Technical Report: Ohio's Primary Headwater Streams- Macroinvertebrate Assemblages

September 2002

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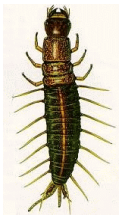

Introduction

This report summarizes macroinvertebrate information collected by Ohio EPA during surveys of primary headwater streams. Primary headwater habitat streams (PHWH) are herein defined by Ohio EPA as surface drainage ways that have a defined stream bed and bank and a watershed area less than 1 mi^2 (633 ac; 2.59 km^2; 256 ha), or with deepest pools less than 40 cm. PHWH streams are precursors to larger streams and rivers in Ohio and have important ecological functions (Ohio EPA, 2002c, 2002a; Meyer and Wallace, 2001; Peterson et al., 2001). Additional technical reports will summarize the vertebrate assemblages (Ohio EPA 2002a) and the chemical/physical and habitat characteristics (Ohio EPA 2002b) of these primary headwater streams.

Aquatic macroinvertebrates are essential components of primary headwater stream habitats. The fact that macroinvertebrates utilize the habitat in perennial streams is well known and widely studied. Minshall (1968) studied the community dynamics of 33 (62 total taxa) of the more common macroinvertebrate taxa in a woodland springbrook in Kentucky. Minshall identified 30 common taxa to the species level but did not identify the fly family Chironomidae (commonly called midges) past the family level. Singh and Harrison (1984) studied the community structure of the 62 species of Chironomidae they collected from a similar stream in southern Ontario.

For the past several years, Ohio EPA has been investigating small primary headwater habitat streams in various ecoregions within Ohio. Macroinvertebrate voucher specimens from selected streams were collected and transported to Ohio EPA's Ecological Assessment Section laboratory for identification of the specimens to the lowest practical taxonomic level. These vouchers were derived from 36 primary headwater streams collected during the spring, summer and fall by Ohio EPA staff. In total, the Ohio EPA has identified 384 macroinvertebrate taxa from streams with a drainage area less than or equal to 1 mi^2 in Ohio. In general, three types of macroinvertebrate assemblages have been identified from primary headwater streams in Ohio:

(1) a surface water community with reproducing populations of three or more taxa of native **coolwater adapted** macroinvertebrates; and

(2) a surface water community with native macroinvertebrate populations dominated by **warmwater adapted** taxa with less than three taxa of coolwater adapted

macroinvertebrate taxa; and

(3) a surface water community with reproducing populations of native **short lived, primarily springtime** macroinvertebrate assemblages.

Those primary headwater streams with evidence of annual reproducing populations of three (3) or more coolwater adapted macroinvertebrate taxa (Tables 2, 3) are referred to as **Class III-PHWH** streams (Ohio EPA, 2002c). Class III streams will harbor warmwater adapted macroinvertebrate species as well, due to the wide temperature tolerance of warmwater adapted macroinvertebrates in Ohio. A defining characteristic of Class III streams is that they are associated with cool groundwater derived flow which is continuous throughout the year, either on the surface of the stream bed or interstitially below or adjacent to the stream bed. These primary headwater streams are often the precursors to streams that are designated Cold Water Habitat in Chapter 3745-1-07 of the Ohio Administrative Code. On average, Class III primary headwater streams have water temperatures less than 20 ^{o}C in summer months (July-August), even in apparently isolated pools of water which are connected by interstitial flow.

Primary headwater streams with macroinvertebrates comprised primarily of warm water adapted taxa are referred to as **Class II-PHWH** streams (Ohio EPA, 2002c). The flow hydraulics of Class II streams are primarily derived from precipitation events including overland flow and shallow subsurface flow, as opposed to the predominately spring-fed aquifer (deep groundwater) origin of the Class III headwater streams. Class II-PHWH streams may have permanent flow or intermittent flow (e.g., isolated pools not apparently connected by interstitial flow), as water is nearly always present, if only in isolated pools. Class II headwater streams may contain coolwater adapted macroinvertebrate taxa but usually harbor fewer than the three taxa that are associated with the Class III designation. The average water temperature of Class II streams is usually greater than 20 ^{o}C during the summer months (July-August).

Primary headwater streams that are normally dry (ephemeral) for extended periods of time, with no evidence of isolated pools of water, are called **Class I-PHWH** streams (Ohio EPA, 2002c). Class I streams may have biology present within the hyporheic zone (hyporheos) or seasonally when water is flowing after snow melt or during extended rain runoff events. Pioneering fish species may also be found during these times of the year. Class I streams are often associated with fine grained, less permeable substrates.

The headwater stream network of watersheds is complex, and the proportions of the three different stream classes differ in various ecoregion areas in Ohio (OSU, 2001). Some drainageways do not have defined stream bed and banks, and thus fall outside the Ohio EPA definition of a PHWH stream. The most common type of primary headwater stream in Ohio is the Class I or "ephemeral" stream (OSU, 2001). Primary headwater streams can abruptly shift stream class, such as when cool spring-fed groundwater intersects a dry stream channel. Other changes in species composition may be gradual, e.g., when a cool Class III stream is sequentially warmed by runoff water and shallow subsurface flows through the drainage network. Yet other primary headwater streams maintain the same stream class and type of biological community throughout their length. Field sampling techniques to distinguish among the different classes of primary headwater streams and more detailed definitions of flow terminology are provided in the Ohio EPA Field Evaluation Manual for

Primary Headwater Streams (Ohio EPA, 2002c).

Primary headwater streams are an important component of the stream continuum concept and inhabit the uppermost reaches of stream systems. These streams can begin as mere swales or drainageways or as perennial flowing "springs". A spring that discharges directly into a channel is termed a rheocrene. Springs that form pools prior to overflowing into a channel are termed limnocrenes. These type of habitats that form defined bed and banks are part of the primary headwater habitat streams investigated by Ohio EPA. Springs that create marshy areas and do not form defined bed and banks are termed helecrenes and are regulated by the Ohio wetland rules. Rheocrenes and limnocrenes form special stream habitats and differ from normal streams by being more uniform in temperature (usually the average ambient air temp) and flow, higher in dissolved carbon dioxide, lower in dissolved oxygen and deposit iron. These habitats are where relics of previous times still occur (Hynes, 1970).

In addition to small streams with perennial flowing water, aquatic macroinvertebrates may also be present in interstitial, intermittent, ephemeral or other apparently "summer dry" streams. Although some streams may appear dry and "lifeless", they can provide for an important and surprisingly diverse community of aquatic macroinvertebrates. Williams and Hynes (1976, 1977) found 55 and 62 aquatic macroinvertebrate taxa in what they termed an ephemeral and an intermittent stream, respectively, in southern Ontario. These streams maintained continuous flow from about October to the end of May and then become either completely dry or sustained a series of isolated pools during the summer. Investigations in a stream in Indiana found the two dominant aquatic macroinvertebrate species in a stream had burrowed as much as 60 cm (23.6 in.) below the surface of a dry stream bed into the damp substrate (Clifford, 1966). The fauna inhabiting these streams have various methods of surviving the dry periods such as a drought resistant cyst, egg, or pupa on or near the stream bed surface; as an immature or larva inhabiting the interstical spaces of the substrates below the stream bed (the hyporheic zone); or as an adult. Other surface watercourses such as typical ephemeral stream channels do not maintain sufficient flow during the year and contain substrates that are not favorable to support a viable population of macroinvertebrates.

The habitat comprising the zone of saturated sediments beneath and adjacent to an active stream channel that is available for aquatic organisms is called the hyporheic zone or ecotone. This zone is the biologically and chemically active interface among the atmosphere, land, surface waters and ground waters. This portion of a stream can provide habitat and rearing area for macroinvertebrates and a stable refugia from disturbance. A study by Williams and Hynes (1974) estimated that 80% of their study stream's fauna (by numbers) was located below 5 cm deep in the substrates. Permeable sediments are essential for a diverse and abundant hyporheic community as found by Williams and Hynes. Stream disturbances such as land use changes and channel modifications can lead to a narrowing and incision of the stream bed and subsequent removal of sediments favorable to a diverse hyporheic community.

