Ohio Biological Survey Notes 2: 1-24, 1999.

Algal and Macroinvertebrate Assemblages of Selected Ohio Springs

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Abstract. A qualitative study of the algal flora, macroinvertebrate fauna, and water quality of ten Ohio springs was conducted during July-September 1996. The springs were primarily in central and northern Ohio on a variety of surficial geology settings including karst, till, and exposed bedrock. Water quality varied with the ground-water source and local environment (agriculture, woodland). The algal community varied greatly in diversity among sites. One woodland site (Styx River) had only three taxa. In contrast, Cedar Bog (an open alkaline fen) had a great diversity of diatoms (246 taxa) with a total of 258 taxa. At most locations, between 15 and 56 taxa were reported. Like the algal community, the diversity of the macroinvertebrate fauna differed considerably among sites, ranging from 2 to 40 identified taxa. This variation may have been due to the site-specific differences in water chemistry and/or habitat. Computation of Jaccard similarity coefficients for both the algal and macroinvertebrate data resulted in low similarity values among sites. The data collected provide a basis for proposed sampling methods (spring biotic survey protocols) that could be used for the range of spring/seep types found in Ohio.

Introduction

Throughout the United States, including Ohio, springs are of local importance in rural areas as drinking water and agricultural-water supplies. Because springs also represent surface outlets for ground-water, chemical analysis of springs can be employed to help evaluate ground-water quality (Breen and Dumouchelle, 1991). Biological communities, which have been used to evaluate surface-water quality for more than two decades (Patrick, 1973; Davis and Simon, 1995), could potentially provide an additional mechanism for evaluating the quality of ground water exiting at springs with respect to human consumption and agricultural supply. However, little is known about the biota of springs in Ohio or how biotic communities differ in relation to ground-water quality.

Springs are unusual and varied environments. Because the water temperature and chemistry for springs remain relatively constant, springs harbor biotic communities that are unique and, in some cases, include endemic taxa of macroalgae (Sheath and Cole, 1990; Vis and Sheath, 1996), invertebrates (Cole and Watkins, 1977), and diatoms (Czarnecki and Blinn, 1979). Springs also can harbor taxa that are climatic relicts from the glacial epochs of the Pleistocene in North America and Europe (Strayer *et al*., 1995). Biotic communities of springs have been studied sparingly in Ohio (Hunt, 1983) and elsewhere in the United States (Noel, 1954; Minshall, 1968; Whitford, 1956; Whitford and Schumacher, 1963), compared with the more extensive studies in Europe (Neilsen, 1950; Berg, 1951; Thorup, 1963) and Canada (Biological Survey of Canada, 1990; Williams and Danks, 1991; Williams and Smith, 1990).

As a step toward filling the information gap on spring biota in Ohio, a baseline survey was done to characterize the periphyton and benthic organisms from ten Ohio springs and to create a database. The database could then be used in combination with other surveys (Webb *et al*., 1995 [Illinois], Whitford, 1956 [Florida], Christensen, 1978, and Sherwood and Sheath, 1999 [Texas]) to provide guidance for future studies in Ohio. A secondary purpose was to develop an approach to sampling spring sites using qualitative collecting methods that could be applied to the range of spring environments found in Ohio.

Methods and Materials

Springs were located by use of the U.S. Geological Survey ground-water database and by consultation with Ohio EPA biologists and others. Ten springs in six counties (Champaign, Fairfield, Madison, Medina, Sandusky, and Summit) were selected to represent a variety of natural hydrogeologic settings in Ohio (Figure 1), specifically karst, till, and exposed bedrock. Springs from quarry walls or acid mine drainage sites, however, were excluded.

The collection of the algal flora, macroinvertebrate fauna, and field measures of water quality from the discharge areas of the ten springs was conducted from July through September 1996, during low-flow conditions undisturbed by precipitation. The sampled areas differed considerably among the springs. General criteria for selecting the sampled area were (1) a position between the point of emergence of water from the ground and any channeled, streamlike flow downgradient from the point of emergence, and (2) sufficient size to be representative of the biota present, as well as could be determined by visual inspection. At some springs, Cedar Bog in particular, multiple areas were sampled because of multiple points of emergence. Field measurements of basic water-quality characteristics (temperature, dissolved oxygen, pH, and specific conductance) were made with a calibrated multiparameter instrument at each spring above and below where the biota were sampled (where possible), and the measurements were then averaged to represent the conditions at the site (Table 1). Each site was visited only once.

The organisms collected, for the most part, represent the epigaean flora and fauna (those living on or near the surface of the water). No attempt was made to collect invertebrates specialized for living in ground-water (stygobionts), which could potentially have been found deeper in the substrate of the spring-discharge area (Strayer *et al*., 1995).

Qualitative periphyton (algae) samples were collected by scraping, pipetting, or hand-sampling all available substrate surfaces according to the protocols used in the U. S. Geological Survey National Water-Quality Assessment (NAWQA) Program (Porter *et al*., 1993). Substrates typically included soft substrate, rocks, wood, and macrophyte leaves. The algal material was preserved in 5% buffered glutaraldehyde and sent to the Bowling Green State University Center for Algal Microscopy and Image Digitization for identification of microalgae <http://www.bgsu.edu/Departments/biology/algae/index.html>. Macroalgae were identified at the Department of Environmental and Plant Biology, Ohio University <http://vis-pc.plantbio.ohiou.edu/algaeindex.htm>. Benthic organisms were collected by use of dip-nets, kick-nets, grab samplers, and handpicking. Specimens were preserved in 80% ethanol in the field and subsequently sent to the laboratory for identification. Identifications were made to the lowest taxonomic level possible, which ranged from species for most algae to genus for many macroinvertebrates (such as the Diptera) and higher levels for some groups (such as the Oligochaeta worms).

Once the qualitative samples were collected and identified, Jaccard similarity coefficients were computed on the basis of a presence/absence matrix of taxa recorded from each site (Sneath and Sokal, 1973). Sequential, agglomerative, hierarchical, and nested clustering methods (SAHN) (Sneath and Sokal, 1973) were used to generate tree matrices and cluster diagrams. These cluster diagrams were used as a measure of between-site similarity of the biological communities, where the similarity coefficients range from 0 to 1, with 1 representing the maximum similarity.

Spring Descriptions

Millers Blue Hole near Vickery and Green River Spring at Green Springs (Figures 2-5) are large springs in Sandusky County, north-central Ohio. Because of the high discharge rates and local topography associated with these springs, large spring-fed ponds, whose water chemistry has been influenced by the Silurian and Devonian carbonate bedrock rocks, are found. The carbonate aquifer that supports these springs is the primary source of rural domestic and agricultural water supplies in the area (Breen and Dumouchelle, 1991: pp. 3-9). Both springs are in a karst area (Hull, 1999). Millers Blue Hole is capable of discharging more than 3,000 gal/min (Breen and Dumouchelle, 1991: p. 46; Ohio Division of Water, 1968), and Green River Spring has a discharge of about 5,500 gal/min (Breen and Dumouchelle, 1991: p. 48). The pond of Millers Blue Hole appears milky-blue and is surrounded by a ring of native wetland vegetation, including an algal mat of *Chara* (Figures 2 and 3). Green River Spring (also referred to as “St. Francis Spring S-34-G31,” in Breen and Dumouchelle, 1991: pp. 176-179) is clear with blue-green algal mats extending to form stalagmite shapes along the bottom of the pond (Figures 4 and 5). Dissolution of the calcium sulfate mineral (gypsum) that is present in the Silurian/Devonian aquifer supplying Green River Spring contributes to elevated concentrations of sulfate, which approach 2,000 mg/L. The unusual sulfur-rich water of Green River Springs, which has an odor of hydrogen sulfide, attracted Native Americans, as well as early settlers who built a health institution in 1868 that has persisted since that time (H.K. Williams & Bro., 1882; Works Projects Administration, Writers Program, Ohio, 1940). Currently, the spring is surrounded by mowed lawns, cement walkways, a public park, a hospital, and a large population of Canada Geese.

