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Benthic Algae Taxa (Exclusive of Diatoms) of the Little River Basin, Western Kentucky, 2000–2003

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ABSTRACT

The Little River is a highly disturbed system, heavily impacted by non-point source pollution from agricultural runoff in the form of excessive siltation, nitrogen and phosphorus, and organic pollution. Sixty-seven taxa of non-diatom benthic algae were documented for 16 sites in the Little River basin of western Kentucky during four sampling periods in 2000 and 2003. Algal taxa most often encountered included members of the Cyanophyta: *Oscillatoria lutea* (15 of 16 sites), *O. subbrevis* (13 of 16 sites), and *Schizothrix calcicola* (15 of 16 sites). Chlorophyta taxa most often encountered included *Oedogonium* sp. and *Rhizoclonium hieroglyphicum*, both at 10 of 16 sites. No trends were found between the algal taxa and areas of nutrient enrichment in the Little River basin. Because little is known of the benthic algal flora in the Little River, this report represents information complementary to that published previously on the benthic diatom taxa found at the same sites during the same study period.

KEY WORDS: "soft" benthic algae, water quality, pollution, streams, agricultural, Kentucky, North America

INTRODUCTION

Algae have been used as water quality indicators for over a century. Although most of the attention and effort has focused on diatoms (Bacillariophyta) as environmental indicators (Patrick and Reimer 1966, 1975; Lowe 197; Dixit et al. 1992; Stoermer and Smol 1999; Mezor et al. 2006), the non-diatom, "soft" algae have been shown to give further insights into habitat characteristics and water quality of lotic ecosystems as well (Prescott 1951; Palmer 1977; VanLandingham 1982; Rott 1991; Wehr and Sheath 2003). Benthic algal community composition reflects changes in nutrient and organic pollution inputs resulting from human activities.

The Little River basin drains a variety of land-uses; however, non-point source agricultural runoff is the primary contributor of pollutants (KDOW 1996; KWRRI 1999). While several references exist for algae in the southeastern U.S. (e.g., Dillard 1990, 1991, 1993, 2000), relatively few publications describe the composition of algal communities of western Kentucky streams and rivers. The purpose of this paper is to document the non-diatom benthic algal taxa found at 16 sites in the Little River basin during four sampling surveys in 2000 and 2003. This report complements the diatom taxa list of Hendricks et al. (2006) in the Little River basin.

STUDY SITES

The study sites in the Little River basin were characterized by Hendricks et al. (2006). Briefly, the Little River is located in the Lower Cumberland basin in western Kentucky and drains approximately 1190 km^2 (KDOW 1996). Geology of the basin is karst limestone, sandstone, and shale. Numerous springs provide the Little River with a relatively constant baseflow, and substrates are dominated by gravel, sand, silt, and bedrock. Land-use is primarily agricultural, but there also is extensive urban/suburban development around the towns of Hopkinsville and Cadiz. Little riparian vegetation exists in the basin to act as buffer strips for runoff.

Sixteen sites (Figure 1) were sampled for algae as part of a larger assessment of habitat, biological, and chemical conditions (White et