Spring fed primary headwater habitat streams are often in close approximation with ground water. As groundwater is usually near the average annual ambient air temperature for a region, these headwater streams are often cooler than larger streams and rivers and contain organisms adapted to the cooler waters. Coolwater macroinvertebrates are taxa that primarily inhabit streams which maintain a summer water temperature below about 20˚C in Ohio. Ohio EPA used the MIDGES

database of macroinvertebrate samples collected from sites across the State to develop a coolwater taxa list for Ohio (Tables 2, 3). Coolwater taxa were, in part, chosen by analysis of the 25th, 50th, and 75th percentile statistics of the number of coolwater taxa at a taxon's collection sites and the 75th percentile of the percent coolwater taxa at the collection sites during the summer collection period (June 15 to September 30). Coolwater taxa generally were expected to have the 25th %ile $\geq$2, 50th %ile $\geq$3, and 75th %ile $\geq$5 for the number of coolwater taxa, and the 75th %ile $\geq$7 for the percent of coolwater taxa at collection sites. Information in the published scientific literature was also considered when assigning taxa to the coolwater list. Some species emerge in the spring and their larvae are not present during the summer collection period. For these taxa, the nature of the collection sites were taken into account along with an analysis of the associated taxa and a review of the scientific literature to determine if the taxa should be included on the coolwater taxa list.

A growing percentage of primary headwater streams in Ohio have been modified by channelization, riparian alteration, mining, agriculture (drainage) and urban development (culverts). Habitat modification to Class II-PHWH streams does not appear to have significant impacts upon macroinvertebrate populations in primary headwater habitat streams once the channel riparian zone has been allowed to recover (Ohio EPA, 2002b). However, the water temperature of coolwater streams can be raised to critical levels when riparian cover is removed, and species adapted to life in cobble-gravel substrate, especially vertebrates, can be eliminated after a stream's channel is dredged, the original stream slope is altered or fine sediment in the system causes the substrates in the stream bed to become severely embedded. Modification of the physical habitat integrity of streams is a major cause of non-attainment of current aquatic life uses in Ohio (Ohio EPA, 2000).

Macroinvertebrate Assessment Methods

Over the past 20 years, the Ohio EPA has used qualitative sampling techniques to evaluate the macroinvertebrate community of 78 streams (116 individual samples) with a drainage area less than or equal to 1 mi^2 throughout Ohio. Qualitative sample methods are detailed in the Ohio EPA (1989) bioassessment users manual. From 1999 to 2000 the Ohio EPA sampled an additional 274 primary headwater streams in different ecoregions of Ohio using rapid bioassessment qualitative techniques. For this survey, 215 primary headwater streams were selected at random from 10 different counties identified as having potential for rapid population growth: Geauga, Medina, Wood, Fulton, Delaware, Union, Butler, Warren, Logan, and Hocking (Fig. 1). Sites were randomly selected from drainage ways identified on NRCS county soil maps.

The following analysis was conducted on select voucher samples from the 1999 and 2000 surveys supplemented by additional seasonal sampling in order to understand the seasonal variation of the fauna. Macroinvertebrate sampling methods followed the procedures found in the Ohio EPA (2002c) headwater stream assessment manual. Macroinvertebrates were collected along a 200 foot stream reach using qualitative kick-netting and hand picking from natural substrates. Macroinvertebrates were identified to various taxonomic levels in the field and relative abundances were noted. Enumeration of readily discernible EPT (mayfly, stonefly, and caddisfly) taxa was also made. This information was recorded on field sheet forms and voucher specimens were collected and preserved at select sites. There were no attempts to collect hyporheos from any of the sites.

Results

Macroinvertebrate Assemblage (qualitative sampling):

Voucher collections from selected macroinvertebrate sampling sites were analyzed by the Ohio EPA Ecological Assessment Section laboratory for identification of the specimens to the lowest practical taxonomic level. These vouchers were derived from 36 primary headwater streams (85 samples) collected by Ohio EPA staff. The collections were made during the spring (40 samples) and summer (39 samples) seasons and in a few cases fall (6 samples) to assess seasonal variability. Forty-six of these samples were from Class III streams, 29 samples from Class II streams, and ten samples from Class I streams. The data are summarized in Table 4.

The macroinvertebrate communities in Class III streams usually supported at least three coolwater taxa (Figs. 3, 5, 6). The Class II streams, for the most part, did not harbor more than two coolwater taxa (Figs. 4, 5, 6). The number of coolwater taxa in a stream reach tended to be highest during the spring and declined as the summer progressed (Figs. 3, 4). Even with this seasonal trend, there remained a good separation between Class II and III streams. A thorough collection from a stream and identification of the sample to the lowest practical level in the laboratory is the most accurate procedure to separate Class II and III streams using the macroinvertebrate assemblage.

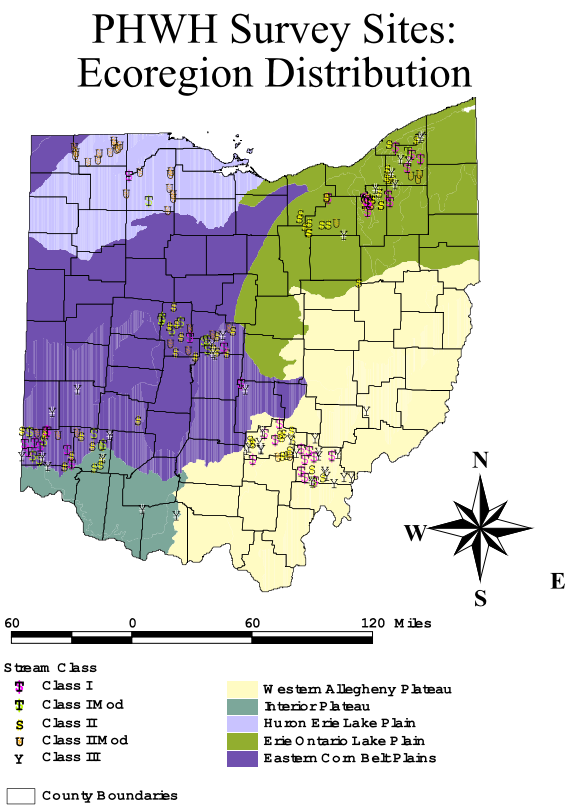

Figure 1. Map of 1999 and 2000 sample locations by ecoregion for primary headwater habitat streams in Ohio.

The indicator lists for Class III and II primary headwater streams (Tables 5 and 6) were constructed by taking the list of all the taxa collected from PHWH streams and indicating how many times each taxa was collected from the Class III and II streams. Taxa that so far have been collected from only one type of stream (with more than one record) or has been collected overwhelmingly from one type of stream were considered as an indicator taxa for that type of stream. These lists are, for the most part, valuable only when a voucher sample is laboratory identified to the lowest practical level. They are, however, a good indication of the different quality of fauna associated with these two classes of streams. The Class III streams have a higher diversity of mayflies, stoneflies, caddisflies, and midges associated with them compared to the Class II streams. The great majority of insects that inhabit PHWH streams have univoltine life histories (require one year to complete their life cycle). Class III streams are sometimes inhabited by species of insects with a semivoltine life history (requires two years to complete their life cycle). Taxa of this type include the dragonfly

Lanthus parvulus (Carle, 1980), the stoneflies *Acroneuria carolinensis* (Schmidt & Tarter, 1985) and *Eccoptura xanthenes* (Allen & Tarter, 1985) and probably the fishfly *Nigronia fasciata* (Wallace & Anderson, 1996).