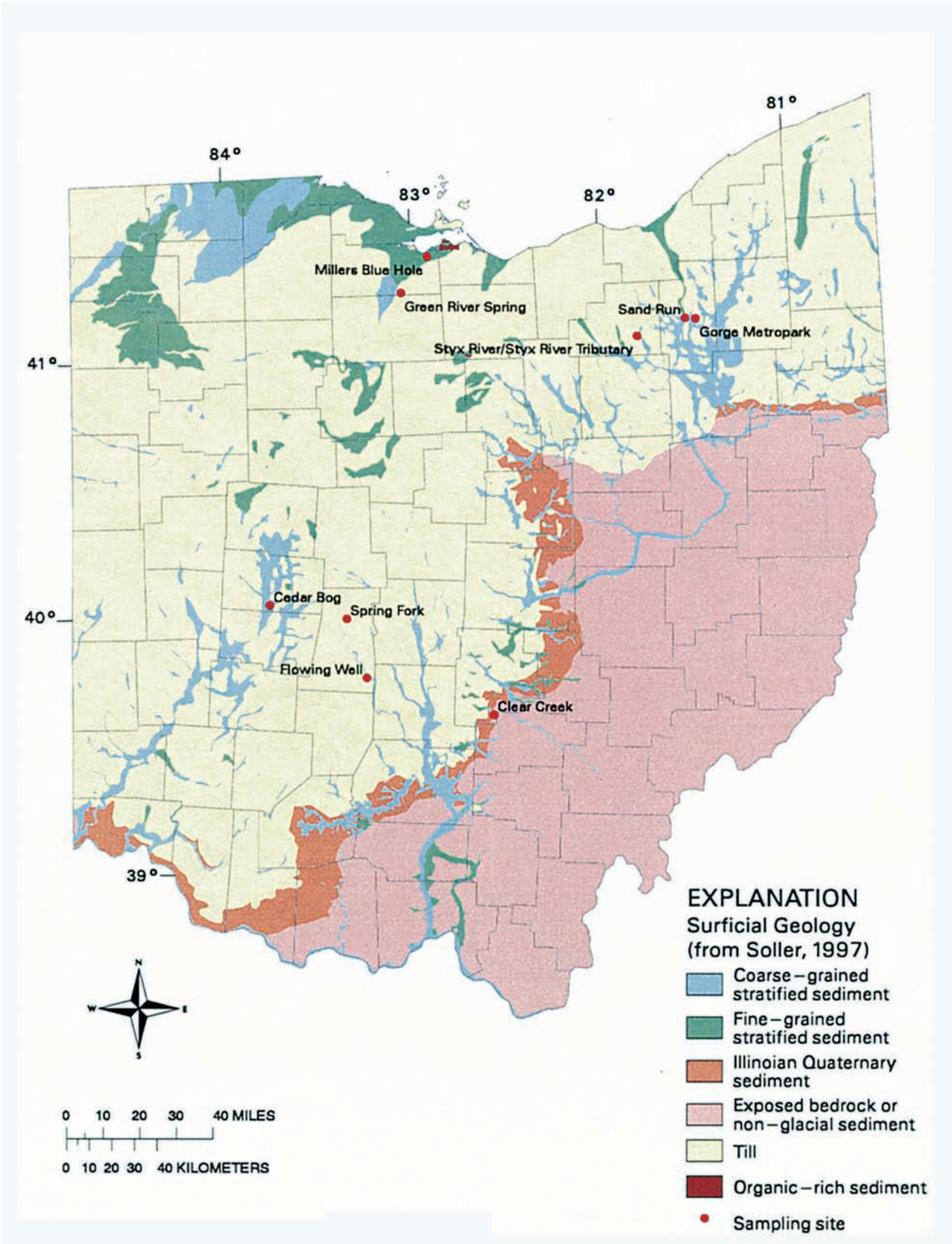
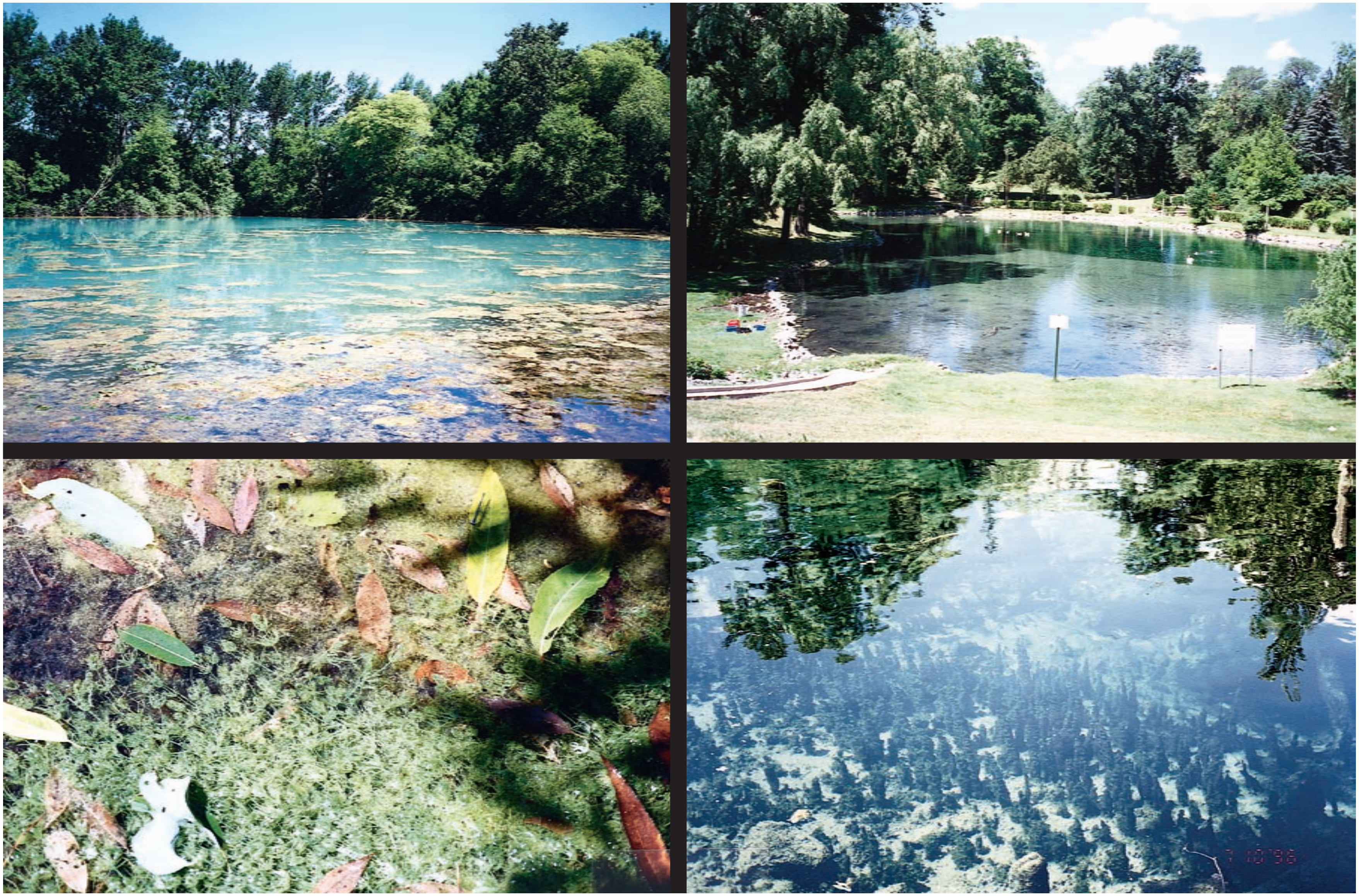


Figure 1. Surficial geology (Soller, 1997) and location of ten spring sites in Ohio.



Figures 2-5: Habitat photographs. **2**- Millers Blue Hole, Ohio Department of Natural Resources, Nature Preserve, Sandusky County, Ohio; **3**- Millers Blue Hole, illustrating mats of *Chara vulgaris* at the edge of the "blue hole;" **4**- Green River Spring, Green Springs, Sandusky County, Ohio; **5**- Green River Spring, detail illustrating growth of benthic stalagmite forms of Cyanophyta blue-green algae.

Figures 6-9: Habitat photographs. **6**- Gorge Metropark wooded area seep, above the trail along the Cuyahoga River dam and past Mary Campbell's Cave, Summit County, Ohio; **7**- Styx River Tributary spring, illustrating orange-red bacterial mat, Medina County, Ohio; **8**- Sand Run spring, a boggy lowland seep in Sand Run State Park, Summit County, Ohio (Julie Hambrook holding a water-quality meter); **9**- Cedar Bog, Ohio Historical Society Preserve, Champaign County, Ohio (Morgan Vis and Wayne Chiasson collecting macroalgal samples).

In contrast to Millers Blue Hole and Green River Spring, the four springs sampled in the Cuyahoga River Valley in northeastern Ohio are low-volume seeps that flow out of bedding planes and fractures in the sandstone and shale bedrock. Three of these springs are in gorges. Two of these springs contribute to the headwaters of the Styx River, whereas the spring in Gorge Metropark (Figure 6) is above the dam of the Cuyahoga River in Cuyahoga Falls. The Styx River tributary spring outlet (Figure 7) was marked by orange-red bacterial mats produced by the oxidation of dissolved ferrous iron in the springwater. The other spring is in a floodplain and contributes to Sand Run in Sand Run State Park (Figure 8).

Cedar Bog in Champaign County, central Ohio, is an alkaline fen (Bolton, 1992) formed by numerous springs that discharge from thick deposits of coarse-grained carbonate-rich glacial outwash (Figure 9). When the ground water, rich in calcium, magnesium, and bicarbonate, recharges the fen, calcareous muds (marl) are precipitated (Bolton, 1992). This marl forms the substrate for the algae and invertebrates collected in this study.

The springs called Spring Fork and Flowing Well in Madison County are in agricultural areas established over glacial till. The discharge from the Flowing Well (known locally as Anderson's Spring) was formerly piped to a pit for watering cattle and horses, and to a roadside fountain for local use by residents and travelers, but the spring was subsequently capped because of high nitrate concentrations after storms, (Niel Babb, Madison County Engineer, oral communication, 1999). These two springs emerge from the till soil and form small wetlands before draining into their respective streams, Spring Fork and Deer Creek.

The Clear Creek spring in Fairfield County flows out of Mississippian shale bedrock and drains into the dam area of Lake Ramona, which, in turn, discharges into Clear Creek. Springwater emerges from the bedrock and flows across the rock, forming small pools with relatively little substrate diversity.

