine streams as being polluted because of low diversity. The biotic index, however, worked very well, and a biotic index (BI) based on a collection of 100+ insects, amphipods, and isopods from a riffle, or from a run or a snag in rapid

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[2]Department of Entomology, University of Wisconsin, Madison, WI 53706.

current if no riffle was present, was proposed (Hilsenhoff 1977). Each arthropod species or genus was assigned a tolerance value of 0 (intolerant) to 5 (tolerant), the BI being the average of tolerance values of all individuals in the sample. Revised procedures and tolerance values were published after additional research, and after use of the BI by the Wisconsin Department of Natural Resources (DNR) to evaluate spring and fall samples from 1,018 stream sites (Hilsenhoff 1982). Further analysis of the 2,036 DNR samples and additional studies resulted in further revision of tolerance values using a scale of 0–10 for greater precision, and assignment of tolerance values to several additional species (Hilsenhoff 1987). The BI primarily measures effects of oxygen depletion resulting from organic or nutrient pollution. However, I have also found it to be sensitive to effects of impoundments, pollution from heated discharges, and some types of chemical pollution, the latter reducing numbers as well as diversity.

In summer, streams are warmer and contain less dissolved oxygen; often water levels are also low. Many insects that require high levels of dissolved oxygen for larval survival (intolerant species) have evolved to pass this stressful period as eggs or diapausing larvae, which require lower levels of dissolved oxygen. This results in about a five to six week period in late spring or summer when BI values are abnormally high in most streams (Figures 1 and 2). I recommended (Hilsenhoff 1977) that use of the BI should be restricted to spring and autumn, which limited its usefulness. An effort to provide a correction factor for these abnormal samples (Hilsenhoff 1988) was not entirely satisfactory, and sampling in early spring, late summer, or autumn was recommended. Also, sampling after 1 November was not recommended because BI values were abnormally low in cold-water streams and abnormally high in warm-water streams (Figures 1 and 2).

Other factors that influence the BI must also be considered. Drift of small numbers of intolerant arthropods from tributaries may lower BI values in larger polluted streams, especially from late autumn to early spring when the water is cold. On the other hand, many ubiquitous tolerant species inhabit both pristine and polluted streams year around, but are usually much less abundant than intolerant species in unpolluted streams. Therefore, BI values are rarely less than 2 or as great as 10. Another problem with the BI exists in some clean streams where some fairly tolerant species inhabit riffle substrates in large numbers (especially *Gammarus pseudolimnaeus* and species of Elmidae, Simuliidae, and Chironomidae), causing abnormally high BI values. Large numbers of tolerant species, especially *Simulium vittatum* and *Caecidotea (=Asellus) intermedia*, also may cause unusually high BI values in November in "fair to "fairly poor" streams. Also, larvae in many insect genera cannot be identified to species, and generic tolerance values must be used. In some of these genera, such as *Cheumatopsyche*, the different species apparently have a wide range of tolerance values. Substantial numbers of larvae of a species that can be identified only to genus will cause the BI to be shifted toward the generic tolerance value (usually 4 or 5).

In 1994 Lillie and Schlesser proposed using a mean tolerance value ("TBI") as an additional metric to evaluate streams. To calculate the TBI they added tolerance values of all taxa and divided by the number of taxa; in the BI, tolerance values of all individuals are added and divided by the number of individuals. They compared the TBI and "HBI" (Hilsenhoff biotic index) from 3 replicate samples collected in the spring and fall of three consecutive years from Rattlesnake Creek, and additional samples from six different riffles on three spring and fall dates. In this stream the TBI was consistently lower than the HBI; TBI values for fall 1988 averaged 0.90 lower than HBI values (5.61 vs 6.51), suggesting a less polluted stream. An impor-