A less precise, but acceptable, method of separating Class I, II, and III streams is the use of an index that utilizes the level of identification possible in the field. The Ohio EPA developed the Headwater Macroinvertebrate Field Evaluation Index (HMFEI) for use with field level identifications (Table 7). The HMFEI is roughly based on the ODNR Stream Quality Monitoring scoring system with modifications to reflect the faunal composition in headwater streams. In addition to redefining the taxa belonging to the different scoring categories, the new index multiplies each taxa of mayflies, stoneflies, and caddisflies, that are recognizable in the field, by the scoring value of three rather than just once for each group (see HMFEI Scoring Example and Macroinvertebrate Scoring Sheet). The HMFEI is designed on the concept that the cool Class III streams will have a higher diversity of taxa and in particular the groups of taxa (Group 3 Taxa in Table 7) that are usually associated with high quality stream faunas.

The HMFEI is reasonably good at separating Class II and III streams (Fig. 9). To protect for all Class III streams an HMFEI of 12 would have to be used. However, this value is lower than the median of the Class II streams. It is also possible that some of the Class III streams with lower HMFEI scores may have been impaired. A natural break in the percentile curve of Class III streams (Fig. 10) appears at a HMFEI score of 20. Therefore, a HMFEI score of 20 or greater shall be used to catagorize a stream as Class III. In order to separate Class I and II streams, there is a natural break in the Class II streams percentile curve (Fig. 10) at 7. Therefore, a HMFEI score of 7 or greater shall be used to separate a Class II stream from a Class I stream. Primary headwater streams that are ephemeral (predominately dry) and have a HMFEI score of 6 or less are considered to belong to Class I streams.

The HMFEI is the middle tool in a hierarchy of three tools Ohio EPA has developed to evaluate a stream's existing aquatic life use in order to assign a designated use to the water body. The Headwater Habitat Evaluation Index (HHEI) is an evaluation of the physical habitat of the headwater stream (Ohio EPA, 2002 b). The HHEI has conservative factors built into it since it is an evaluation of inanimate features that are used as a surrogate to determine the aquatic life use potentials. The HMFEI is designed to be used with the level of macroinvertebrate identifications possible in the field and is inferior to a thorough voucher sample identified to the lowest practical level in the laboratory. Therefore, it is crucial that a thorough field collection be made and the field biologist conducting the survey have the knowledge and expertise to field identify most macroinvertebrates to at least the family level.

The proportional occurrence of fish, salamanders, frogs, and macroinvertebrates found in the 215 primary headwater streams sampled in year 2000 is given in Table 1. Macroinvertebrates were collected in all 116 (53%) streams with standing or flowing water. Macroinvertebrates were found in all streams that contained vertebrates. Forty-one of the streams sampled (19%) were found to contain macroinvertebrates exclusively. In no instances were vertebrates found without macroinvertebrates. Ninety-nine (46.1%) of the streams contained no evidence of aquatic life at or near the surface of the stream bed. The average watershed size of the headwater streams sampled in 2000 was approximately 0.30 mi^2.

Table 1. Relative proportion of different vertebrate groups and macroinvertebrates from 215 randomly selected primary headwater streams in Ohio. For example, 15 of 215 streams (7%) contained only fish and benthic macroinvertebrate taxa (data from 8th column). Percentages add to 99% due to rounding error.

Fish		X				X	X	X				X	X	X		X
Salamanders			X			X			X	X		X	X		X	X
Frogs				X			X		X		X		X	X	X	X
Invertebrates					X			X		X	X	X		X	X	X
# Streams	**99**	**0**	**0**	**0**	**41**	**0**	**0**	**15**	**0**	**8**	**16**	**13**	**0**	**9**	**9**	**5**
% of Streams	46				19			7		4	7	6		4	4	2

X = Taxa present in a primary headwater stream

Table 2. The macroinvertebrate coolwater taxa list for Ohio.

Crustacea
Gammarus minus
Ephemeroptera
Ameletus sp.
Baetis tricaudatus
Epeorus sp.
Habrophlebiodes sp.
Dannella simplex
Litobrancha recurvata
Odonata
Lanthus parvulus
Plecoptera
Peltoperla sp.
Amphinemura sp.
Soyedina sp.
Leuctra sp.
Eccoptura xanthenes
Megaloptera
Nigronia fasciatus
Trichoptera
Dolophilodes sp.
Wormaldia sp.
Ceratopsyche slossonae
Ceratopsyche ventura
Diplectrona sp.
Parapsyche sp.
Rhyacophila sp. (excluding *R. lobifera*)
Glossosoma sp.
Oligostomis sp.
Frenesia sp.
Goera sp.
Lepidostoma sp.
Psilotreta rufa
Molanna sp.
Diptera
Dicranota sp.
Pedicia sp.
Thaumalea americana
Apsectrotanypus johnsoni
Macropelopia decedens
Meropelopia sp.
Radotanypus florens
Trissopelopia ogemawi
Zavrelimyia sp.
Diptera cont.
Diamesa sp.
Pagastia orthogonia
Odontomesa ferringtoni
Prodiamesa olivacea
Brillia parva
Chaetocladius piger
Corynoneura n. sp. 5
Eukiefferiella devonica group
Heleniella sp.
Heterotrissocladius marcidus
Metriocnemus eurynotus
Parachaetocladius sp.
Parametriocnemus sp.
Psilometriocnemus triannulatus
Rheocricotopus eminellobus
Thienemanniella boltoni
Polypedilum (P.) albicorne
Polypedilum (P.) aviceps
"Constempellina" n. sp. 1
Micropsectra sp.
Paratanytarsus n. sp. 1
"Stempellina" n. sp. 1
Zavrelia n. sp. 1