Results of Data Analysis

Values for field-measured water-quality characteristics (Table 1) varied among the springs, indicating diverse ground-water sources (as would be expected given the diverse hydrogeographic and environmental settings of the stream sites). The highest specific conductance values were measured at Millers Blue Hole and Green River Spring. The range of pH was 6.8-8.1, from nearly neutral to slightly alkaline. Dissolved oxygen concentrations were <5 mg/L at four springs (Millers Blue Hole, Green River Spring, Spring Fork, and Styx River tributary), and water temperature was generally warm (12.9-19.3^{o}C) for ground water in Ohio.

In all, 346 algal taxa were identified during this study (Table 2). The flora is made up largely of diatoms (314 taxa or 91%), primarily from the Cedar Bog site (246 diatom taxa). The taxonomic diversity was greatest at the Cedar Bog, where 258 taxa or 75% of those identified in this study were found; of those, 176 or 51% of the total taxa were not found at the other sites. The results of the number of taxa per site and cluster analyses are presented in Figures 10 and 11. Similarity coefficients were low, as reflected in the dendrogram (Figure 11). The greatest similarity was between Clear Creek and the Styx River, with a similarity coefficient of 0.250 out of a maximum of 1; six taxa were in common between the two sites out of 19 and 21 total taxa, respectively. These springs are similar in that they are perennial seeps that emerge from steep slopes in deciduous woods. Millers Blue Hole and the Cedar Bog are larger open areas (Figures 2 and 8) and had the most taxa; despite a low similarity coefficient, they clustered together, separate from the other sites (Figure 11). Three other open sites Green River Spring, Spring Fork, and Flowing Well cluster together with a 0.145 similarity coefficient to the shaded forested areas. The Sand Run and Styx River Tributary sites had the fewest taxa and the least similarity to other sites.

The 95 macroinvertebrate taxa identified during this study are listed in Table 3. The results of the number of taxa and cluster analyses are presented in Figures 12 and 13. Similarity coefficients were lower than for the periphyton data. Millers Blue Hole, with 40 taxa, had the highest macroinvertebrate diversity of any of the springs sampled. Macroinvertebrate diversity was high at the Flowing Well and Cedar Bog sites also, but was very low at the two Styx River sites, the Gorge, Green River Spring, and Sand Run. In the dendrogram (Figure 13), the four most species-rich sites clustered together but shared low coefficient values, indicating a lack of similarity.

To ensure that the disparity in macroinvertebrate species richness between Millers Blue Hole and the other springs did not influence the relations among the other springs as presented in the dendrogram (Figure 13), the analyses were repeated for the nine springs omitting Millers Blue Hole; the results of the alternative cluster analyses indicated that Millers Blue Hole had little influence on the relation of the other sites to each other.

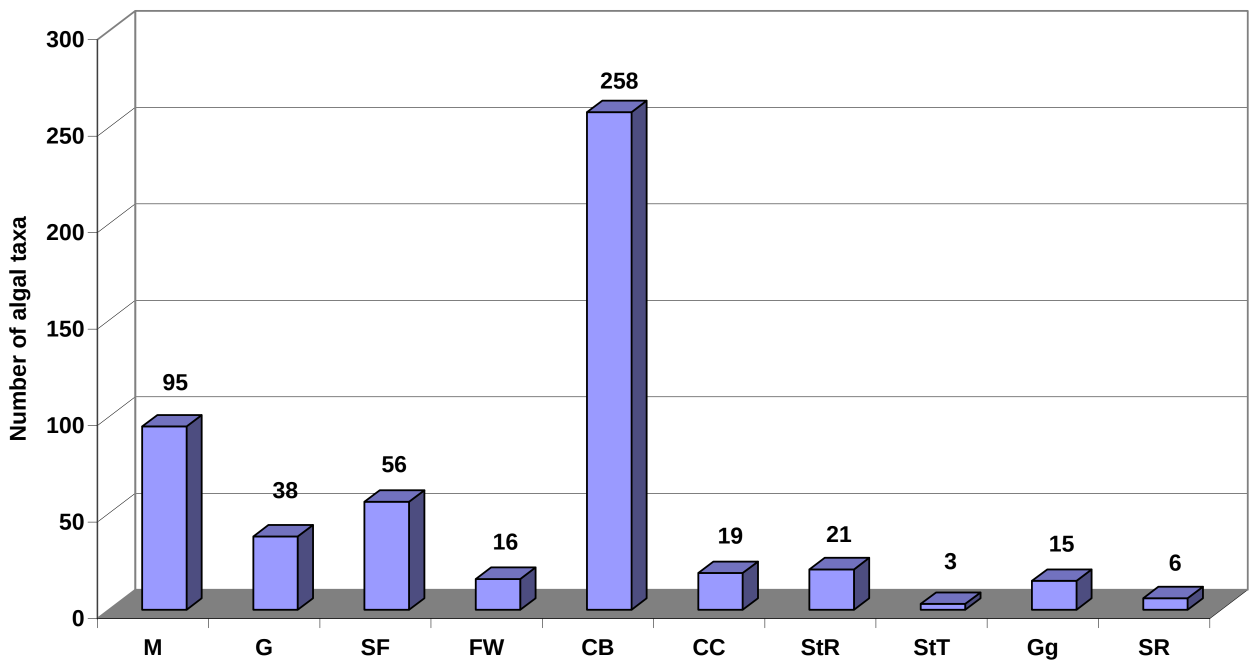


Figure 10. Number of algal taxa found in selected Ohio springs. [M = Millers Blue Hole, G = Green River Spring, SF= Spring Fork, FW = Flowing Well, CB = Cedar Bog, CC = Clear Creek, StR = Styx River, StT = Styx River tributary, Gg = Gorge Run, SR = Sand Run]

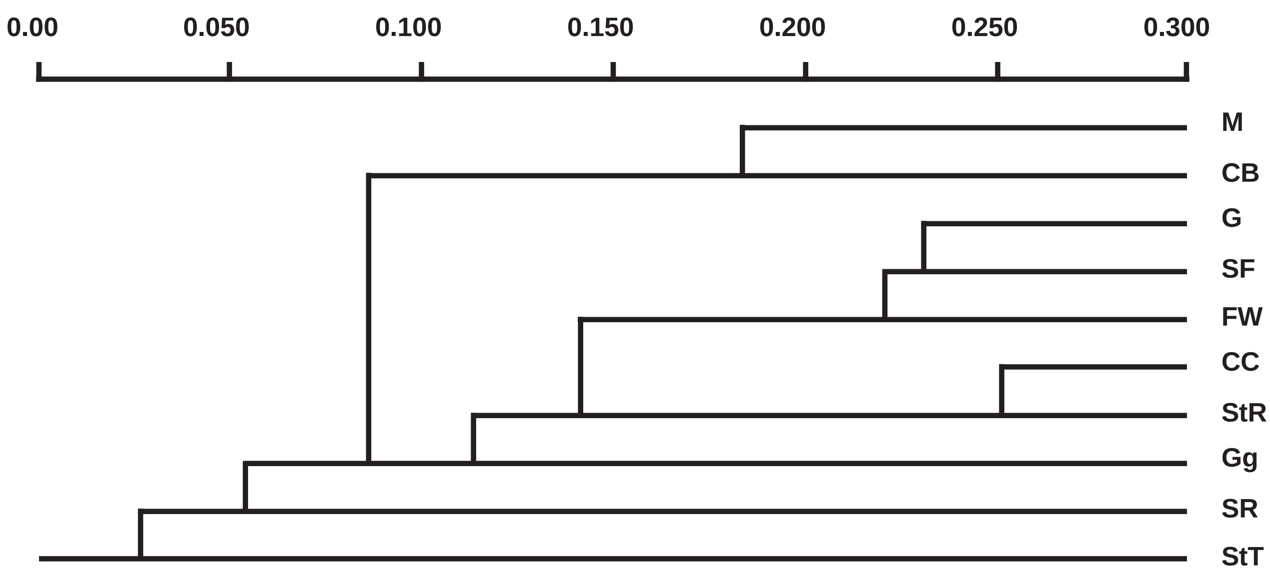


Figure 11. Cluster diagram (dendrogram) of ten Ohio springs based on Jaccard similarity coefficients derived from qualitative algal community composition.