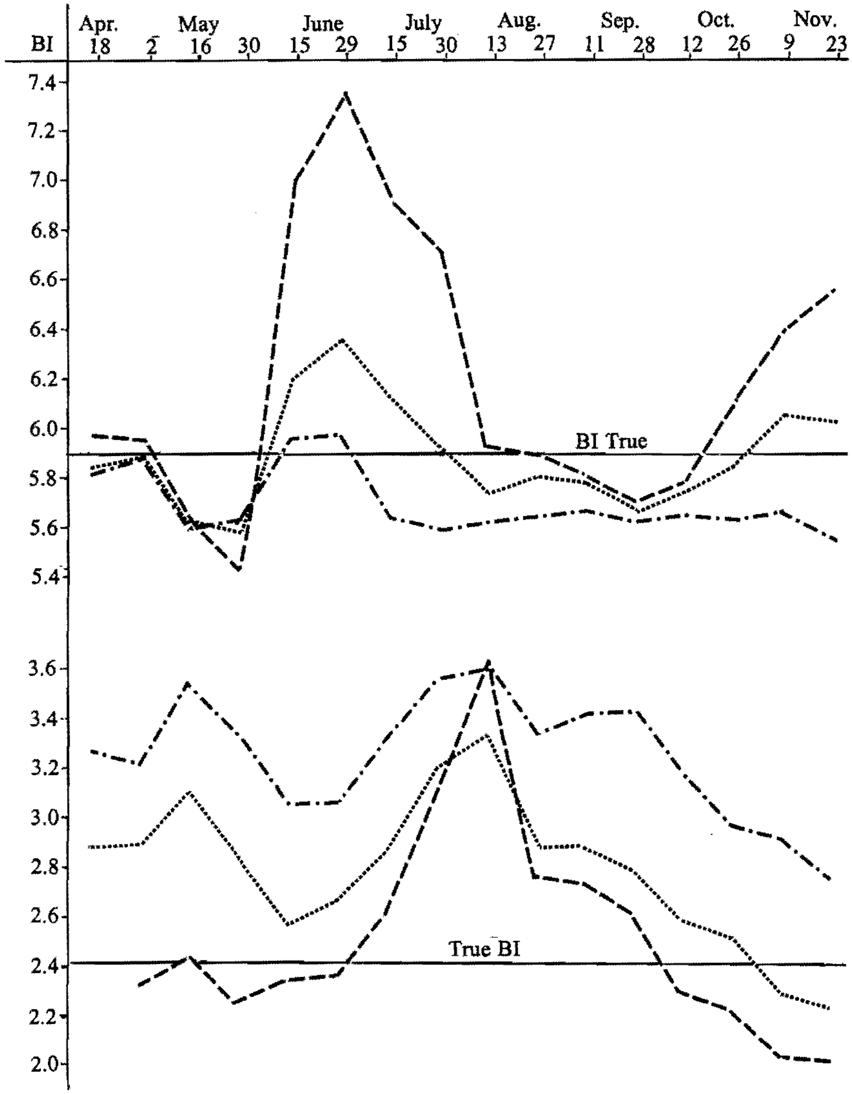

Figure 1. The mean BI (dashes), 10-Max BI (dots), and TBI (dashes and dots) for clean streams (below) and polluted streams (above) compared with the True BI in 1984.