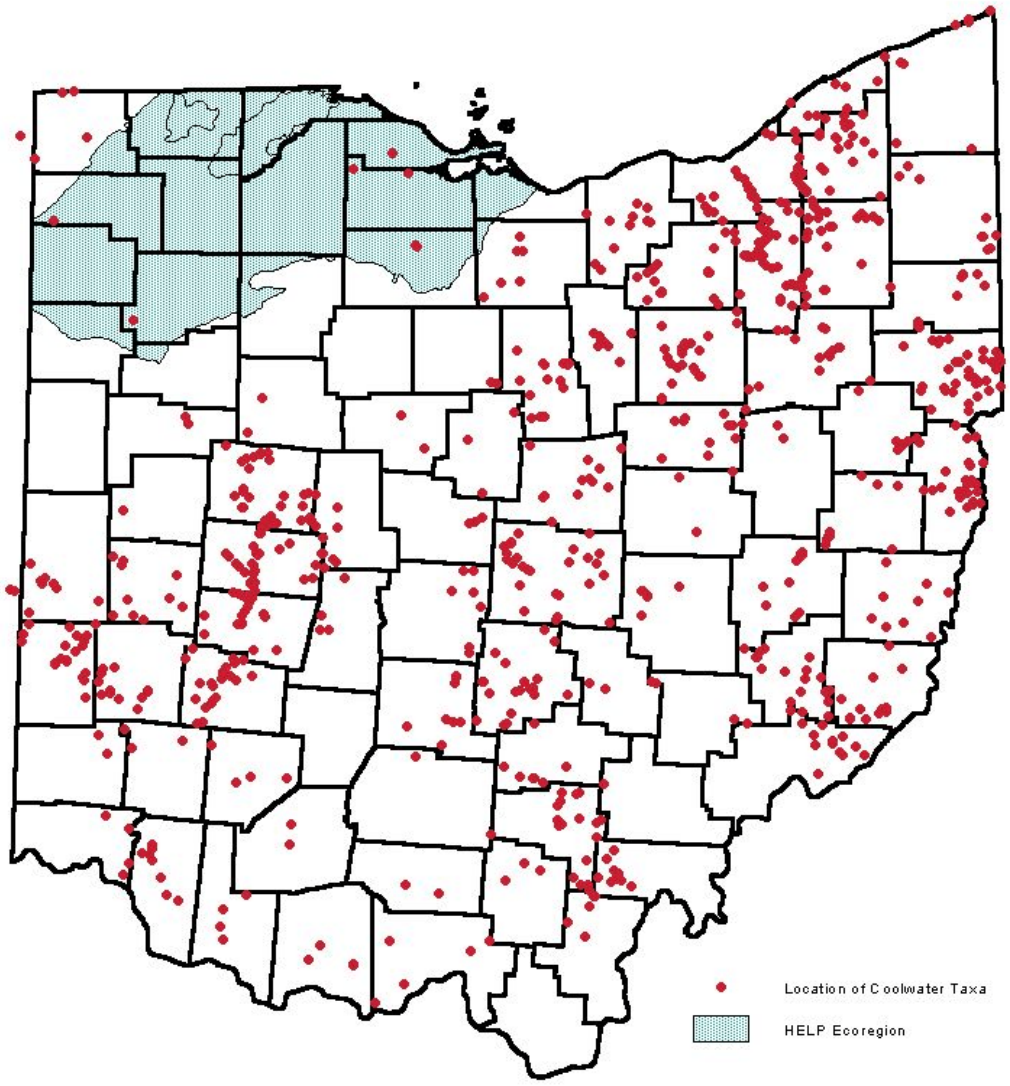

Figure 2: Ohio Distribution of Coolwater Macroinvertebrate Taxa excluding the chironomid taxa *Meropelopia sp.*, *Zavrelimyia sp.*, *Parametriocnemus sp.*, and *Microspectra sp.* These four taxa have relatively wide environmental tolerances compared to the other coolwater taxa and were excluded to represent a more clear distribution of coolwater streams in Ohio.

Table 3. Table of coolwater macroinvertebrate taxa with statistical measures of the number and percentage of coolwater taxa (using the revised 1999 list) at the collection sites during the summer sampling period (June 15 to September 30) and references supporting the coolwater habitat preference of these taxa.

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Taxa (n)	25th %ile No. taxa	50th %ile No. taxa	75th %ile No. taxa	75th %ile % taxa	References
Gammarus minus (25)	1	3	3	-	Holsinger (1972: p. 25)
Ameletus sp. (spring em.)	-	-	-	-	Burks (1953: p. 103)
Baetis tricaudatus (62)	1	3	6	25.4	
Epeorus sp. (spring em.)	-	-	-	-	Burks (1953: p. 195)
Habrophlebiodes sp. (6)	3	5	6	-	
Dannella simplex (8)	3	4.5	6	11.0	
Litobrancha recurvata (2)	-	15	-	-	McCafferty (1975: p. 478)
Lanthus parvulus (9)	1	2	3	0.9	Carle (1980: p. 178)
Peltoperla sp. (1)	-	3	-	-	Surdick & Kim (1976: p.16)
Amphinemura sp. (7)	3	7	9	-	
Soyedina sp. (3)	-	6	-	-	Harper & Hynes (1971: p. 1140)
Leuctra sp. (37)	2	4	8	25.3	
Eccoptura xanthenes (4)	-	6	-	-	Stewart & Stark (1988: p. 308)
Nigronia fasciatus (38)	2	3	4	2.5	Neunzig (1966: p. 15)
Dolophilodes distinctus (24)	4	6.5	7	25.4	Wiggins (1996: p. 154)
Wormaldia sp. (5)	6	8	8	-	Ross (1944: p. 47)
Ceratopsyche slossonae (326)	1	2	4	7.5	Schuster & Etnier (1978: p. 49)
Ceratopsyche ventura (1)	-	10	-	-	Schefter & Wiggins (1986: p. 81)
Diplectrona sp. (83)	2	3	5	7.9	Wiggins (1996: p. 134)
Parapsyche sp. (spring em.?)	-	-	-	-	Wiggins (1996: p. 144)
Rhyacophila sp. (7) (excluding *R. lobifera*)	4	5	9	-	Flint (1962: pp. 482, 492)
Glossosoma sp. (50)	3	4	6	25.3	Wiggins (1996: p. 60)
Oligostomis sp. (1)	-	6	-	-	Wiggins (1996: p. 388)

Table 3. Continued.

Taxa (n)	25th %ile No. taxa	50th %ile No. taxa	75th %ile No. taxa	75th %ile % taxa	References
Frenesia sp. (3)	-	6	-	-	Wiggins (1996: p. 308)
Goera sp. (4)	-	12.5	-	-	Ross (1944: p. 257)
Lepidostoma sp. (8)	6	8.5	10	-	Wiggins (1996: p. 244)
Psilotreta rufa (1)	-	11	-	-	Parker & Wiggins (1987: p. 21)
Molanna sp. (5)	6	8	14	-	Wiggins (1996: p. 354)
Dicranota sp. (35)	2	3	6	5.0	
Pedicia sp. (spring em.?)	-	-	-	-	Alexander (1942: p.344)
Thaumalea americana (1)	-	4	-	-	Stone (1964: p. 120)
Apsectrotanypus johnsoni	-	-	-	-	Fittkau & Roback (1983: p. 43)
Macropelopia decedens (2)	-	5	-	-	Roback (1978: p. 196)
Meropelopia sp. (283)	1	2	3	2.8	
Radotanypus florens (1)	-	16	-	-	Bolton (1992: p. 151)
Trissopelopia ogemawi (14)	4	5.5	7	39.5	Fittkau & Roback (1983: p. 71)
Zavrelimyia sp. (194)	1	2	3	2.8	Fittkau & Roback (1983: p. 73)
Diamesa sp. (27)	2	3	4	-	Oliver (1983: p. 119)
Pagastia orthogonia (14)	2	4.5	9	-	
Odontomesa ferringtoni (4)	1	5.5	16	-	
Prodiamesa olivacea (12)	2	4.5	6	36.0	
Brillia parva (spring em.?)	-	-	-	-	
Chaetocladius piger (spring em.?)	-	-	-	-	
Corynoneura sp. 5 (spring em.?)	-	-	-	-	
Eukiefferiella devonica gr. (32)	2	3.5	5	14.2	

Table 3. Continued.

Taxa (n)	25th %ile No. taxa	50th %ile No. taxa	75th %ile No. taxa	75th %ile % taxa	References
Heleniella sp. (spring em.?)	-	-	-	-	Cranston et al. (1983: p. 174)
Heterotrissocladius mar. (10)	4	6	9	-	Saether (1975: p. 32)
Metriocnemus eurynotus (spring emergence?)	-	-	-	-	
Parachaetocladius sp. (2)	-	5.5	-	-	Cranston et al. (1983: p. 185)
Parametriocnemus sp. (793)	1	2	3	3.2	Cranston et al. (1983: p. 187)
Psilometriocnemus tri. (1)	-	11	-	-	Cranston et al. (1983: p. 195)
Rheocricotopus emin. (spring em.?)	-	-	-	-	
Thienemanniella boltoni (4)	-	8.5	-	-	
Polypedilum albicorne (43)	2	4	5	10.27	Maschwitz & Cook (2000: p. 37)
Polypedilum aviceps (173)	2	3	5	10	
"Constempellina" n. sp. 1 (2)	-	3.5	-	-	
Micropsectra sp. (152)	1	1	3	3.8	
Paratanytarsus n. sp. 1 (174)	2	3	5	12.6	
"Stempellina" n. sp. 1 (spring em.?)	-	-	-	-	
Zavrelia n. sp. 1 (spring em.?)	-	-	-	-	

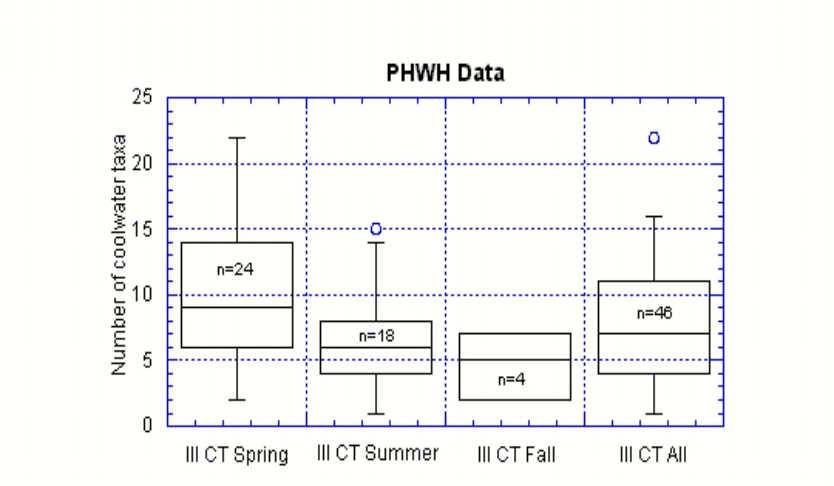

Figure 3. Seasonal number of coolwater taxa in Class III streams.