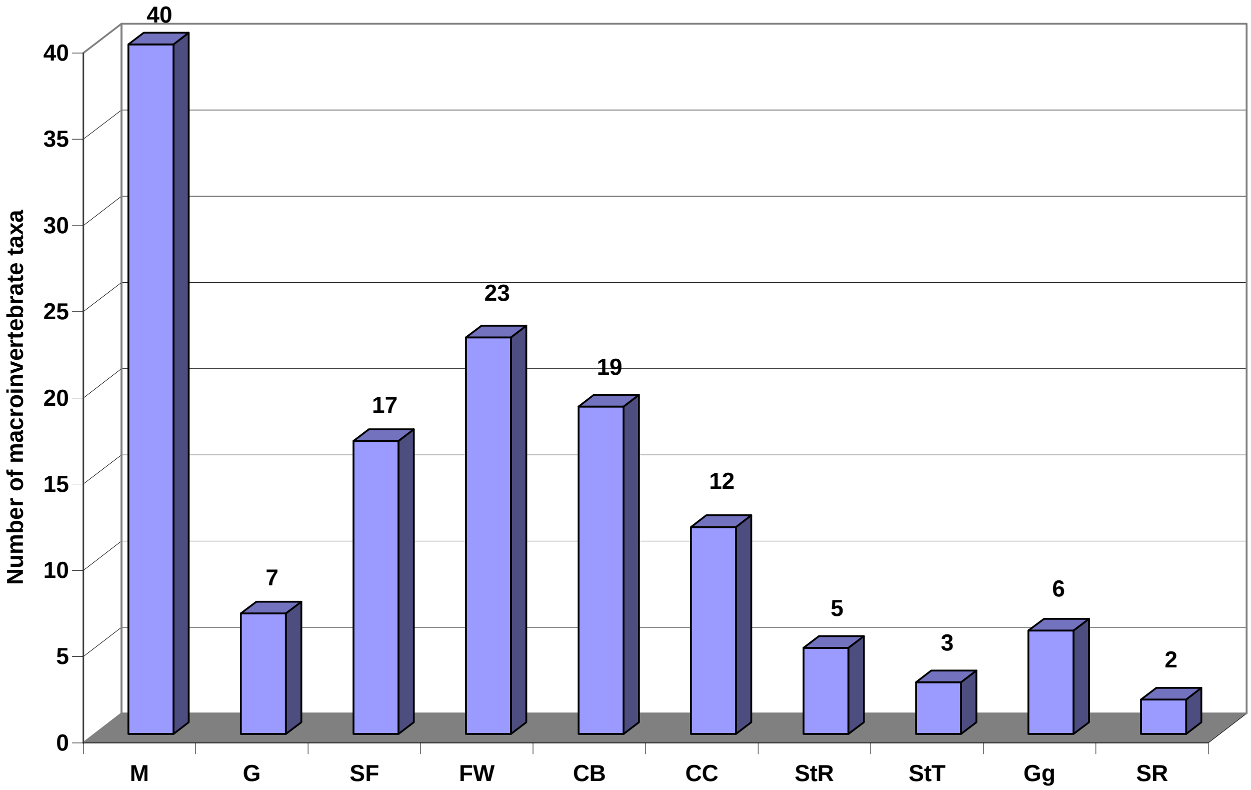


Figure 12. Number of macroinvertebrate taxa found in selected Ohio springs.

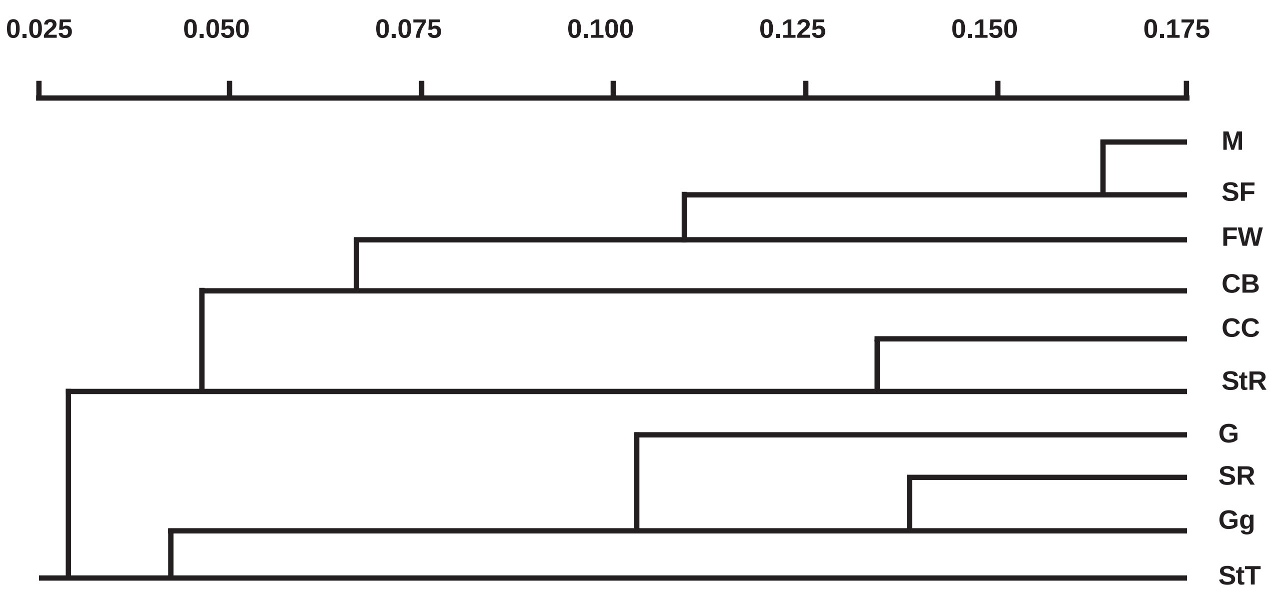


Figure 13. Cluster diagram (dendrogram) of ten Ohio springs based on Jaccard similarity coefficients derived from qualitative macroinvertebrate community composition.

The clustering of the sites based on the macroinvertebrate taxa followed a pattern similar to that for algal communities; *i.e*., the open field sites were the most similar to each other, and they tended to cluster separately from the wooded spring sites. An exception to this generality is that Green River Spring had relatively low macroinvertebrate diversity and was loosely associated with the woodland spring sites.

Discussion

The springs sampled in this study are in areas of the state that have coarse to fine grained glacial deposits, with the exception of the Clear Creek spring, which emerges from Mississippian bedrock (Figure 1). Water from these springs is neutral to slightly alkaline and varies in specific conductance, reflecting differing ground water sources and interactions with differing bedrock materials. The sites are divided into two types of habitats: open field sites and woodland seeps. The open areas had greater biotic diversity, with the exception of the low taxon richness of the macroinvertebrate community at Green River Spring. Some of the factors that contribute to the high diversity at Cedar Bog include more numerous sampling locations than the other sites where water flows out of the ground, openness (availability of light and potential import of taxa through atmospheric transport/deposition), and the state protection of this area by the Ohio Historical Society. The low dissolved-oxygen concentrations at Green River Spring, Spring Fork, and the Styx River tributary may be limiting the macroinvetebrate diversity at these sites. These low concentrations could be related to the short residence time of water at the sampling sites and the limited exposure of water to the atmosphere after emerging from the ground, such as at Green River Springs, where the flow rate is high (5,500 gal/min). Given the regional proximity, high specific conductances, and substantial flow rates, one might expect Millers Blue Hole and Green River Spring to be more similar, but they clearly have different flora and fauna. Factors that contribute to these differences are the presence of elevated hydrogen sulfide (total sulfide= 2.6 mg/L; Breen and Dumouchelle, 1991) low oxygen concentrations, and organic loading from the numerous Canada Geese frequenting the Green River Spring area. Hydrogen sulfide is a biologically active compound, that can be highly poisonous to aquatic organisms. The U.S. Environmental Protection Area criterion for undissociated H_2S for fish and other aquatic life is 2 ug/L (USEPA, 1986). Hydrogen sulfide was not detected at Millers Blue Hole during the same time period (Breen and Dumouchelle, 1991). Dissolved-oxygen concentrations also differ at these two sites; very little oxygen, only 0.6 mg/L, is available for macroinvertebrates at Green River Spring, whereas the dissolved-oxygen concentration at Millers Blue Hole has reportedly been as high as 5.5 mg/L (Table 1; and Breen and Dumouchelle, 1991).

The low algal diversity at most of the spring sites can be attributed in part to shading, the limited area for colonization and sampling in the woodland seeps, and possibly the time of year that the collections were made. Diatoms that made up 90% of the flora are typically highest in diversity in the spring rather than summer, when these samples were collected. One benefit to sampling during summer low flow was that only perennial springs could be sampled. A perennial spring provides a more constant and suitable habitat for aquatic biota than does a spring with intermittent flows. The woodland springs all flowed over soil, and the influence of the soil substrate was reflected by the presence of several soil-type algae. A comparison with a more complete seasonal analysis of soil algae (41 taxa) from a beech-maple forest in northeastern Ohio (Grondin and Johansen, 1995) revealed only three taxa in common (all diatoms). The majority of soil algae in that study were small green algae in the family Chlorophyceae (29 taxa or 71%), none of which were identified in this study.

In addition to the high species diversity of Cedar Bog, several taxa known to be intolerant of nutrient enrichment/pollution were found, including the freshwater red alga *Batrachospermum gelatinosum* and the diatoms *Fragilaria construens* var. *pumila*, *Fragilaria vaucheria*, and *Nitzschia palea*, indicating good water quality. In contrast, the diatom *Cocconeis placentula* and the blue-green alga *Schizothrix calcicola* that formed the stalagmite growths at Green River Spring are both positively associated with nutrient enrichment (Carrick *et al*., 1988).

The overall diversity of 95 macroinvertebrate taxa in this study is comparable with the 85 taxa collected from seven springs in southern Illinois (Webb *et al*., 1995). The differences in diversity between sites were greater in this study (maximum 40 to minimum of 2 taxa). Diptera (30 taxa) were the most diverse group, whereas the oligochaete worms (24 taxa) were the most diverse group in Illinois springs. The maximum diversity for the Illinois springs was 46 taxa, whereas the maximum in this study was 40 taxa, at Millers Blue Hole. The Ohio springs sampled in this study represent a broad range of habitats within agricultural watersheds (unlike the Illinois sites), and were sampled less frequently than the springs in Illinois. The differences in habitat, as well as the amount of flow, are factors influencing biotic diversity recorded from the Ohio spring sites. Millers Blue Hole and Green River Spring, with reported discharges of 3,000 and 5,500 gal/min, respectively (Breen and Dumouchelle, 1991), have formed large pooled areas and a diversity of habitats below their point of emergence. The increased area contributes to the diversity in the protected Millers Blue Hole but not to Green River Spring. The Illinois springs all tended to be low-volume outlets of ground water more closely resembling Ohio's Spring Fork and Flowing Well, except that the Ohio springs were in agricultural pastures.