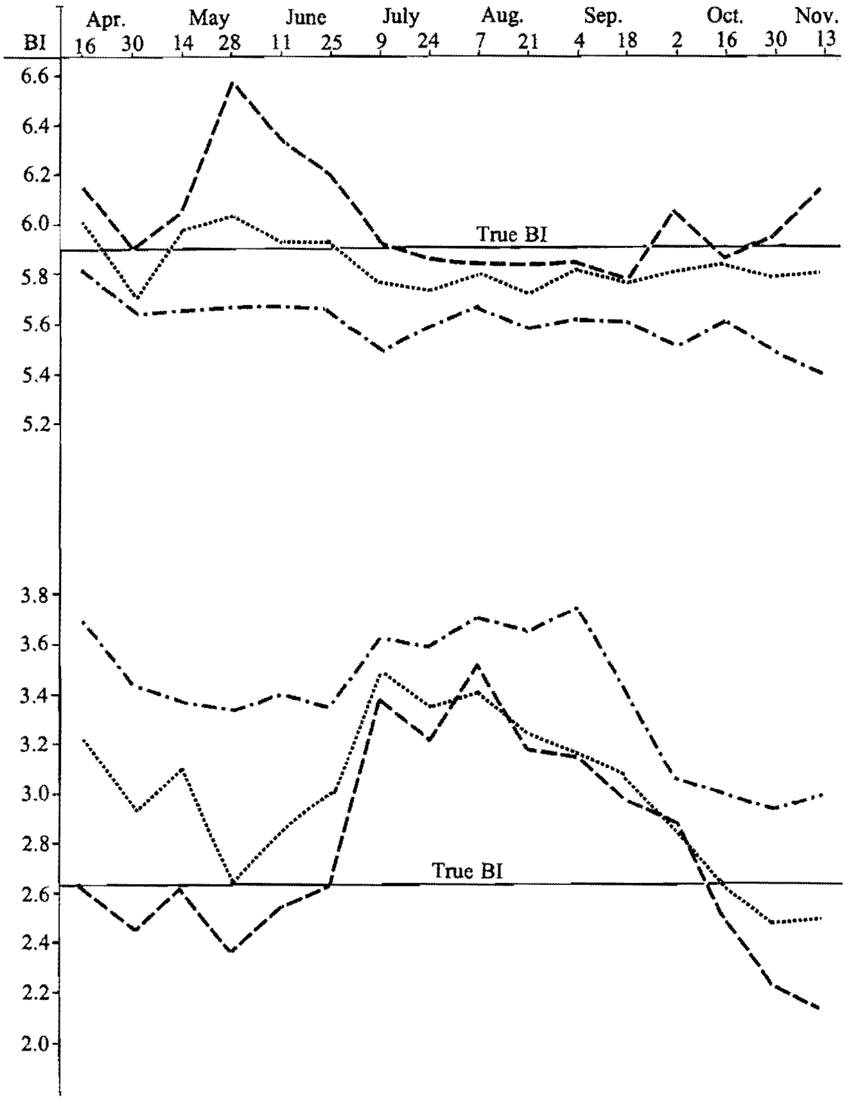

Figure 2. The mean BI (dashes), 10-Max BI (dots), and TBI (dashes and dots) for clean streams (below) and polluted streams (above) compared with the True BI in 1985.

tant discovery, however, was that the TBI had much less temporal variability than the HBI, suggesting it could be used to evaluate summer samples.

Prior to publication I reviewed their manuscript, consulted with Richard Lillie, and applied the TBI to one of my own data sets. The TBI had a distinct advantage over the HBI (=BI) by reducing seasonal variability, but unfortunately it was less sensitive, often judging clean streams to be somewhat polluted and polluted streams to be less polluted. I believed, however, that the BI could be improved by limiting to some number greater than 1, the number of individuals in each taxon used to calculate the BI, thus minimizing seasonal variation, limiting the effect of somewhat tolerant species that are often abundant in clean streams, limiting the effect of tolerant species that are sometimes abundant in only "fairly polluted" streams, and reducing the impact of generic tolerance values when species cannot be identified.

METHODS

More than 100 arthropods had been collected from three different riffles in each of six streams in southern Wisconsin at two-week intervals from April to November in 1984 and 1985 to provide a summer correction factor for the BI (Hilsenhoff 1988). Two were unpolluted, spring-fed, second or third order streams, Otter Creek being a woodland stream and Trout Creek flowing through open country. The Sugar River and Narrows Creek, another woodland stream, were third order streams that were polluted to different degrees by pasturing of cattle. Badfish Creek was a third order stream that received effluent from the Madison Metropolitan Sewerage District, and the West Branch of the Pecatonica River was a second order stream 2 km downstream from the Cobb sewage treatment plant and 50 m downstream from an area where cattle and hogs often frequented the stream. I used this large data set to compare the BI with BI values using a maximum of 5, 10, or 25 individuals in each taxon (5-Max BI, 10-Max BI, 25-Max BI) and with the TBI (1 individual in each taxon). In this data set I believe the "True BI" for each stream is the mean yearly BI, excluding the three consecutive late spring or summer dates having the highest BI values (summer stress period) and November dates (two in 1984, one in 1985). These are the times of the year when use of the BI was not recommended (Hilsenhoff 1988). The summer stress period for warm-water streams included the 15 June to 15 July, 1984 sampling dates and three consecutive dates between 14 May and 25 June 1985; for cold-water streams it included the 30 July to 27 August 1984 sampling dates and three consecutive dates between 9 July and 4 September 1995 (Figures 1 and 2). Thus, 11 dates were used to calculate the True BI in 1984 and 12 dates in 1985.