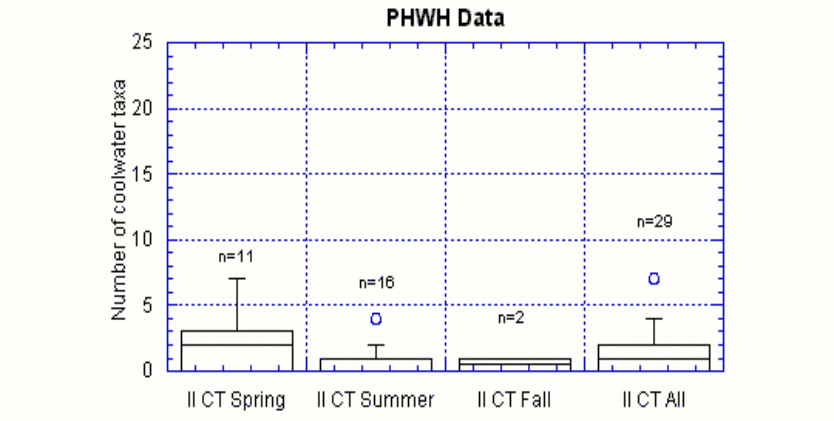

Figure 4. Seasonal number of coolwater taxa in Class II streams.

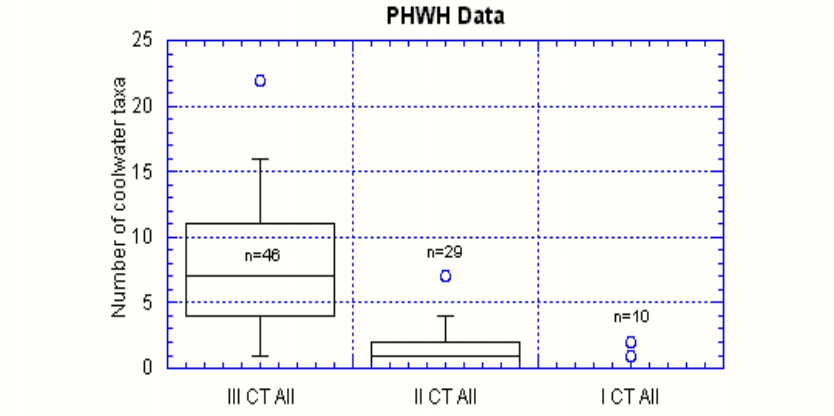

Figure 5. Comparison of number of coolwater taxa among Class III, Class II, and Class I streams.

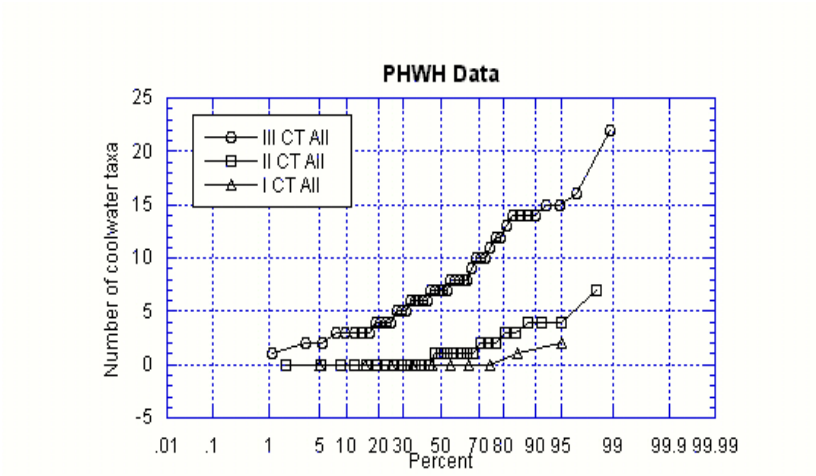

Figure 6. Comparison of coolwater taxa percent among Class III, Class II and Class I streams.

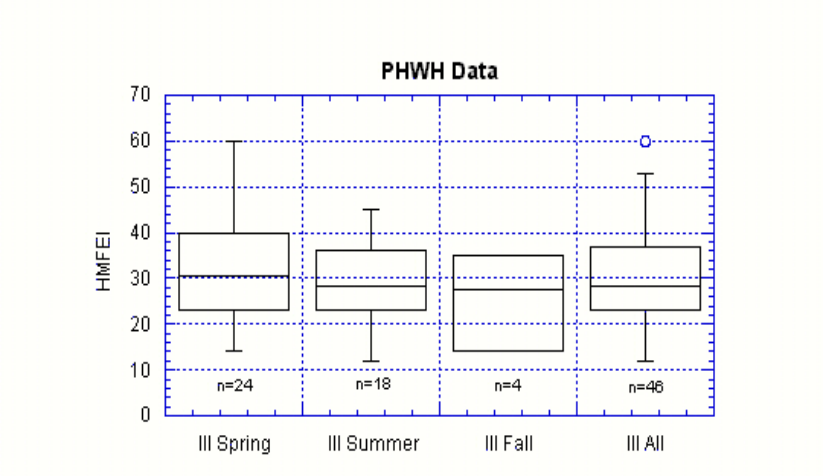

Figure 7. Seasonal HMFEI for Class III streams.

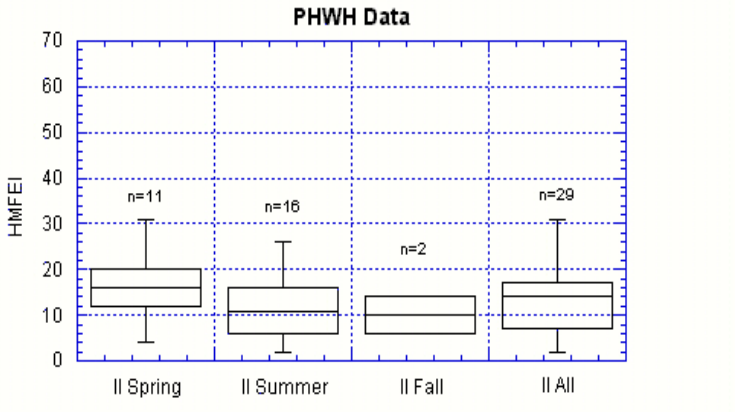

Figure 8. Seasonal HMFEI for Class II streams.

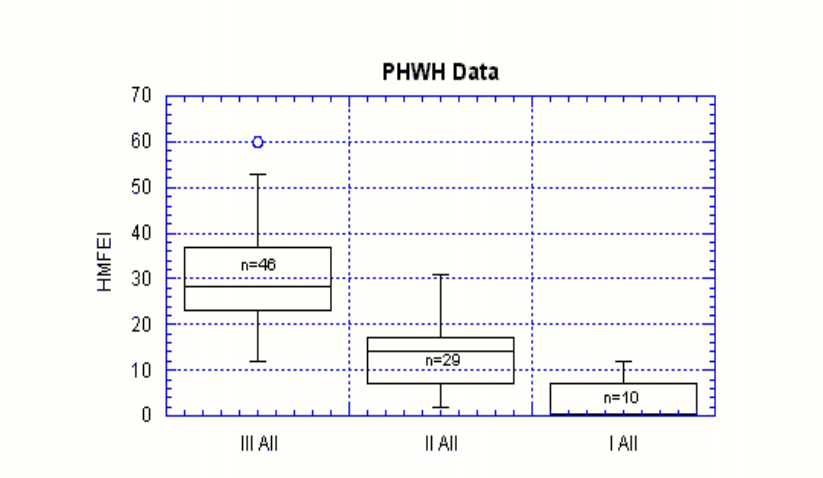

Figure 9. Comparison of HMFEI among Class III, Class II and Class I streams.