The paucity or absence of snails in the five wooded seep sites that were low in algal diversity is understandable because snails use algae for food. The low algal diversity, however, does not explain the absence of beetle (Coleoptera) taxa at the same sites. Except for the Millers Blue Hole, Flowing Well, and Cedar Bog sites, macroinvertebrate diversity among the springs was low, and a variety of factors could be contributing to reduced diversity. Spring macroinvertebrate diversity would be expected to be lower than that for lotic systems in comparable areas simply because of the uniformity of environmental conditions in the spring-discharge areas and our sampling criteria. The low macroinvertebrate diversity in the 2-15 taxa range may be a result of low dissolved oxygen concentration at the ground/surface-water interface or the presence of other chemicals, such as the hydrogen sulfide in the Green River Spring.

Aquatic insects of the orders Coleoptera (beetles) and Diptera (true flies) were best represented in the list of macroinvertebrates compiled during this study. Whereas most of the springs contributed to the dipteran inventory, Millers Blue Hole contributed all but two of the 18 taxa of coleopterans. Previously published reports for Canadian springs (Biological Survey of Canada, 1990; Roughley and Larson, 1991; Williams and Smith, 1990) also include numerous species of aquatic beetles. Only 2 of 63 Canadian and Alaskan species were found in common among the 18 species of aquatic beetles in this study, possibly because of latitudinal differences. In contrast, the high degree of overlap between Canadian spring chironomids and the ones found in this study can be attributed to the widespread distribution of many species in the genera listed. Seven genera of chironomids in this study are new to the published and unpublished lists of spring chironomids by Bolton (Michael Bolton, Ohio EPA, written communication, 1998), who lists more than 136 taxa. Many of these genera are common and widespread, and not peculiar to spring habitats. Moreover, some of the springs we studied did not fall within the criteria that Bolton established for his springs. The absence of many stonefly, mayfly, and caddisfly taxa in our list was the result of a conscious decision on our part to concentrate on the immediate spring area and not to sample the spring run or brook characteristically included in other studies (*e.g.*, Minshall, 1968; Hunt, 1983).

The qualitative periphyton collection methods resulted in as many as 259 taxa at Cedar Bog and as few as 3 species at the Styx River tributary. The low diversity at some sites is not likely the consequence of collection methods that sampled all available substrates, but rather the small size and diversity of those sites and possible contamination of the ground-water source. Although one of the most striking features of permanent springs is the marked uniformity of algal flora throughout the year (Whitford and Schumacher, 1963), increasing the sampling effort to include other seasons (*i.e*., without tree canopy, thus increasing light availability) might add to the diversity of flora in the wooded sites. The culturing of small sediment cores (0.5 X 1.0 cm) at the spring seep sites might also reveal additional taxa, particularly those in the family Chlorophyceae, as found by Grondin and Johansen (1995).

Qualitative survey methods used in this study serve as a valuable initial step for documenting the flora and fauna. Quantitative surveys of periphyton on both hard and soft substrates, however, such as those described in Porter *et al.* (1993), would be more useful for measuring differences in the benthic community structure between sites and over time (Stevenson and Pan, 1999; Lowe and Pan, 1996). Other measures (such as nutrients, pesticides, sulfide, chlorophyll and algal ash-free dry weight), as well as sampling seasonally and after storms (when high concentrations of nutrients and pesticides are more likely to run off into springs), would provide a more complete characterization of the spring biota and water quality. Except for dissolved oxygen, the basic water-quality characteristics measured in this study did little to explain the differences in biotic communities among sites. A more focused attempt to relate spring biota to water-nutrients and toxics would be needed if spring biotas are ever to be used as indicators of ground-water quality with respect to domestic and agricultural use of spring water.

The method employed in collecting macroinvertebrates from the ten springs sampled in this study was perhaps not optimal, because the small and shallow springs pools were not easily sampled with kick-nets. Because of the lack of a water column in which to suspend the organisms prior to capture, a more viable technique in such situations would be to include shallow cores where possible to maximize the inclusion of taxa. For future studies, we suggest a multimethod approach to include collecting samples by kick-net, sweep-net, and sediment cores, as well as picking and washing samples from logs, leaf packs, and rocks. Use of these qualitative methods is suggested for initial surveys of occurrence and distribution of the biota found in springs, but quantitative methods could be developed once appropriate target taxa are selected for the range of physical and geochemical spring environments found in Ohio and elsewhere. These latter methods should include emergence traps for quantitative and life history studies of aquatic insects.

Another addition to this type of work that should be considered is a quality-assurance/quality-control (QA/QC) protocol for sample handling and identification. This is particularly important for laboratory identifications because of the potential for many taxa being uncommon, and in some cases endemic, to springs. We suggest that a stratified random sample of postprocessed/identified taxa be done, with emphasis on rare or endemic taxa. These are the species most likely to be misidentified or misassigned, even by experts. A QA/QC verification sample of 15-20% would be appropriate for such specialized habitats.

Acknowledgments

We extend our sincere thanks for taxonomic expertise to the following individuals: Rex L. Lowe, Bowling Green University, for algae; Wayne K. Gall, Buffalo Museum of Science, for crustaceans; Stephen W. Chordas III, Ohio Biological Survey, for Hemiptera and Odonata; Eric G. Chapman, Kent State University, for aquatic beetles; and Patrick L. Hudson, USGS Biological Resources Division, Great Lakes Science Center, for chironomids. We are also indebted to Michael J. Bolton, Ohio EPA; James J. Farmer, USGS Tennessee District, and numerous USGS personnel for reviewing all or parts of this manuscript.

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Table 1. Location and basic water-quality characteristics for ten Ohio springs.

Sampling Site	**Site ID Figs. 10-13**	**County**	**Latitude**	**Longitude**	**Sampling Date**	**Temp. (oC)**	**DO (mg/L)**	**pH**	Specific **Conductance (uS/cm)**
Millers Blue Hole	M	Sandusky	41º24'17"N	82º54'30"W	10-Jul-96	14.5	3.3	7.1	2310
Green River Spring	G	Sandusky	41º15'51"N	83º03'09"W	10-Jul-96	14.3	0.6	6.8	2520
Spring Fork	SF	Madison	39º59'23"N	83º23'06"W	9-Aug-96	19.0	1.5	7.1	635
Flowing Well	FW	Madison	39º45'29"N	83º17'22"W	9-Aug-96	19.3	5.8	7.4	789
Cedar Bog	CB	Champaign	40º03'00"N	83º47'00"W	6-Sep-96	19.3	6.1	7.5	709
Clear Creek	CC	Fairfield	39º35'58"N	82º38'05"W	17-Sep-96	15.5	6.8	7.7	148
Styx River	StR	Medina	41º03'52"N	81º48'36"W	24-Sep-96	14.0	7.1	8.1	440
Styx River tributary	StT	Medina	41º03'51"N	81º48'37"W	24-Sep-96	12.9	2.5	6.9	1040
Gorge Run	Gg	Summit	41º07'26"N	81º29'54"W	24-Sep-96	14.1	7.4	7.0	1010
Sand Run	SR	Summit	41º07'39"N	81º33'13"W	24-Sep-96	15.6	7.1	7.7	830

Table 2. List of algae identified from ten Ohio spring sites. (The algae reported in this study are arranged in alphabetical order within divisions, which are in phylogenetic order as described by the USGS Biological Unit at URL <http://wwwnwql.cr.usgs.gov/USGS/algae/algae.phylo.info.html>) [M = Millers Blue Hole, G = Green River Spring, SF= Spring Fork, FW = Flowing Well, CB = Cedar Bog, CC = Clear Creek, StR = Styx River, StT = Styx River tributary, Gg = Gorge Run, SR = Sand Run; x = present in the indicated spring].

Taxa	**Spring:**	**M**	**G**	**SF**	**FW**	**CB**	**CC**	**StR**	**StT**	**Gg**	**SR**
Cyanophyta											
Chroococcus turgidus (Kuetz.) Naeg.						x					
Chroococcus varius A. Braun in Rabh.						x					
Hapalosiphon intricatus West and West				x							
Merismopedia punctata Meyen						x					
Phormidium autumnale (C.A. Agardh) Gomont			x								
Phormidium retzii (C.A. Agardh) Gomont			x								
Phormidium tenue (Meneghini) Gomont			x								
Schizothrix calcicola (C.A. Agardh) Gomont		x	x	x	x	x	x	x			
Spirulina major Kuetz.			x								
Lyngbya martensiana Meneghini		x									
N = 10.	**Subtotal for each site:**	2	5	2	1	4	1	1			
Rhodophyta											
Audouinella hermannii (Roth) Duby										x	
Batrachospermum gelatinosum (L.) DeCandolle						x					
N = 2.	**Subtotal for each site:**					1				1	
Cryptophyta											
Cryptomonas erosa Ehr.						x					
N = 1.	**Subtotal for each site:**					1					
Euglenophyta											
Trachelomonas hispida (Perty) Stein				x							
Euglena ehrenbergii Klebs				x							
N = 2.	**Subtotal for each site:**			2							
Chrysophyta											
Tribonema affine G. S. West		x									
N = 1.	**Subtotal for each site:**	1									
Bacillariophyta											
Achnanthes clevei Grun						x					
Achnanthes conspicua v. brevistriata Hust.		x									
Achnanthes deflexa Reim.						x					
Achnanthes exigua Grun.						x					
Achnanthes exigua v. constricta (Grun.) Hust						x					
Achnanthes exigua v. heterovalva Krasske						x					
Achnanthes hauckiana Grun.			x								
Achnanthes hungarica (Grun.) Grun.						x					
Achnanthes lanceolata (Breb. In Kutz.) Grun.		x	x	x	x	x	x	x		x	x
Achnanthes lanceolata v. dubia Grun.					x	x					
Achnanthes lanceolata v. omissa Reim.						x					
Achnanthes lapponica (Hust.) Hust.						x					
Achnanthes lapponica v. ninckei (Guerm and Mang.) Reim.							x				
Achnanthes linearis (W. Sm.) Grun.						x					
Achnanthes linearis f. curta H. L. Sm.						x					

Table 2. List of algae identified from ten Ohio spring sites, continued.