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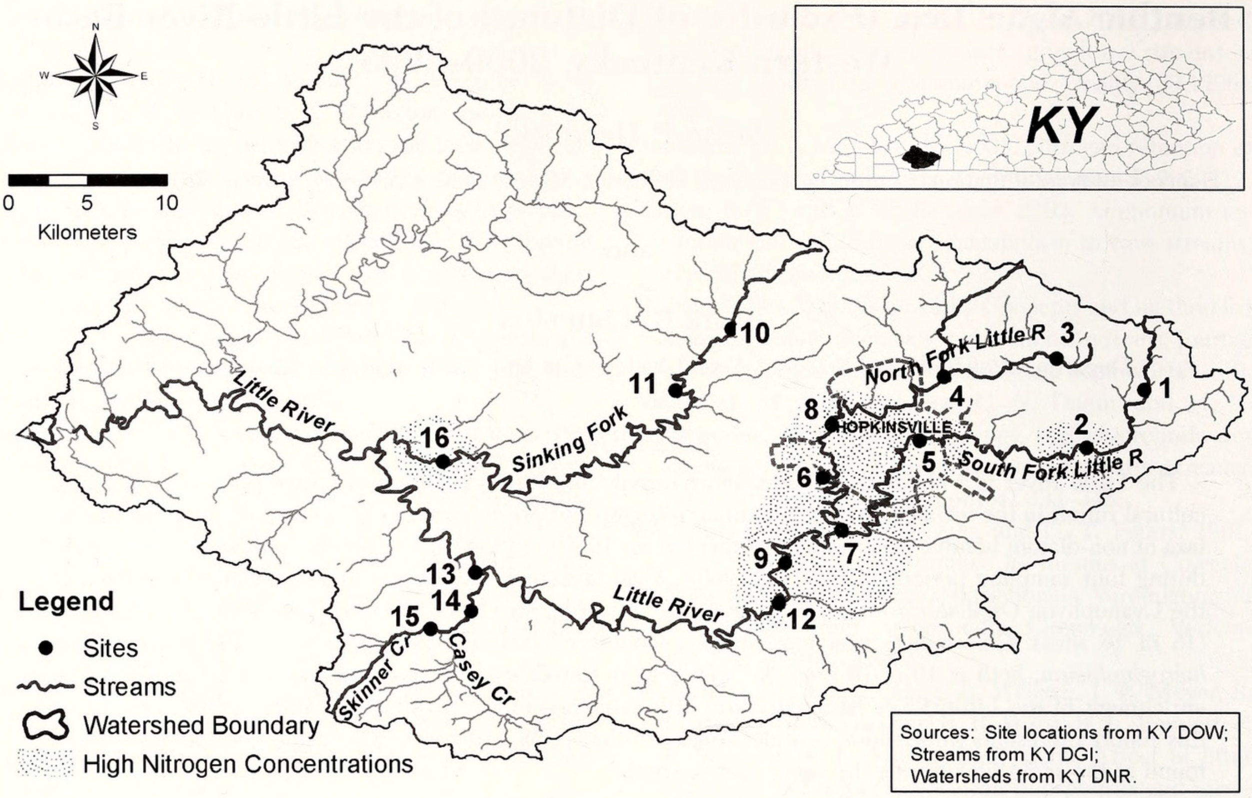

Figure 1. Study reaches in the Little River Basin. Stippled areas represent sites where NO_3+NO_2-N concentrations were highest in the basin (3.6–4.7 mg/l). Sites 6–9 and 12 around Hopkinsville were where PO_4-P concentrations were high (> 0.1 mg/l). Modified from Hendricks et al. (2006).

al. 2001; Hendricks et al. 2006) in the Little River. All sampling took place in spring (May or June) and summer (early September) of 2000 and 2003. NO_3+NO_2-N concentrations were highest in many areas of the basin during the study period, ranging from 3.6–4.7 mg/l (Figure 1). Sites 6–9 and 12 near or downstream from Hopkinsville were relatively high in PO_4-P as well with concentrations ranging from 0.10–0.37 mg/l. Other physicochemical conditions have been presented in detail in a previous publication (see Hendricks et al. 2006) and, therefore, are not included here.

MATERIALS AND METHODS

Composite, qualitative algal samples were collected at all sites from all major habitats and substrate types including riffles, pools, runs, rock, sand, and woody debris. Standard collection and identification methods used have been described in KDOW (2002). All samples were collected from natural substrates when stream flow was normal to low. Algae were sampled using a micro-spatula for scraping substrates and/or a turkey baster for sucking material from substrates. Algae were placed in 60-ml Nalgene™ bottles as a composite sample from each site, preserved in 2% gluteraldehyde, and refrigerated until processed.

The non-diatom, soft-bodied algae were subsampled from the preserved, composite sample, mounted on pre-cleaned microscope slides, identified to the lowest possible taxon (genus and species where possible) using standard taxonomic keys (Drouet 1981; Komárek and Fott 1983; Prescott 1951; Wehr and Sheath 2003; Whitford and Schumacher 1984), and counted. A minimum of 3 slides was created and counted for each sample. Some species were reported as being of uncertain identity but were identified to genus and included on the checklist. These taxa, noted as sp. 1, 2, 3, etc., were consistently recognized as taxonomic units and were included in the total number of taxa.

Fixed slides, preserved samples, bench sheets, and field shields were archived at Hancock Biological Station.

RESULTS AND DISCUSSION

Sixty-seven taxa representing five phyla of benthic "soft" algae were identified from the Little River basin in 2000 and 2003 (Table 1). Twenty-three taxa belonged to the Chlorophyta, 37 taxa to the Cyanophyta, 5 taxa to the Rhodophyta, and one taxon each to the Euglenophyta and the Cryptophyta. Sixteen taxa identified to genus only were noted; their species were unknown or of uncertain identity. Some species, such as those in the genera *Closterium* and *Gonium*, are known to occur but have not yet been described; hence the notation sp. 1.