For each year (16 dates) I compared the standard deviation among replicates (SD), the SD of means for each date, and the yearly mean with the True BI (Table 1). I compared means of all values for the two clean streams (Trout and Otter creeks) and the four polluted streams (others), and these means with the True BI (Table 2). Deviations of mean yearly index values from 3.5, the upper limit for BI values in "excellent" streams, were also compared (Table 3). Most important was a comparison of the mean deviation from the True BI (without regard for + or – signs), of the BI, the BI with three different taxon limits, and the TBI for all dates each year (Table 4). In addition, mean deviations from the True BI of the three high summer samples were compared (Table 5). Mean BI, 10-Max BI, and TBI values for clean streams (Otter and Trout creeks) and polluted streams (other 4 streams) in 1984 and 1985 are compared with the mean True BI in Figures 1 and 2.

Table 1. Yearly mean, standard deviation (SD), and SD between dates for the BI, BI with three different taxon limits, and TBI for six streams. Bold values are means closest to the True BI and lowest SDs.

Stream	Year		BI	25-Max	10-Max	5-Max	TBI
Otter Creek	1984	Mean	**2.60**	2.61	2.61	2.65	2.84
True BI = 2.57		SD	0.21	0.19	**0.16**	0.19	0.15
		SD Date	0.51	0.47	0.32	0.30	**0.23**
	1985	Mean	**2.62**	**2.62**	2.67	2.69	2.90
True BI = 2.40		SD	0.27	0.27	0.22	**0.19**	0.26
		SD Date	0.68	0.65	0.55	0.54	**0.40**
Trout Creek	1984	Mean	**2.41**	2.71	3.01	3.26	3.72
True BI = 2.25		SD	0.32	0.24	**0.23**	0.28	0.24
		SD Date	0.49	0.39	0.36	0.37	**0.33**
1985		Mean	**2.92**	3.06	3.30	3.56	3.89
True BI = 2.84		SD	0.37	0.29	0.21	**0.18**	0.23
		SD Date	0.54	0.44	0.30	0.29	**0.27**
Sugar River	1984	Mean	5.19	5.10	5.10	**5.09**	5.14
True BI = 4.77		SD	0.28	0.22	**0.16**	0.17	0.22
		SD Date	0.65	0.59	0.33	0.28	**0.21**
	1985	Mean	5.51	5.52	**5.39**	5.29	5.15
True BI = 5.42		SD	0.23	0.22	0.18	**0.16**	0.19
		SD Date	0.38	0.29	0.20	0.17	**0.16**
W. Br. Pecatonica River	1984	Mean	6.10	5.85	**5.62**	5.50	5.35
True BI = 5.71		SD	0.26	0.21	**0.16**	0.17	0.17
		SD Date	0.93	0.59	0.26	0.21	**0.18**
	1985	Mean	5.78	**5.65**	5.55	5.48	5.44
True BI = 5.66		SD	0.29	0.21	0.17	**0.13**	0.16
		SD Date	0.42	0.27	0.17	**0.15**	0.17
Narrows Creek	1984	Mean	6.55	**6.39**	6.09	5.94	5.76
True BI = 6.34		SD	0.18	**0.16**	0.20	0.22	0.24
		SD Date	0.49	0.31	**0.23**	0.27	0.25
	1985	Mean	**6.23**	6.18	6.02	5.86	5.69
True BI = 6.23		SD	0.21	0.18	**0.16**	0.18	0.19
		SD Date	0.40	0.32	0.25	0.21	**0.19**
Badfish Creek	1984	Mean	6.93	6.84	**6.75**	6.67	6.54
True BI = 6.74		SD	0.16	0.12	0.10	**0.09**	0.16
		SD Date	0.36	0.24	**0.17**	0.18	0.20
	1985	Mean	6.57	6.54	**6.42**	**6.32**	6.13
True BI = 6.37		SD	0.13	**0.10**	0.11	0.13	0.17
		SD Date	0.42	0.33	**0.30**	0.31	**0.30**
Mean Standard Deviation			0.24	0.20	**0.17**	**0.17**	0.20
Mean Standard Deviation Between Dates			0.52	0.41	0.29	0.27	**0.24**