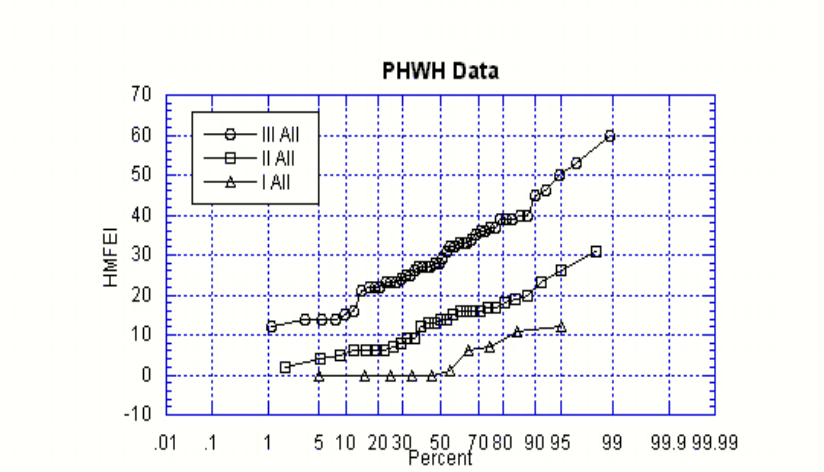

Figure 10. Comparison of HMFEI percent among Class III, Class II and Class I streams.

Table 4. Macroinvertebrate summary table for the primary headwater stream stations sampled seasonally.

		Spring Sampling				Summer Sampling				Fall Sampling			
Site Number / Stream Code	**Class**	**NT**	**EPT**	**CT**	**HMF**	**NT**	**EPT**	**CT**	**HMF**	**NT**	**EPT**	**CT**	**HMF**
NE-99-001/19-079	III	25	9	8	27	21	5	8	29	15	6	4	23
NE-99-003/19-082	III	22	3	8	16	12	3	4	12	14	3	2	14
NE-99-010/15-015	III	31	11	14	39	18	5	10	22	20	10	7	35
NE-00-010/15-015	III	17	7	7	27	29	11	14	36				
NE-99-011/19-062	III	35	19	10	53					27	10	6	32
NE-00-011/19-062	III	14	9	3	28	21	7	5	32				
18-080 (1986-RM 0.15)	III	42	10	22	36								
18-080 (1990-RM 0.15)	III	26	5	10	22								
18-080 (2000-RM 0.15)	III					13	6	8	25				
18-080 (1986-RM 0.1)	III	35	8	15	33								
18-080 (2000-RM 0.10)	III					13	7	6	33				
18-080 (1986-RM 0.02)	III	22	10	12	33								
02-658 (1993 RM 0.2)	III	35	11	16	39								
02-658 (2000 RM 0.2)	III	32	17	14	60	32	13	15	45				
02-659 (2000 RM 0.2)	III					19	7	9	37				
02-659 (2001 RM 0.1)	III	16	12	7	40								
17-583 (1989 RM 0.02)	III	26	7	13	26								
19-100 (1986 RM 0.02)	III	23	5	14	22								
19-100 (1996 RM 0.02)	III	15	4	11	14								
19-100 (2000 RM0.02)	III					16	7	6	31				
19-099 (1984 RM 0.06)	III	22	8	12	25								
19-099 (2000 RM 0.06)	III					11	4	5	15				
19-101 (2000 RM 0.05)	III					14	6	8	23				
SE-01-045/01-056	III	29	18	7	46	25	7	4	37				
SE-01-011/01-175	III	25	14	6	40	23	4	3	28				
SE-01-025/02-661	III	28	18	6	50	31	8	7	39				
CD-01-026/02-349	III?	16	4	3	23	17	2	1	14				
CD-01-016/02-449	III	26	3	2	21	30	5	3	27				

Table 4. Continued.

		Spring Sampling				Summer Sampling				Fall Sampling			
Site Number / Stream Code	**Class**	**NT**	**EPT**	**CT**	**HMF**	**NT**	**EPT**	**CT**	**HMF**	**NT**	**EPT**	**CT**	**HMF**
SW-01-021/11-220	III	17	9	5	27	20	5	3	24				
NE-99-002/19-080	II	21	6	7	23	10	1	1	9	4	0	1	6
NE-99-004/19-081	II	11	2	0	16		D	R	Y	10	2	0	14
NE-00-004/19-081	II	11	3	2	13	28/26	2/4	1/0	18/16				
NE-99-007/19-084	II	21	4	2	19	17	2	1	13				
NE-00-007/19-084	II	23	3	3	16	20	2	0	16				
NE-00-031	II					4	0	0	2				
NE-00-038	II					13	0	0	6				
NW-00-019	II					11	0	0	8				
NW-00-022	II					6	1	0	6				
CD-00-032	II	12	2	0	17								
SW-00-001	II					18	2	0	15				
SW-00-041	II					8	2	0	14				
SE-01-009/01-055	II	12	2	0	12	6	1	1	5				
CD-01-028/02-448	II	7	0	1	6	13	0	0	7				
CD-01-023/02-351	II	7	0	1	4	17	0	4	9				
SW-01-036/11-221	II	22	6	4	31	37	6	2	26				
SW-01-008/14-185	II	12	4	3	20	20	3	3	17				
NE-99-005	I	0	0	0	0		D	R	Y				
SE-01-013/01-303	I	6	3	1	12		D	R	Y				
SE-01-049/01-212	I	5	3	2	11		D	R	Y				
CD-01-022/02-350	I	8	1	0	6	7	1	0	7				
CD-01-047/02-348	I	2	0	0	1		D	R	Y				

Abbreviations:

Site Number/Stream Code: Collection site number assigned by NEDO or stream code if no site number was available along with the year of collection and the river mile (RM)

NT: Number of taxa identified in lab

EPT: Number of EPT taxa (E=Ephemeroptera, P=Plecoptera, T=Trichoptera) identified in lab

CT: Number of coolwater taxa identified in lab

HMF: HMFEI (Headwater Macroinvertebrate Field Evaluation Index score)

Table 5. PHWH Class III Indicator Taxa

Ephemeroptera
Baetis tricaudatus
Diphetor hageni
Epeorus sp.
Ephemerella sp.
Eurylophella sp.
Odonata: Anisoptera
Boyeria grafiana
Lanthus parvulus
Plecoptera
Soyedina sp.
Acroneuria carolinensis
Eccoptura xanthenes
Diploperla robusta
Isoperla transmarina
Sweltsa sp.
Megaloptera: Corydalidae
Nigronia fasciatus
Trichoptera
Dolophilodes distinctus
Wormaldia moesta
Polycentopus sp.
Diplectrona metaqui
Diplectrona modesta
Ceratopsyche slossonae
Ceratopsyche ventura
Parapsyche apicalis
Rhyacophila carolina
Rhyacophila invaria complex
Frenesia sp.
Goera sp.
Lepidostoma sp.
Psilotreta rufa
Molanna sp.
Coleoptera: Psephenidae
Ectopria sp.
Psephenus herricki
Coleoptera: Dryopidae
Helichus sp.
Diptera: Tipulidae
Dicranota sp.
Hexatoma sp.
Limnophila sp.
Pedicia sp.
Diptera: Ptychopteridae
Ptychoptera sp.
Diptera: Dixidae
Dixa sp.
Diptera: Thaumaleidae
Thaumalea americana
Diptera: Chironomidae
Macropelopia sp.
Trissopelopia ogemawi
Pagastia orthogonia
Corynoneura lobata
Heleniella sp.
Parachaetocladius sp.
Psilometriocnemus triannulatus
Rheocricotopus eminellobus
Thienemanniella boltoni
Tvetenia bavarica group
Polypedilum (P.) albicorne
Polypedilum (I.) aviceps
"Constempellina" sp. 1
Paratanytarsus n. sp. 1
"Stempellina" sp. 1
Zavrelia n. sp. 1

Table 6. PHWH Class II Indicator Taxa

Crustacea: Amphipoda
Hyalella azteca
Ephemeroptera
Callibaetis sp.
Cloeon cognatum
Odonata: Zygoptera
Coenagrionidae
Odonata: Anisoptera
Somatochlora sp.
Trichoptera
Ptilostomis sp.
Coleoptera
Peltodytes sp.
Laccophilus sp.
Anacaena sp.
Diptera: Culicidae
Culex sp.
Diptera: Chironomidae
Rheocricotopus sp.
Mollusca: Gastropoda
Planorbella sp.