Ten taxa (15% of total) were found during both 2000 and 2003. Thirty-two taxa (50% of total) were found only in 2000 while 23 taxa (35% of total) were found only in 2003. Site 12 had the fewest taxa (8), while site 3 had the highest (27).

Soft, benthic algal taxa most often encountered included members of the Cyanophyta: *Oscillatoria lutea* (15/16), *O. subbrevis* (13/16), and *Schizothrix calcicola* (15/16). *O. lutea* is tolerant of high salinities (Cloern and Dufford 2005). *O. subbrevis* is commonly found in sewage treatment ponds (Haughey 1969) and, therefore, is highly tolerant of organic pollution. *Schizothrix* species are also tolerant of saline conditions (Komárek et al. 2003). Cyanophyta in general are known to reside under highly eutrophic conditions, such as those found in the Little River, and were fairly evenly distributed throughout the basin.

Two members of the Chlorophyta, *Oedogonium* sp. and *Rhizoclonium hieroglyphicum*, were commonly encountered at 10 of 16 sites. *R. hieroglyphicum* is the most common of the 5 freshwater *Rhizoclonium* species found in North America and lives on turtles (John 2003). *Mougeotia* sp. was another chlorophyte found fairly commonly throughout the basin.

Two phyla, the Euglenophyta and the Cryptophyta, were represented by one taxon each, *Euglena* sp. and *Cryptomonas* sp., respectively. *Euglena* species are known to be tolerant of organic pollution (Lackey 1968) and reside in aquatic systems surrounded by agriculture (Rosowski 2003).

In a previous study carried out on the Little River in 1988 (KDOW 1996) five phyla and 42 taxa were represented: Chlorophyta (24), Chrysophyta (2), Cyanophyta (11), Euglenophyta (3), and Rhodophyta (2). Notable differences between the two studies were that no chrysophytes were found in the present study, and no cryptophytes were found in the 1988 study. Further, the Euglenophyta in the 1988 study were represented by *Phacus* and *Traechelomonas*; only *Euglena* was found in this study. Euglenophytes in general are known to tolerate organic pollution and eutrophic conditions.

The Rhodophyta (red algae) were represented by different taxa in the two studies. It should be noted that *Batrachospermum* was found during the 1988 study, and although it was observed in the field and collected during the present study, it did not appear in any subsamples. *Batrachospermum* has been included in Table 1 because of our field observations. A total of 16 taxa was shared between the two studies, and when both studies were combined, a total of 77 taxa of soft-bodied algae now have been recorded for the Little River basin since 1988. Notably, many more cyanophytes were found during this study than in 1988 (37 vs. 11, respectively).

We have no explanation for the discrepancies in taxa held in common between the two sampling years of this study, 2000 and 2003, or between the present study and that of 1988 (KDOW 1996). Perhaps the sample composites made in the present study were more representative of the total flora than those in 1988. Results of the 1988 study were based on only one sampling survey, whereas the present study was based on two sampling periods (two seasons) from two years with the results combined (Table 1). Thus, the greater diversity presented here should not be too surprising. Similarly, many more diatoms were found in 2000 and 2003 than in the 1988 study (Hendricks et al. 2006).

CONCLUSIONS

The Little River is a highly disturbed system, receiving excessive agricultural runoff and some urban/suburban inputs in the form of nutrients (N and P), organics, pesticides, and silt. The canopy has been opened up throughout much of the basin with little riparian vegetation. With high nutrient loading and higher light intensity reaching these disturbed habitats, algal growth may be stimulat-