Taxa Spring:	M	G	SF	FW	CB	CC	StR	StT	Gg	SR
Bacillariophyta (continued)										
Achnanthes minutissimum (Kutz.) Czar.	x	x	x	x	x	x	x			
Achnanthes oestrupi (A. Cl.) Hust.					x					
Achnanthes peragalli v. fossilis Temp. and Perag.					x					
Achnanthes subrostrata (Hust.)						x				
Achnanthes wellsiae Reim.					x					
Amphipleura pellucida Kutz.	x				x					
Amphora michiganensis Stoerm. and Yang					x					
Amphora normanii Rabh.				x						
Amphora ovalis (Kutz.) Kutz.					x					
Amphora ovalis v. affinis (Kutz.) V. H. ex DeT.	x		x		x					
Amphora ovalis v. pediculus (Kutz.) V. H. ex DeT.					x					
Amphora perpusilla Grun.	x	x				x	x		x	
Amphora submontana Hust.			x		x					x
Amphora veneta Kutz.	x				x					
Amphora sp.										x
Aulicoseira granulata (Ehr.) Thwaites	x									
Brachysira vitrea (Grun.) Round and Mann					x					
Caloneis alpestris (Grun.) Cl.	x				x					
Caloneis bacillaris v. thermalis (Grun.) A. Cl.	x				x					
Caloneis bacillum (Grun.) Meresch.	x		x	x	x		x			
Caloneis hyalina Hust.			x							
Caloneis limosa (Kutz.) Patr.					x					
Caloneis ventricosa (Ehr.) Meist.					x					
Caloneis ventricosa v. alpina (Cl.) Patr.					x					
Caloneis ventricosa v. minuta (Grun.) Patr.					x					
Caloneis ventricosa v. truncatula (Grun.) Meist					x					
Campylodiscus noricus Hust.					x					
Cavinula pseudoscutiformis Mann and Stickle					x					
Cocconeis diminuta Pant.					x					
Cocconeis disculus (Schum.) Cl.					x					
Cocconeis fluviatilis Wallace					x					
Cocconeis pediculus Ehr.		x			x				x	
Cocconeis placentula Ehr.		x	x		x	x			x	
Cocconeis placentula v. euglypta (Ehr.) Cl.					x				x	
Cocconeis placentula v. intermedia (Herib. and Perag.) Cl.					x					
Cocconeis placentula v. lineata (Ehr.) V. H.	x				x					
Cocconeis thumensis A. Mayer					x					
Craticula cuspidata (Kutz.) Mann	x		x							
Ctenophora pulchella (Ralfs) Williams and Round	x									
Cyclotella comta (Ehr.) Kutz.	x									
Cyclotella kutzingiana Thwaites					x					
Cyclotella kutzingiana v. planetophora Fricke					x					
Cyclotella menenghiniana Kutz.	x		x		x					
Cyclotella operculata Kutz.					x					
Cymatopleura elliptica (Breb.) W. Sm.					x					
Cymatopleura solea (Breb.) W. Sm.					x					
Cymbella aequalis W. Sm. In Grev.					x					
Cymbella aequalis v. subaequalis Grun.					x					
Cymbella affinis Kutz.					x					
Cymbella amphicephala Naeg. Ex. Kutz.					x					
Cymbella angustata (W. Sm.) Cl.					x					

Table 2. List of algae identified from ten Ohio spring sites, continued.

Taxa	Spring:	M	G	SF	FW	CB	CC	StR	StT	Gg	SR
Bacillariophyta (continued)											
Cymbella aspera (Ehr.) H. Perag.						x					
Cymbella cesatii (Rabh.) Grun. Ex. A. S.						x					
Cymbella cistula (Ehr.) Kirchn.		x				x					
Cymbella cymbiformus v. nonpunctata Font.			x								
Cymbella delicatula Kutz.						x					
Cymbella heteropleura (Ehr.) Kutz.						x					
Cymbella incerta (Grun.) Cl.						x					
Cymbella laevis Naeg. Ex Kutz.		x				x					
Cymbella microcephala Grun.		x	x			x					
Cymbella norvegica Grun.		x									
Cymbella obtussa (Greg.) Cl.						x					
Cymbella obtusiuscula (Kutz.) Grun.						x					
Cymbella parva (Hempr.) Kirchn.		x				x					
Cymbella parvula Krasske						x					
Cymbella rupicola Grun.						x					
Cymbella schmidtii Grun.						x					
Cymbella tumida (Breb. Ex Kutz.) V. H.						x					
Denticula elegans Kutz.						x					
Denticula tenuis Kutz.						x					
Denticula thermalis Kutz.						x					
Diadesmus contenta (Grun. Ex Heurck.) Mann		x					x	x			
Diadesmus perpusilla (Grun.) Mann								x			
Diatoma hiemale (Roth) Heib.						x			x		
Diatoma tenue Agardh						x					
Diatoma tenue v. elongatum Lyngb.						x					
Diatoma vulgare Bory				x							
Diatoma vulgare v. linearis Grun.						x					
Diploneis elliptica Kutz.						x		x			
Diploneis oblongella (Naeg.) Cl. - Euler		x		x		x		x			
Diploneis smithii (Breb.) Cl.						x					
Diploneis smithii v. dilata (M. Perag.) Boyer						x					
Encyonema brehmii (Hust.) Mann						x					
Encyonema minuta (Hilse in Rabenhorst) D.G. Mann		x		x		x					
Encyonema turgidum (Greg.) Grun. In A. S.						x					
Epithemia argus v. alpestris Grun.		x									
Epithemia argus v. longicornis (Ehr.) Grun.		x									
Epithemia sorex Kutz.		x									
Epithemia turgida (Ehr.) Kutz.		x				x					
Epithemia zebra v. saxonica (Kutz.) Patr.		x									
Eucocconeis flexella (Kutz.) Hust.						x					
Eucocconeis flexella v. alpestris Brun.						x					
Eunotia arcus Ehr.						x					
Eunotia curvata (Kutz.) Lagerst.				x		x					
Eunotia elegans Ostr.						x					
Eunotia pectinalis (O. F. Mull) Rabh.				x		x					
Eunotia pectinalis v. minor (Kutz). Rabh.						x					
Eunotia valida Hust.		x									
Fragilaria brevistriata v. capitata Herib.			x			x					
Fragilaria brevistriata v. inflatata (Pant.) Hust.		x									
Fragilaria capucina v. lanceolata Grun.						x					
Fragilaria capucina v. mesolepta Rabh.		x				x					
Fragilaria construens v. pumila Grun.						x					

Table 2. List of algae identified from ten Ohio spring sites, continued.

Taxa	Spring: M	G	SF	FW	CB	CC	StR	StT	Gg	SR
Bacillariophyta (continued)										
Fragilaria construens v. subsalina Hust.					x					
Fragilaria construens v. venter (Ehr.) Grun.					x					
Fragilaria crotonensis Kitton	x									
Fragilaria lapponica Grun.	x									
Fragilaria leptostauron v.dubia (Grun.) Hust.					x					
Fragilaria pinnata v. intercedens (Grun.) Hust.					x					
Fragilaria pinnata v. lancetula (Schum.) Hust.					x					
Fragilaria vaucheriae (Kutz.) Peters			x		x				x	
Fragilaria vaucheriae v. capitellata (Grun.) Patr.					x					
Fragilaria vaucheriae v. continua (C-Eul.) C-Eul.	x									
Fragilariforma virescens (Ralfs) Williams and Round	x				x					
Frustulia vulgaris (Thwaites) DeT.					x					
Gomphonema acuminatum Ehr.			x		x	x				
Gomphonema acuminatum v. brebissonii Kutz.	x				x					
Gomphonema acuminatum v. coronata (Her.) W. Sm.					x					
Gomphonema acuminatum v. pusilla Grun.					x					
Gomphonema acuminatum v. trigonocephala (Ehr.) Grun. In V. H.					x					
Gomphonema angustatum (Kutz.) Rabh.	x		x	x	x	x	x	x		
Gomphonema angustatum v. naviculaformis Mayer					x					
Gomphonema angustatum v. sarcophagus (Greg.) Grun.					x					
Gomphonema gracile Ehr. emend. V. H.		x			x					
Gomphonema gracile v. aurita Braun	x				x					
Gomphonema gracile v. lanceolata (Ehr.) emend. V. H.					x					
Gomphonema insigne Greg.	x	x	x		x					
Gomphonema intricatum Kutz.					x					
Gomphonema intricatum v. dichotomum Kutz.					x					
Gomphonema intricatum v. pumila Grun.	x				x					
Gomphonema intricatum f. pusilla Mayer					x					
Gomphonema lanceolata Ehr.	x				x					
Gomphonema montanum Schum.					x					
Gomphonema montanum v. subclavatum Grun. In V. H.					x					
Gomphonema olivaceum (Lyngb.) Kutz.	x	x	x		x			x		
Gomphonema parvulum Kutz.	x	x	x		x					
Gomphonema sphaerophorum Ehr.			x							
Gomphonema subclavatum (Grun.) Grun.									x	
Gomphonema subtile Ehr.	x				x					
Gomphonema subtile v. sagitta (Schum.) Cl.	x									
Gomphonema tergestinum (Grun.) Fricke		x	x	x						
Gomphonema truncatum Ehr.	x	x			x					
Gyrosigma acuminatum (Kutz.) Rabh.					x					
Gyrosigma attenuatum (Kutz.) Rabh.					x					
Gyrosigma scalproides (Rabh.) Cl.			x							
Gyrosigma spencerii (Quek.) Griff. and Henfr.			x		x					
Gyrosigma spencerii v. curvula (Grun.) Reim.					x					
Hantzschii amphioxys (Ehr.) Grun.	x		x			x				
Luticola heufleriana (Grun.) Mann			x							
Luticola mutica (Kutz.) Mann						x				
Luticola mutica v. tropica	x									