Because it is frequently used, I also recorded the EPT index for each sample (Lenat 1988), which is the number of species of Ephemeroptera, Plecoptera, and Trichoptera in the sample. The EPT index of each replicate and means for the 16 dates were compared. Seasonal differences were evident, so mean EPT's of spring, summer, and autumn samples were also compared

Table 2. Deviations from the True BI of yearly means for the BI, the BI with three different taxon limits, and the TBI for six streams. Lowest deviations are in bold type. Means for each stream, for clean streams (Otter Cr. and Trout Cr.) and for polluted streams (other 4 streams) are without regard for sign.

Stream	Year	BI	25-Max	10-Max	5-Max	TBI
Otter Creek	1984	**+0.03**	+0.04	+0.04	+0.08	+0.27
	1985	**+0.22**	**+0.22**	+0.27	+0.29	+0.50
	Mean	**0.12**	0.13	0.15	0.18	0.38
Trout Creek	1984	**+0.16**	+0.46	+0.76	+1.01	+1.47
	1985	**+0.08**	+0.22	+0.46	+0.72	+1.05
	Mean	**0.12**	0.34	0.61	0.86	1.26
Sugar River	1984	+0.42	+0.33	+0.33	**+0.32**	+0.37
	1985	+0.09	+0.10	**–0.03**	–0.13	–0.27
	Mean	0.25	0.21	**0.18**	0.22	0.32
W. Br. Pecatonica River	1984	+0.39	+0.14	**–0.09**	–0.21	–0.36
	1985	+0.12	**–0.01**	–0.11	–0.18	–0.22
	Mean	0.25	**0.07**	0.10	0.19	0.29
Narrows Creek	1984	+0.21	**+0.05**	–0.25	–0.40	–0.58
	1985	**0.00**	–0.05	–0.21	–0.37	–0.54
	Mean	0.10	**0.05**	0.23	0.38	0.56
Badfish Creek	1984	+0.19	+0.10	**+0.01**	–0.07	–0.20
	1985	+0.20	+0.17	**+0.05**	**–0.05**	–0.24
	Mean	0.19	0.13	**0.03**	0.06	0.22
Mean clean streams		**0.12**	0.23	0.38	0.52	0.82
Mean polluted streams		0.20	**0.12**	0.13	0.22	0.35

Table 3. Deviation each year from 3.5 of yearly means for the BI, the BI with three different taxon limits, and the TBI for six streams. The mean deviation of clean streams (Otter Cr. and Trout Cr.) and polluted streams (other 4 streams).