Table 1. Non-diatom algal taxa found in the Little River basin by site. Occurrences are noted from 2000 (x/) and 2003 (/x) or both (x/x). Sites are ordered from upstream to downstream in respective reaches and correspond with Figure 1.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
Taxon																
CHLOROPHYTA																
Ankistrodesmus falcatus var. *mirabilis* (West & West) G. S. West					/x											
Characium pringsheimii A. Braun		x/		x/				x/				x/				x/
C. rostratum Reinhard ex Printz				x/												
Cladophora sp.	/x	/x				x/			x/	x/			x/			x/
Closterium moniliferum Ehrenberg ex Ralfs					/x											
C. sp. 1															x/	
Cylindrocapsa conferta W. West				/x												
Dichotomosiphon tuberosus (A. Braun ex Kützing) A. Ernst											/x					
Eudorina elegans Ehrenberg				x/												
Gonium pectorale O. F. Müller														x/		
Gonium sp.1														x/	x/	
Hydrodictyon reticulatum (L.) Lagerheim					/x											
Mougeotia sp.		x/		x/x					x/		x/	x/	x/	x/	x/	
Oedogonium sp.	x/	x/x		x/x	x/x	x/					/x	x/x		x/x	/x	/x
Pithophora kewensis Wittrock		x/		x/		x/		x/								
Rhizoclonium crassipelitum West & West													/x			
R. hieroglyphicum (C. Agardh) Kützing	x/			x/x	/x				x/		/x	x/x	/x	/x	x/x	/x
R. hookeri Kützing		x/		/x	/x		/x	/x								
Scenedesmus dimorphus (Turpin) Kützing				x/	x/											
S. quadricauda (Turpin) Brébisson				x/			/x									
Spirogyra sp.	/x			x/x	/x											
Stigeoclonium sp.														x/		
Ulothrix sp.								x/								
CRYPTOPHYTA																
Cryptomonas sp.					x/											
CYANOPHYTA																
Anabaena sp.				/x	/x										x/	x/
Aphanocapsa sp.				x/												
Calothrix parietina (Nägeli) Thuret														x/		
C. sp.											/x					
Chamaesiphon incrustans Grunow		x/									x/	x/				
Chroococcus turgidus (Künzing) Nägeli				x/												
Chroococcus sp.								x/		x/		/x				
Coccochloris elabans (Breb.) Drouet and Daily				x/												
Coelosphaerum sp.							/x									
Dactylococcopsis acicularis Lemmermann	/x	/x														
Lyngbya diguetii Gomont		/x		/x		/x										
L. limnetica Lemmermann								/x								
L. nana Tilden	/x															
Merismopedia punctata Meyen	x/		x/	x/		x/					x/	x/		x/		
Nostoc sp.			x/		x/							x/				
Oscillatoria agardhii Gomont									/x						/x	/x
O. amoena (Kützing) Gomont							/x							/x		
O. articulata (Gard.)			/x													
O. limnetica Lemmermann	/x										/x					
O. lutea C. Agardh	x/		x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/
O. nigra Vaucher							/x	/x		/x		/x		/x	/x	
O. rubescens De Candolle			/x	/x	/x		/x									
O. splendida Greville											/x					
O. subbrevis Schmidle			/x	/x	/x	/x	/x	/x	/x	/x	/x		/x	/x	/x	/x
O. submembranacea Ardissone & Strafforello ex Gomont							x/									
O. tenuis C. Agardh		/x	/x	/x		/x					/x	/x				

Table 1. Continued.

	South Fork			North Fork				Little River			Sinking Fork			Casey/Skinner		
Sites	1	2	5	3	4	8	6	7	9	12	10	11	16	15	14	13
O. terebriformis C. Agardh	/x															
Oscillatoria sp.		x/	x/			x/										
Poryphyrosiphon animalis (C. Agardh) Drouet										x/						
P. notarisii Kützing ex Gomont						x/										
P. splendidus (Greville) Drouet		x/	x/	x/								x/		x/	x/	
Schizothrix arenaria Berkeley						x/						x/				
S. calcicola (C. Agardh) Gomont	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/	x/		x/	x/	x/	
S. friesii (C. Agardh) Gomont				x/												
S. sp.			x/		x/			x/	x/						x/	
Spirulina subsalsa Örsted				x/												
Stichosiphon sansibaricus Örsted			x/		x/	x/		x/	x/						x/	
EUGLENOPHYTA																
Euglena sp.	x/															
RHODOPHYTA																
**Batrachospermum* sp.																
Lemanea cf. *fluviatilis*		x/	x/				x/		x/	x/			x/			
Lemanea sp.	/x		/x	/x					/x							
Rhotochorton sp.		/x	/x				x/	/x	x/x	x/	x/		x/			
Total Number of Taxa	13	15	15	27	17	13	13	12	13	8	15	13	9	14	14	9

* Encountered in the field and collected, but did not appear in subsamples. May be common throughout the basin.

ed rather than impaired as has been observed in other agriculturally impacted streams (Niyogi et al. 2004). High numbers of diatom taxa were found at sites with higher NO_3+NO_2-N (Hendricks et al. 2006); however, the soft-bodied algae were more evenly distributed throughout the basin and did not exhibit a strong pattern that reflected responses to higher nitrogen and phosphorus inputs.

Further studies of both diatom and non-diatom taxa, in relation to physicochemical conditions, will need to be carried out in order to clarify relationship between the algae and factors controlling their diversity in this lotic ecosystem. The list presented here is a useful documentation of the presence of algal taxa in the Little River basin that could be used in future comparative studies.

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