Table 2. List of algae identified from ten Ohio spring sites, continued.

Taxa Spring:	M	G	SF	FW	CB	CC	StR	StT	Gg	SR
Bacillariophyta (continued)										
Martyana ansata (as Opephora ansata Horn and Hellerman)					x					
Martyana martyi (Heribaud) Round comb. Nov.					x					
Mastogloia grevillei W. Sm.	x									
Mastogloia smithii v. lacustris Grun.	x				x					
Melosira varians C. A. Ag.		x	x							
Meridion circulare (Grev.) Ag.	x	x	x	x	x					
Meridion circulare v. constricta (Ralfs) V. H.					x					
Meridion lineare D. M. Williams					x					
Navicula abiskoensis Pant.	x		x							x
Navicula atomus (Kutz.) Grun.					x					
Navicula cryptocephala Kutz.			x	x	x					
Navicula cryptocephala v. exilis (Kutz.) Grun.			x							
Navicula cryptocephala v. veneta (Kutz.) Rabh.		x	x		x	x				
Navicula elginensis (Greg.) Ralfs					x					
Navicula elginensis v. rostrata (A. Mayer) Patr.					x					
Navicula falaisiensis v. lanceolata Grun.					x					
Navicula graciloides A. Mayer			x							
Navicula gregaria Donk.									x	
Navicua halophila (Grun.) Cl.		x								
Navicua halophila v. tenuirostris Hust.					x					
Navicula hasta Pant.					x					x
Navicula heufleri Grun.					x		x			
Navicula heustedtii Krasske			x	x						
Navicula lanceolata (Ag.) Kutz.		x	x		x					
Navicula minuscula Schumn.	x									
Navicula minima Grun.					x					
Navicula muralis Grun.					x					
Navicula nigrii De Not.	x									
Navicula nivalis Ehr.	x									
Navicula notha Wallace					x					
Navicula oblonga (Kutz.) Kutz.	x	x			x					
Navicula paludosa v. rhomboidea Reimer					x					
Navicula paucivisitata Patr.					x					
Navicula pelliculosa Hilse.					x					
Navicula potzgeri Reim.					x					
Navicula pupula v. capitata Skv. and Meyer					x					
Navicula pupula v. mutata (Krasske) Hust.					x					
Navicula pupula v. rectangularis (Greg.) Grun.	x				x					
Navicula radiosa Kutz.	x				x					
Navicula radiosa v. tenella (Breb. Ex Kutz.) Grun.	x	x	x		x	x	x			
Navicula rhychocephala Kutz.					x					
Navicula salinarum v. intermedia (Grun.) Cl.					x					
Navicula seminuloides Cl. Et Grun.					x					
Navicula seminulum Grun.	x		x	x	x				x	
Navicula seminulum v. hustedtii Patr.					x				x	
Navicula seminulum v. intermedia Gust.					x					
Navicula simplex Krasske	x									
Navicula simula Patr.					x					
Navicula sohrensis Krasske							x			
Navicula subbacillum Hust.					x					
Navicula subhamulata Grun.					x					

Table 2. List of algae identified from ten Ohio spring sites, continued.

Taxa	M	G	SF	FW	CB	CC	StR	StT	Gg	SR
Bacillariophyta (continued)										
Navicula symmetrica Patr.					x	x				
Navicula tenelloides Hust.					x					
Navicula tridentula Krasske					x					
Navicula tripunctata (O. F. Mull) Bory			x		x					
Navicula tripunctata v. schizonemoides (V. H.) Patr.					x					
Navicula vanheurckii Patr.					x					
Navicula viridula (Kutz.) Kutz. Emend. V. H.					x					
Navicula viridula v. argunensis Skv.	x									
Navicula viridula v. avenacea (Breb. Ex. Grun.) V. H.					x					
Navicula viridula v. rostellata (Kutz.) Cl.					x					
Neidium binode (Ehr.) Cl.					x	x				
Neidium bisulcatum (Lagerst.) Cl.					x					
Neidium iridis (Ehr.) Cl.					x					
Neidium iridis v. ampliatum (Ehr.) Cl.	x									
Nitzschia acicularis (Kutz.) W. Sm.			x		x					
Nitzschia adapta Hust.					x					
Nitzschia amphibia Grun.	x	x	x	x	x					
Nitzschia angustata (W. Sm.) Grun.					x					
Nitzschia angustata v. acuta Grun.					x					
Nitzschia apiculata (Greg.) Grun.					x					
Nitzschia capitellata Hust.					x					
Nitzschia clausii Hantz.					x					
Nitzschia debilis (Kutz.) Grun.	x						x			
Nitzschia denticula Grun.	x				x					
Nitzschia dissipata (Kutz.) Grun.		x	x		x					
Nitzschia dubia W. Sm.			x							
Nitzschia filiformis (W. Sm.) Hust.					x					
Nitzschia fonticola Grun.					x					
Nitzschia frustulum Kutz.	x				x					
Nitzschia gracilis Hantz.					x					
Nitzschia hantzschiana Rabh.					x					
Nitzschia kutzingiana Hilse					x					
Nitzschia linearis W. Sm.	x		x		x	x	x			x
Nitzschia palea (Kutz.) W. Sm.		x	x	x	x					
Nitzschia parvula W. Sm.				x						
Nitzschia perminuta (Grun.) Perag.		x	x	x					x	
Nitzschia recta Hantz.					x					
Nitzschia romana Grun.					x					
Nitzschia sigmoidea (Nitz.) W. Sm.	x				x					
Nitzschia sinuata v. delognei (Grun.) Lange-Bert.									x	
Nitzschia spectibilis (Ehr.) Ralfs and W. Sm.					x					
Nitzschia stagnorum Rabh.					x					
Nitzschia sublinearis Hust.					x					
Nitzschia subtilis Grun.					x					
Nitzschia tropica Hust.	x				x					
Nitzschia vivax (W. Sm.) Hantz.					x					
Pinnularia abaujensis v. rostrata (Patr.) Patr.					x					
Pinnularia braunii v. amphicephala (A. Mayer) Hust.					x					
Pinnularia brebissonii (Kutz.) Rabh.	x						x			
Pinnularia brebissonii v. diminuta (Grun.) Cl.						x				
Pinnularia brevicostata Cl.					x					
Pinnularia flexuosa Cl.					x					

Table 2. List of algae identified from ten Ohio spring sites, continued.