Stream	Year	BI	25-Max	10-Max	5-Max	TBI
Otter Creek	1984	–0.90	–0.89	–0.89	–0.85	–0.66
	1985	–0.88	–0.88	–0.83	–0.81	–0.60
Trout Creek	1984	–1.09	–0.79	–0.49	–0.24	+0.22
	1985	–0.58	–0.44	–0.20	+0.06	+0.39
Sugar River	1984	+1.69	+1.60	+1.60	+1.59	+1.64
	1985	+2.01	+2.02	+1.89	+1.79	+1.65
W. Br. Pecatonica River	1984	+2.60	+2.35	+2.12	+2.00	+1.85
	1985	+2.28	+2.15	+2.05	+1.98	+1.94
Narrows Creek	1984	+3.05	+2.89	+2.59	+2.44	+2.26
	1985	+2.73	+2.68	+2.52	+2.36	+2.19
Badfish Creek	1984	+3.43	+3.34	+3.25	+3.17	+3.04
	1985	+3.07	+3.04	+2.92	+2.82	+2.63
Mean deviation clean streams		–0.86	–0.75	–0.60	–0.46	–0.16
Mean deviation polluted streams		+2.61	+2.51	+2.37	+2.27	+2.15

Table 4. Mean deviation of 16 dates each year from the True BI of the BI, the BI with three different taxon limits, and the TBI for six streams. Smallest deviations are in bold type. Mean deviations for clean streams (Otter Cr. and Trout Cr.), polluted streams (other 4 streams), and all streams are also included.

Stream	Year	BI	25-Max	10-Max	5-Max	TBI
Otter Creek	1984	0.40	0.37	**0.26**	**0.26**	0.30
	1985	0.50	0.50	0.50	**0.49**	0.55
	Mean	0.45	0.44	0.38	**0.37**	0.42
Trout Creek	1984	**0.36**	0.49	0.76	1.01	1.47
	1985	0.51	**0.39**	0.49	0.72	1.04
	Mean	**0.43**	0.44	0.62	0.86	1.25
Sugar River	1984	0.64	0.50	0.40	0.40	**0.38**
	1985	0.31	0.25	0.18	**0.15**	0.27
	Mean	0.48	0.38	0.29	**0.28**	0.33
W. Br. Pecatonica River	1984	0.72	0.44	0.28	**0.25**	0.36
	1985	0.33	0.21	**0.18**	0.20	0.25
	Mean	0.52	0.32	0.23	**0.22**	0.30
Narrows Creek	1984	0.40	**0.25**	0.29	0.42	0.58
	1985	0.32	0.26	**0.23**	0.37	0.54
	Mean	0.36	**0.26**	**0.26**	0.40	0.56
Badfish Creek	1984	0.31	0.20	**0.14**	0.16	0.24
	1985	0.33	0.27	**0.25**	0.27	0.33
	Mean	0.32	0.24	**0.20**	0.22	0.29
Mean clean streams		**0.44**	**0.44**	0.50	0.61	0.83
Mean polluted streams		0.42	0.30	**0.24**	0.28	0.37
Mean all streams		0.43	0.35	**0.33**	0.39	0.53

(Table 6). Because spring in 1985 was unusually warm and summer arrived two weeks early (Hilsenhoff 1988), six sampling dates were averaged in spring 1984 and summer 1985; other seasonal averages were for five dates.

RESULTS AND DISCUSSION

The True BI was most closely approached by the yearly mean of the BI in clean streams (Otter and Trout creeks) and by yearly means of the 10-Max BI and 25-Max BI in polluted streams (Tables 1 and 2). In clean streams, BI values increased and in polluted streams they decreased as lower numbers of each taxon were used in calculations (Table 2), causing index values to approach 3.5 (Table 3), the point at which the BI separates "excellent" streams from "very good" streams (Hilsenhoff 1987), with values for Trout Creek even exceeding 3.5 in the 5-Max BI and the TBI. This is because intolerant arthropod species (tolerance values 0–3) predominate and are often abundant in clean streams, while in polluted streams tolerant arthropod species (tolerance values 5–10) predominate and are often abundant. It is these abundant species that have the greatest impact on the BI and increasingly less impact as smaller numbers are used in the calculation. The impact of using smaller numbers is often greatest in small streams (first order) and streams in open

Table 5. Mean deviation from the True BI of the three high summer dates for the BI, the BI with three different taxon limits, and the TBI for six streams. Smallest deviations are in bold type. Mean deviations for clean streams (Otter Cr. and Trout Cr.), polluted streams (other 4 streams), and all streams are also included.