Table 7. Headwater Macroinvertebrate Field Evaluation Index (HMFEI) scoring categories for use in assessing primary headwater streams in Ohio.

Headwater Macroinvertebrate Field Evaluation Index (HMFEI)		
Group 1 Taxa (scoring value 1)	**Group 2 Taxa (scoring value 2)**	**Group 3 Taxa (scoring value 3)**
Sessile Animals (Porifera, Cnidaria, Bryozoa)	Crayfish (Decapoda)	Mayfly Nymphs (Ephemeroptera)
Aquatic Worms (Turbellaria, Oligochaeta, Hirudinea)	Dragonfly Nymphs (Anisoptera)	Stonefly Nymphs (Plecoptera)
Sow Bugs (Isopoda)	Riffle Beetles (Dryopidae, Elmidae, Ptilodactylidae)	Fishfly Larvae (Corydalidae)
Scuds (Amphipoda)		Caddisfly Larvae (Trichoptera)
Water Mites (Hydracarina)		Water Penny Beetles (Psephenidae)
Damselfly Nymphs (Zygoptera)		Cranefly Larvae (Tipulidae)
Alderfly Larvae (Sialidae)		
Other Beetles (Coleoptera)		
Midges (Chironomidae)		
Larvae of Other Flies (Diptera)		
Snails (Gastopoda)		
Clams (Bivalvia)		

Hemiptera (True Bugs) do not receive any points.

The HMFEI is calculated by multiplying each taxa group present at the site by the appropriate scoring value with the exception of the mayfly, caddisfly and stonefly groups for which each recognizable taxa belonging to these groups are multiplied by their scoring value.

HMFEI Scoring Example:

Taxa:	Score:
Flatworms (Turbellaria)	1
Aquatic Segmented Worms (Oligochaeta)	0
Mayflies: 2 taxa	2 x 3 = 6
Fishflies (*Nigronia*)	3
Caddisflies: 3 taxa	3 x 3 = 9
Craneflies	3
Blackflies (Simulidae)	1
Biting Midges (Ceratopogonidae)	0
Midges (Chironomidae)	1
Snails	1
Total	**25**

3. Macroinvertebrate Scoring Sheet:

THE HEADWATER MACROINVERTEBRATE FIELD EVALUATION INDEX (HMFEI) SCORING SHEET

Indicate Abundance of Each Taxa Above each White Box.

Record HMFEI Scoring Value Points Within each Box.

For EPT taxa, also indicate the different taxa present.

Key: V = Very Abundant (> 50); **A** = Abundant (10 -50); **C** = Common (3 -9); **R** = Rare (< 3)

Sessile Animals **(Porifera, Cnidaria, Bryozoa**) (HMFEI pts = 1) ☐	Crayfish (**Decapoda**) (HMFEI pts = 2) ☐	Fishfly Larvae (**Corydalidae**) (HMFEI pts = 3) ☐
Aquatic Worms (**Turbellaria, Oligochaeta, Hirudinea**) (HMFEI pts = 1) ☐	Dragonfly Nymphs (**Anisoptera**) (HMFEI pts = 2) ☐	Water Penny Beetles (**Psephenidae**) (HMFEI pts = 3) ☐
Sow Bugs (**Isopoda**) (HMFEI pts = 1) ☐	Riffle Beetles (**Dryopidae, Elimidae, Ptilodactylidae**) (HMFEI pts = 2) ☐	Cranefly Larvae (**Tipulidae**) (HMFEI pts = 3) ☐
Scuds (**Amphipoda**) (HMFEI pts = 1) ☐	Larvae of other Flies (**Diptera**) Name: (HMFEI pts = 1) ☐	**EPT TAXA*** Total No. EPT Taxa = _____
Water Mites (**Hydracarina**) (HMFEI pts = 1) ☐	Midges (**Chironomidae**) (HMFEI pts = 1) ☐	Mayfly Nymphs (**Ephemeroptera**) Taxa Present: [HMFEI pts = No. Taxa (x) 3] ☐
Damselfly Nymphs (**Zygoptera**) (HMFEI pts = 1) ☐	Snails (**Gastropoda**) (HMFEI pts = 1) ☐	
Alderfly Larvae (**Sialidae**) (HMFEI pts = 1) ☐	Clams (**Bivalvia**) (HMFEI pts = 1) ☐	Stonefly Nymphs (**Plecoptera**) Taxa Present: [HMFEI pts = No. Taxa (x) 3] ☐
Other Beetles (**Coleoptera**) (HMFEI pts = 1) ☐	Other Taxa :	
Other Taxa:	Other Taxa:	Caddisfly Larvae (**Trichoptera**) Taxa Present: [HMFEI pts = No. Taxa (x) 3] ☐
Other Taxa:	Other Taxa	

*Note: EPT identification based upon Family or Genus level of taxonomy

Voucher Sample ID_____ Time Spent (minutes):_____

Notes on Macroinvertebrates: (Predominant Organisms; Other Common Organisms; Diversity Estimate)

_____

_____

_____

Final HMFEI Calculated Score (Sum of All White Box Scores) = ☐

IF Final HMFEI Score is > 19, Then CLASS III PHWH STREAM
IF Final HMFEI Score is 7 to 19, Then CLASS II PHWH STREAM
IF Final HMFEI Score is < 7, Then CLASS I PHWH STREAM

References:

Alexander, C.P. 1942. Family Tipulidae. (pp. 196-486) Guide to the insects of Connecticut. Part VI. The Diptera or true flies of Connecticut. First Fascicle. State Geological and Natural History Survey of Connecticut. Bulletin 64 509 pp. plus 4 plates.

Allen, B.L. and D.C. Tarter. 1985. Life history and ecology of Eccoptura xanthenes (Plecoptera: Perlidae) from a small Kentucky (USA) stream. Trans. Ky. Acad. Sci. 46:87-91.

Bolton, M.J. 1992. Chironomidae (Diptera) of Cedar Bog, Champaign County, Ohio. Ohio Journal of Science 92(5):147-152.

Burks, B.D. 1953. The Mayflies, or Ephemeroptera, of Illinois. Illinois Natural History Survey Division Bulletin Volume 26, Article 1, 216 pp.

Carle, F.L. 1980. A new Lanthus (Odonata:Gomphidae) from eastern North America with adult and nymphal keys to American octogomphines. Annals of the Entomological Society of America 73(2):172-179.

Clifford, H.F. 1966. The ecology of invertebrates in an intermittent stream. Invest. Indiana Lakes Streams. 7: 57-98.

Cranston, P.S., D.R. Oliver, and O.A. Saether. 1983. Chapter 9. The larvae of Orthocladiinae (Diptera:Chironomidae) of the Holarctic region - Keys and diagnoses. In: Wiederholm, T. (ed.). Chironomidae of the Holarctic region - Keys and diagnoses. Part 1. Larvae. Entomologica Scandinavica Supplement 19:149-291.