Taxa	Spring:	M	G	SF	FW	CB	CC	StR	StT	Gg	SR
Bacillariophyta (continued)											
Pinnularia gibba Ehr.				x							
Pinnularia kneuckeri Hust.		x									
Pinnularia mesogongyla Ehr.						x					
Pinnularia mesolepta (Ehr.) W. Sm.						x					
Pinnularia rupestris Hantz.						x					
Pinnularia viridis (Nitz.) Ehr.		x				x	x				
Pinnularia viridis v. minor Cl.						x					
Pinnularia viridis v. sedetica (Hilse) Herib.						x					
Reimeria sinuata (Greg.) Kociolek and Stoermer								x			
Rhoicosphenia curvata (Kutz.) Grun. Ex. Rabh.		x	x	x	x	x	x			x	
Rhopalodia gibba (Ehr.) O. F. Mull		x				x					
Rhopalodia gibberula (Ehr.) O. F. Mull		x									
Sellophora laevissima Mann						x					
Sellophora pupula Hust.			x			x					
Stauroneis anceps Ehr.				x		x					
Stauroneis anceps v. americana Reim.				x							
Stauroneis kriegeri Patr.				x							
Stauroneis phoenocentron (Nitz.) Ehr.						x					
Stauroneis phoenocentron v. braunii (M. Perag. and Herib.) Voigt						x					
Stauroneis smithii Grun.						x		x			
Staurosira construens Ehr.						x					
Staurosirella leptostauron (Ehr.) Williams and Round						x					
Staurosirella pinnata (Ehr.) Williams and Round						x					
Stenopterobia delicatissima Breb.						x					
Stephanodiscus hantzschii Grun.		x									
Stephanodiscus invisitatus Hohn and Hellerm.		x									
Surirella angustata Kutz.		x		x		x		x			
Surirella ovata Kutz.				x		x					
Surirella ovata v. pinnata W. Sm.				x							
Surirella robusta Ehr.						x					
Surirella robusta v. spendida Ehr.						x					
Synedra fasciculata (Ag.) Kutz.			x			x					
Synedra fasciculata v. truncata (Grev.) Patr.						x					
Synedra filiformis v. exilis Cl.-Eul.						x					
Synedra minuscula Grun.		x				x					
Synedra parasitica (W. Sm.) Hust.						x					
Synedra parasitica v. subconstricta (Grun.) Hust.						x					
Synedra radians Kutz.		x				x					
Synedra ulna (Nitz.) Ehr.				x		x					
Synedra ulna v. danica (Lutz.) V. H.		x									
Synedra ulna v. longissima (W. Sm.) Brun.						x					
Synedra ulna v. subaequalis (Grun.) V. H.						x					
Thalassiosira pseudonanna Hasle and Heimdal		x									
Tryblionella calida (Grun. and Cl.) Mann				x							
Tryblionella hungarica Grun.		x		x		x					
N = 314.	**Subtotal for each site:**	85	29	56	16	246	18	18	3	14	6

Table 2. List of algae identified from ten Ohio spring sites, continued.

Taxa	Spring:	M	G	SF	FW	CB	CC	StR	StT	Gg	SR
Chlorophyta											
Chaetophora elegans (Roth) C.A. Agardh			x								
Cladophora glomerata (L.) Kuetz.			x							x	
Closterium moniliferum Breb.			x								
Closterium subulatum (Kutz.) Breb.						x					
Cosmarium reniforme (Ralfs) Arch.						x					
Microthamnion strictissimum Rabh.								x			
Mougeotia sp.		x	x		x	x					
Oedogonium sp.		x									
Oocystis submarina Lager.		x									
Pleurotaenium ehrenbergii (Breb.) DeBary						x					
Rhizoclonium crassipellitum West and West				x	x						
Spirogyra sp.		x			x	x					
Tribonema minus (Wille) Hazen		x									
Ulothrix subtilissima Rabh.								x			
Zygnema sp.		x									
N = 15.	**Subtotal for each site:**	6	4	1	3	5		2		1	
Charophyta											
Chara vulgaris L.		x				x					
N = 1.	**Subtotal for each site:**	1				1					
All Algal Divisions											
Total		**M**	**G**	**SF**	**FW**	**CB**	**CC**	**StR**	**StT**	**Gg**	**SR**
N = 346.	**Subtotal for each site:**	95	38	56	16	258	19	21	3	15	6

Note on algal taxonomy:

Most of the *Achnanthes* belong in the genus *Achnanthidium* but authorities were not available at this time. Thus, the varieties of some new genera were listed above under their old generic names.

New Name	=	Old Name with Authority
Pseudostaurosira brevistriata v. capitata	=	Fragilaria brevistriata v. capitata Herib.
Pseudostaurosira brevistriata v. inflata	=	Fragilaria brevistriata v. inflatata (Pant.) Hust.
Sellophora pupula v. capitata	=	Navicula pupula v. capitata Skv. and Meyer
Sellophora pupula v. mutata	=	Navicula pupula v. mutata (Krasske) Hust.
Sellophora pupula v. rectangularis	=	Navicula pupula v. rectangularis (Greg.) Grun.
Staurosira construens v. pumila	=	Fragilaria construens v. pumila Grun.
Staurosira construens v. subsalina	=	Fragilaria construens v. subsalina Hust.
Staurosira construens v. venter	=	Fragilaria construens v. venter (Ehr.) Grun.
Staurosirella leptostauron v. dubia	=	Achnanthes lanceolata v. dubia Grun.
Staurosirella pinnata v. intercedens	=	Fragilaria pinnata v. intercedens (Grun.) Hust.

Table 3. List of macroinvertebrates identified from the ten Ohio spring sites (*x* = present in the indicated spring). [M=Millers Blue Hole; G = Green River Spring; SF = Spring Fork; FW = Flowing Well; CB = Cedar Bog; CC = Clear Creek; StR = Styx River; StT = Styx Tributary; Gg = Gorge; SR = Sand Run].

Taxa	Spring:	M	G	SF	FW	CB	CC	StR	StT	Gg	SR
Annelida											
Oligochaeta		x	x	x	x					x	x
Hirudinea - Erpobdellidae		x		x							
Mollusca											
Gastropoda											
Amnicola limosus						x					
Elimia livescens						x					
Fossaria parva		x			x	x					
Gyraulus parvus		x	x								
Marstonia decepta					x						
Physella gyrina		x		x	x						
Physella integra				x		x					
Planorbella armigera				x	x						
Pomatiopsis lapidaria				x							
Pseudosuccinea columella					x						
Bivalvia											
Pisidium sp.					x	x					
Arthopoda											
Crustacea											
Amphipoda											
Crangonyx sp.		x									
Hyallela azteca		x		x		x					
Synurella dentata					x						
Isopoda											
Caecidotea cf. racovitzai		x		x	x						
Caecidotea cf. intermedius										x	
Lirceus cf. fontinalis					x						
Insecta											
Coleoptera - Haliplidae											
Haliplus immaculicollis		x									
Peltodytes sp.		x									
Coleoptera - Dytiscidae											
Copelatus glyphicus		x									
Dytiscus sp.					x						
Hygrotus nubilis		x									
Hydroporus niger		x									
Coleoptera - Elmidae											
Dubiraphia sp.						x					
Coleoptera - Hydrophilidae											
Anacaena limbata		x									
Berosus striatus		x									
Enochrus cinctus		x									
Enochrus ochraceus		x									
Enochrus sayi		x									
Helophorus lineatus		x									
Helophorus linearis		x									

Table 3. List of macroinvertebrates identified from the ten Ohio spring sites, continued.

Taxa	**Spring:**	**M**	**G**	**SF**	**FW**	**CB**	**CC**	**StR**	**StT**	**Gg**	**SR**
Coleoptera - Hydrophilidae, continued.											
Helophorus maginicollis		x									
Hyrdrobius fuscipes		x									
Paracymus subcupreus		x									
Tropisternus lateralis nimb.		x									
Diptera - Ceratopogonidae											
Bezzia sp.		x									
Forcipomyia sp.										x	
Probezzia sp.											x
Diptera - Chironomidae											
Ablabesmyia sp.						x					
Acricotopus sp.		x	x								
Brillia sp.		x					x			x	
Chaetocladius sp.					x						
Chironomus sp.			x								
Conchapelopia sp.					x	x					
Cryptochironomus sp.						x					
Heterotrissocladius sp.					x	x	x				
Krenopelopia sp.					x		x	x			
Larsia sp.		x		x			x				
Micropsectra sp-1.		x			x						
Micropsectra sp-2.							x	x			
Pagastia sp.								x			
Paracladopelma sp.						x	x				
Parakiefferiella sp.			x								
Paralauterborniella sp.						x					
Paraphaenocladius sp-1.		x			x		x			x	
Paraphaenocladius sp-2.					x		x				
Paratendipes sp.					x						
Polypedilum sp.							x				
Procladius sp.						x					
Prodiamesa sp.					x						
Psectrotanypus sp.				x							
Pseudochironomus sp.		x									
Rheocricotopus sp.								x			
Rheotanytarsus sp.						x					
Stempellinella sp.						x					
Symposiocladius lignicola								x			
Thienemannimyia sp.					x						
Zavrelimyia sp.						x	x				
Diptera -Culicidae											
Culex sp.		x		x							
Diptera - Dixidae											
Dixa sp.					x						
Diptera - Muscidae											
Limnophora sp.				x							
Diptera - Ptychopteridae											
Ptychoptera sp.					x						
Diptera - Simulidae											
Simulium sp.		x									

Table 3. List of macroinvertebrates identified from the ten Ohio spring sites, continued.

Taxa	**Spring:**	**M**	**G**	**SF**	**FW**	**CB**	**CC**	**StR**	**StT**	**Gg**	**SR**
Diptera - Stratiomyidae											
Stratiomys sp.						x					
Diptera - Tipulidae											
Hexatoma sp.									x	x	
Pedicia sp.				x							
Prionocera sp.									x		
Ephemeroptera											
Hexagenia sp.				x							
Paraleptophlebia sp.						x					
Hemiptera - Corixidae											
Hesperocorixa obliqua		x									
Sigara alternata		x									
Hemiptera - Gerridae											
Gerris insperatus				x							
Gerris remigus			x								
Megaloptera											
Chauliodes sp.				x							
Nigronia sp.							x		x		
Odonata - Anisoptera											
Anax junius		x		x							
Cordulegaster sp.							x				
Libellula sp.		x									
Pachydiplax longipennis		x									
Odonata - Zygoptera											
Coenagrion/Enallagma sp.			x								
Ischnura verticallis		x									
Lestes rectangularis		x									
Total		**M**	**G**	**SF**	**FW**	**CB**	**CC**	**StR**	**StT**	**Gg**	**SR**
N = 95	**Subtotal for each site:**	40	7	17	23	19	12	5	3	6	2