Stream	Year	BI	25-Max	10-Max	5-Max	TBI
Otter Creek	1984	0.69	0.66	**0.39**	0.40	0.51
	1985	1.28	1.22	0.99	0.88	**0.81**
	Mean	0.99	0.94	0.69	**0.64**	0.66
Trout Creek	1984	**0.85**	0.97	1.15	1.46	1.73
	1985	0.62	**0.61**	0.64	0.95	1.19
	Mean	**0.74**	0.79	0.89	1.21	1.46
Sugar River	1984	1.74	1.16	0.77	0.60	**0.48**
	1985	0.65	0.50	0.16	**0.15**	0.25
	Mean	1.19	0.83	0.47	0.37	**0.36**
W. Br. Pecatonica River	1984	1.91	1.14	0.40	**0.19**	0.51
	1985	0.72	0.35	**0.01**	0.16	0.29
	Mean	1.31	0.74	0.21	**0.17**	0.40
Narrows Creek	1984	0.58	0.28	**0.06**	0.11	0.40
	1985	0.28	**0.26**	0.36	0.52	0.64
	Mean	0.43	0.27	**0.21**	0.31	0.52
Badfish Creek	1984	0.59	0.40	0.23	**0.15**	0.34
	1985	0.83	0.62	0.48	0.37	**0.09**
	Mean	0.71	0.38	0.36	0.25	**0.22**
Mean clean streams		0.86	0.86	**0.79**	0.92	1.06
Mean polluted streams		0.91	0.56	0.31	**0.28**	0.37
Mean all streams		0.89	0.66	**0.47**	0.49	0.60

areas, which have fewer dominant species. This impact was especially great in Trout Creek where *Ephemerella inermis* and *Brachycentrus occidentalis* (tolerance values of 1) were the dominant species. Also, when fewer arthropods were used for calculations, the SD between dates decreased (Table 1), indicating less seasonal variation. In all streams the yearly mean BI was always higher than the True BI (Table 1) because the three highest summer dates were not used in calculating the True BI. An exception was Narrows Creek in 1985, where the BI was the same as the True BI because BI values in late May and June had a minimal increase and those from August through October were much higher, probably because of increased pollution from pasturing of cattle later in the year. Thus, in clean streams the TBI always had the greatest deviation from the True BI while in polluted streams deviations ranged from positive to negative and most closely approached the True BI in the 10-Max BI and 25-Max BI (Table 2). However, since yearly means are often the result of values that are both higher and lower than the True BI (Figures 1 and 2), a better measure is the mean deviation from the True BI of mean BI values (for the three replicates) on each of the 16 dates (Table 4).

Considering all evaluations (Tables 1–4), especially Table 4, the 10-Max BI is the best choice. In addition, the 10-Max BI and 5-Max BI had the lowest SD (0.17) among replicates (Table 1), indicating they were most sensitive to differences in the degree of organic pollution. I believe the 10-Max BI is

Table 6. The EPT index of six streams for two years with high and low values each year for replicates (number in parenthesis) and dates (mean of 3 replicates), and mean EPT values for spring, summer, autumn, and entire year.

		Replicates		Dates		Mean			
Stream	Year	High	Low	High	Low	Spring	Summer	Autumn	Year
Otter Creek	1984	19(3)	9(1)	17.3	10.3	15.0	12.1	14.8	12.0
	1985	19(1)	9(1)	16.3	10.3	15.2	11.2	13.4	13.1
	Mean			16.8	10.3	15.1	11.6	14.1	13.6
Trout Creek	1984	10(4)	2(3)	9.0	3.0	3.9	6.4	7.7	5.9
	1985	10(1)	3(2)	8.3	3.3	5.3	5.0	7.7	6.0
	Mean			8.7	3.2	4.6	5.7	7.7	5.9
Sugar River	1984	12(1)	4(1)	9.7	5.7	7.2	8.7	8.2	8.0
	1985	15(1)	3(1)	13.7	3.7	6.3	9.6	11.9	9.3
	Mean			11.7	4.7	6.7	9.2	10.0	8.6
W. Br. Pecatonica River	1984	6(1)	1(6)	5.3	1.3	2.5	3.2	4.5	3.3
	1985	8(1)	1(8)	6.7	1.0	2.4	3.7	5.1	3.7
	Mean			6.0	1.2	2.4	3.5	4.8	3.5
Narrows Creek	1984	8(1)	1(1)	7.0	2.3	3.8	5.0	3.6	4.1
	1985	8(2)	1(3)	6.7	1.7	4.7	3.9	4.9	4.5
	Mean			6.8	2.0	4.3	4.4	4.3	4.3
Badfish Creek	1984	4(3)	0(3)	3.0	0.3	1.5	1.5	2.7	1.9
	1985	9(1)	0(1)	8.0	0.7	1.4	4.3	6.5	4.1
	Mean			5.5	0.5	1.4	2.9	3.7	3.0