Fittkau, E.J. and S.S. Roback. 1983. Chapter 5. The larvae of Tanypodinae (Diptera:Chironomidae) of the Holarctic region - Keys and diagnoses. In: Wiederholm, T. (ed.). Chironomidae of the Holarctic region - Keys and diagnoses. Part 1. Larvae. Entomologica Scandinavica Supplement 19:33-110.

Flint, O.S., Jr. 1962. Larvae of the caddis fly genus Rhyacophila in eastern North America (Trichoptera: Rhyacophilidae). Proceedings of the United States National Museum. 113:465-493.

Harper, P.P. and H.B.N. Hynes. 1971. The nymphs of the Nemouridae of eastern Canada (Insecta: Plecoptera). Canadian Journal of Zoology 49:1129-1142.

Holsinger, J.R. 1972. The freshwater amphipod crustacieans (Gammaridae) of North America. USEPA Biota of Freshwater Ecosystems Identification Manual No. 5, 89 pp.

Hynes, H.B.N. 1979. The Ecology of Running Waters. University of Toronto Press, Toronto 555 pp.

Jones, J.B. and P.J. Mulholland. 2000. Streams and Ground Waters. Academic Press, San Diego, California 425 pp.

Maschwitz, D.E. and E.F. Cook. 2000. Revision of the Nearctic species of the genus Polypedilum Kieffer (Diptera:Chironomidae) in the subgenera P. (Polypedilum) Kieffer and P. (Uresipedilum) Oyewo and Saether. Bulletin of the Ohio Biological Survey. New Series. Volume 12, Number 3, 135 pp.

McCafferty, W.P. 1975. The burrowing mayflies of the United States (Ephemeroptera: Ephemeroidea). Transactions of the American Entomological Society 101:447-504.

Minshall, G.W. 1968. Community dynamics of the benthic fauna in a woodland springbrook. Hydrobiologia 32:305-339.

Meyer J. L., and J. B. Wallace. 2001. Lost linkages and lotic ecology: rediscovering small streams. pp 295-317 *in* M. C. Press, N. J. Huntly, and S. Levin, editors. Ecology: Achievement and Challenge. Symposium of British Ecological Society ans Ecological Society of America, Orlando, Fl

Neunzig, H.H. 1966. Larvae of the genus Nigronia Banks. Proceedings of the Entomological Society of Washington 68:11-16.

Ohio Department of Natural Resources Division of Natural Areas and Preserves. 1985. Ohio's Scenic River Stream Quality Monitoring. Fountain Square, Columbus, Ohio 43224.

Ohio Environmental Protection Agency. 1989. Addendum to biological criteria for the protection of Aquatic Life:.Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Planning and Assessment, Surface Water Section, Columbus, Ohio 43216-1049.

___ 2000. Ohio Water Resource Inventory: Causes & Sources of Impairment: Year 2000. Fact Sheet #: FS-2-EAS-2000. Ohio EPA, Division of Surface Water, P.O. Box 1049, Columbus, Ohio 43216-1049

___ 2001a. Clean Rivers Spring from Their Source: The Importance & Management of Headwater Streams. Ohio EPA, Division of Surface Water, P.O. Box 1049, Columbus, Ohio 43216-1049, August 2001.

___ 2002a. Technical Report: Ohio's Primary Headwater Habitat Streams - Fish and Amphibian Assemblages. Ohio EPA, Division of Surface Water, P.O. Box 1049, Columbus, Ohio 43216-1049, September 2002.

___ 2002b. Ohio EPA Primary Headwater Habitat Initiative Data Compendium, 1999-2000: Habitat, Chemistry, and Stream Morphology Data. Ohio EPA, Division of Surface Water, P.O. Box 1049, Columbus, Ohio 43216-1049, September 2002.

___ 2002c. Field Evaluation Manual for Ohio's Primary Headwater Habitat Steams. Ohio EPA, Division of Surface Water, P.O. Box 1049, Columbus, Ohio 43216-1049, September 2002.

Ohio State University. 2001. Primary Headwater Stream Rapid Assessment Study. Statistical Consulting Service, Department of Statistics, The Ohio State University 14pp.

Oliver, D.R. 1983. Chapter 7. The larvae of Diamesinae (Diptera:Chironimidae) of the Holarctic region - Keys and diagnoses. In: Wiederholm, T. (ed.). Chironomidae of the Holarctic region - Keys and diagnoses. Part 1. Larvae. Entomologica Scandinavica Supplement 19:115-138.

Parker, C.R. & G.B. Wiggins. 1987. Revision of the caddisfly genus Psilotreta (Trichoptera:Odontoceridae). Royal Ontario Museum, Life Sciences Contributions 144. 55 pp.

Peterson, B. J., et al. 2001. Control of nitrogen export from watersheds by headwater streams. *Science* 292:86-90.

Roback, S.S. 1978. The immature chironomids of the eastern United States III. Tanypodinae-Anatopyniini, Macropelopiini and Natarsiini. Proceedings of the Academy of Natural Sciences of Philadelphia 129(11):151-202.

Ross, H.H. 1944. The caddis flies, or Trichoptera, of Illinois. Illinois Natural History Survey Division Bulletin Volume 23, Article 1 326 pp.

Saether O.A. 1975. Nearctic and Palaearctic Heterotrissocladius (Diptera:Chironomidae). Bulletin of the Fisheries Research Board of Canada. No. 193. 67 pp.

Schefter, P.W. and G.B. Wiggins. 1986. A systematic study of the Nearctic larvae of the Hydropsyche morosa Group (Trichoptera:Hydropsychidae). Royal Ontario Museum, Life Sciences Miscellaneous Publications. 94 pp.

Schmidt, D.A. and D.C. Tarter. 1985. Life history and ecology of Acroneuria carolinensis (Banks) in Panther Creek, Nicholas County, West Virginia (Plecoptera: Perlidae). PSYCHE 92:393-406.

Schuster, G.A. and D.A. Etnier. 1978. A manual for the identification of the larvae of the caddisfly genera Hydropsyche Pictet and Symphitopsyche Ulmer in eastern and central North America (Trichoptera:Hydropsychidae). United States Environmental Protection Agency 600/4-78-060, Cincinnati. 129 pp.

Singh, M.P. and A.D. Harrison. 1984. The chironomid community (Diptera: Chironomidae) in a southern Ontario stream and the annual emergence patterns of common species. Archiv fur Hydrobiologie 99: 221-253.

Stewart, K.W. and B.P. Stark. 1988. Nymphs of North American stonefly genera (Plecoptera). Thomas Say Foundation. Series, Entomological Society of America Volume 12, 460 pp.

Stone, A. 1964. Family Thaumaleidae. (pp. 119-122). Guide to the insects of Connecticut. Part VI. The Diptera or true flies of Connecticut. Ninth Fascicle. State Geological and Natural History Survey of Connecticut. Bulletin 97. 126 pp.

Surdick, R.F. and K.C. Kim. 1976. Stoneflies (Plecoptera) of Pennsylvania. A synopsis. Bulletin of the Pennsylvania State University College of Agriculture No. 808, 73 pp.

Wallace J.B. and N.H. Anderson. 1996. Habitat, life history, and behavioral adaptations of aquatic insects. pp. 41-73 In: Merritt, R.W. and K.W. Cummins (eds.). An introduction to the aquatic insects of North America. Dendall/Hunt Publishing Co. Dubuque, Iowa 862 pp.

Wiggins, G.B. 1996. Larvae of the North American caddisfly genera (Trichoptera). Second edition. University of Toronto Press, Toronto 457 pp.

Williams, D.D. and H.B.N. Hynes. 1974. The occurrence of benthos deep in the substratum of a stream. Freshwater Biology 4: 233-256.

___ 1976. The ecology of temporary streams. I. The faunas of two Canadian streams. Int. Revue ges Hydrobiol. 61: 761-787.

___ 1977. The ecology of temporary streams. II General remarks on temporary streams. Int. Revue ges Hydrobiol. 61: 761-787.