superior to the BI for evaluating polluted streams because it can be used year-around and the yearly mean was close to the True BI (Figs. 1 and 2, Table 4). It also minimizes in all streams some detrimental effects described above. In clean streams, however, mean yearly 10-Max BI values were distinctly higher than those of the BI (Table 2), and were especially high during the summer stress period (Table 5, Figs. 1 and 2). Since most "excellent" streams usually have a BI well below 3.0, the 0.38 mean yearly deviation above the True BI should not affect evaluations. However, if samples are collected during the summer stress period and the 10-Max BI is less than 4.5, one should be aware that 10-Max BI values are likely to be almost as high as BI values (Table 5, Figs. 1 and 2) and as much as 0.8 above the True BI. The TBI was the poorest biotic index for evaluating water quality (as measured by the True BI) throughout the year, especially in clean streams (Tables 2 and 4), and the BI was also poor if used throughout the year.

The EPT index was found to be highly variable between sampling dates (Table 6). It also varied seasonally in most streams, with values often being lowest in spring and highest in autumn; in Otter Creek summer values were lowest and in Narrows Creek summer values were highest in 1984 and lowest in 1985. As with all species richness or diversity indexes, the EPT is strongly influenced by many other factors in addition to pollution. These include stream size, substrate variability, current, water temperature, food resources (allochthonous vs autochthonous), and life cycles. An example of the effect of stream size is provided by two thoroughly-studied streams about 15km apart that flow south out of the Baraboo Hills (80 km north of Madison, WI) through similarly forested State Scientific Areas. Both are spring-fed and unpolluted. Parfrey's Glen Creek is a first order stream that is inhabited by 2 species of Ephemeroptera, 6 species of Plecoptera, and 16 species of Trichoptera (Karl and Hilsenhoff 1980). Otter Creek is a second or third order stream, and it is inhabited by 15 species of Ephemeroptera, 17 species of Plecoptera (Narf and Hilsenhoff 1974), and 52 species of Trichoptera (Steven and Hilsenhoff 1984), 3.5 times as many species as Parfrey's Glen Creek.

RECOMMENDATIONS

1. All procedures for collecting, sorting, and evaluating with the BI (Hilsenhoff 1987) should be followed, including the collection and identification of 100+ arthropods for the sample. I recommend, however, that in taxa having more than 10 individuals, only ten be used for calculation of the biotic index (10-Max BI). This will minimize the effect of our inability to identify species in some genera, effects of certain fairly tolerant species in some clean streams and tolerant species in moderately polluted streams, and permit year-around use of the BI. However, if cleaner streams are sampled during the summer stress period (Hilsenhoff 1988) and found to have a 10-Max BI of 4.5 or less, their True BI values may be as much as 0.8 too high. Sampling at times other than during the summer stress period is always desirable.

2. Although diversity and species richness indexes (including the EPT) are sensitive to pollution, they should not be used to supplement evaluations with the BI because many other factors (listed above) often have a greater impact on these indexes than pollution. They are of value only for comparing similar sites on the same stream, the same stream site from year to year, or streams in which the characteristics mentioned above are the same.

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