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Comparison of Macroinvertebrate Communities of Two Intermittent Streams with Different Disturbance Histories in Letcher County, Kentucky

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ABSTRACT

Small headwater streams receive little attention with regard to land management and regulatory policy, yet they greatly contribute to regional biodiversity and ecosystem function of their receiving streams. To ascertain differences associated with past logging and mining disturbances, I surveyed the macroinvertebrate communities of two first-order streams in the Eastern Coalfield Region (Letcher County, Kentucky) in spring, summer, fall, and winter 1998–1999. The reference stream drains old-growth forest in Lilley Cornett Woods; the disturbed stream lies in an adjacent hollow that was logged ca. 1940s and contour-mined ca. 1975. Benthic macroinvertebrates were collected using both quantitative and qualitative techniques at one site in each watershed. Results showed that the reference stream scored higher in measures of taxon richness, EPT richness, density, and diversity (H') but did not differ greatly in the pollution tolerance index (mHBI) or functional feeding group organization. Seasonal differences in taxon richness, EPT richness, density, and diversity within individual streams were noted and were attributed to life history phenologies of the resident taxa. Both streams had dominant taxa in common in spring (e.g., *Paraleptophlebia, Epeorus*), summer (e.g., *Leuctra, Paraleptophlebia*), fall (e.g., *Diplectrona, Paraleptophlebia*), and winter (e.g., *Ephemerella, Epeorus*), but wide variation in relative abundances were observed for most species. These results provide a reference for future comparisons of macroinvertebrate community structure in these and other small streams in the region.

INTRODUCTION

Streams draining old-growth forests offer valuable reference information on stream ecosystem structure and function. In Kentucky, only remnants of old growth forest exist, but they still provide a valuable source of baseline ecological data. Stream systems degraded by anthropogenic activities such as agriculture, logging, mining, and urbanization are widespread in Kentucky (Kentucky Division of Water 1996). In the eastern coal field region of the state, many small streams have been directly impacted by surface mining and recent logging. Therefore, it is important to document those biological communities in the remaining undisturbed streams. Since the turn of the century, aquatic organisms have been used extensively in water quality monitoring and impact assessment (Cairns and Pratt 1993). In addition to their use in biological monitoring and assessment, aquatic invertebrates are extremely important in stream ecosystem processes (Cummins 1974). Furthermore, general inventories of invertebrate taxonomic groups are needed to help document and explain patterns of biodiversity in Kentucky.

Lilley Cornett Woods (LCW) has served as an Appalachian ecological research station since 1969. It has been the focus of numerous environmental studies including hydrogeology (Conrad 1983); vegetation (Martin 1975; Martin and Sheperd 1973; Muller 1982; Sole et al. 1983; and others); mammals (Barels 1985); birds (Hudson 1972; Schwierjohann and Elliott unpub. data); and reptiles and amphibians (Cupp and Towels 1983; Towels unpubl. data). My study compared macroinvertebrate community structure in an undisturbed, first-order stream in Big Everidge Hollow (BEH), an old-growth forested watershed in LCW, with an adjacent first-order stream in Poll Branch Hollow (PBH) that had been previously logged and contour mined. Objectives were (1) to estimate community composition and structure in an exceptional, first-order stream in the Eastern Coalfield region, (2) to compare fauna occurring in an "old-growth" stream and a "second-growth" stream having previous coal mining disturbances, and (3) to determine seasonal differences in community structure in these streams. This was the first extensive survey of benthic macroinvertebrates in BEH and

Table 1. Selected physico-chemical characteristics of Poll Branch Hollow and Big Everidge Hollow, Letcher County, Kentucky. Parameters marked with an asterisk (*) were measured on 12 Dec 1998.

	Big Everidge Hollow	Poll Branch Hollow
Watershed area (ha)	~60	~90
Site elevation (m)	~340	~340
Aspect	East	East
Channel		
Gradient	7%	6%
Length (m)	800	900
Width (m)	0.5–2.5	0.5–2.5
Depth (cm)	2–45	2–25
Canopy	Full	Full
Temperature °C	7.3–17.8	6.7–17.6
Conductivity (μmho)	52–72	126–161
pH (S.U.)	7.4–7.6	7.1–7.7
Total hardness (mg/liter)*	26.5	58.2
Sulfate (mg/liter)*	12.3	35.1
Aluminum (mg/liter)*	0.05	0.43
Iron (mg/liter)*	0.06	0.89
Manganese (mg/liter)*	0.001	0.088

should provide a foundation for future comparisons.

STUDY AREA

LCW is a 222 ha natural preserve north of Pine Mountain in southeastern Kentucky in the Cumberland Plateau section of the Appalachian Plateau physiographic province. The preserve lies within the Tilford and Roxanna USGS 7.5 minute quadrangles. Both BEH and PBH are east-facing, first-order tributaries to Line Fork Creek, a fourth-order tributary to the North Fork Kentucky River. Both watersheds are underlain by interbedded sandstones, siltstones, shales, and coal. Physicochemical attributes for the streams are shown in Table 1. The study streams may have periods of intermittency in late summer and early fall of dry years, but they may remain perennial during wet summers (M. Brotsge, LCW, pers. comm., 12 Nov 1997). Mixed mesophytic forest made up the riparian corridor in both streams and was dominated by *Acer rubrum, Aesculus octandra, Fagus grandifolia, Liriodendron tulipifera,* and *Tsuga canadensis* (in alphabetical order). The upland slope assemblage in BEH consisted of old-growth stands of *Acer saccharum, Carya* spp., *Fagus grandifolia, Liriodendron tulipifera,* and *Quercus alba*; and ridge top forest was dominated by old-growth *Carya* spp., *Quercus montana,* and *Quercus coccinea.* The upland forest in PBH is second-growth and generally consists of the same species typical of BEH (Muller 1982).

A single 100 m sampling reach was selected in the lower portion of each watershed. Both channels are tightly constrained, bedrock-dominated streams having high gradient. Both fast and slow water bedrock habitat collectively comprised nearly 50% of the each sampling reach. However, each stream had a variety of geomorphological habitat units that included cobble-boulder riffles and pools, and bedrock glides and trench pools. Areas of fine gravel, sand, and silt were limited to pool areas and the margins of slow riffles. However, upstream of the sample reach in PBH, access roads and a sediment retention dam were constructed for mining operations in the mid 1970s. Since that time, the roads have been reforested but the dam has breached after filling with sediment. Despite natural reforestation, it was apparent that PBH experienced serious bank erosion upstream of the sample reach. It was also evident that interstitial substrates were burdened with excessive silt fines, and the degree of embeddedness was greater in riffle habitats compared to BEH. With regard to stream vertebrates, desmognathine salamanders were commonly observed in both streams. The headwater position of the streams preclude the establishment of a diverse fish community; the only species observed was the creek chub, *Semotilus atromaculatus.*

METHODS

Sample Collection

I collected macroinvertebrates using both quantitative and qualitative techniques once in spring (16 Apr 1998), early summer (24 Jun 1998), late fall (12 Dec 1998), and winter (9 Feb 1999). Quantitative data were taken from four replicate Surber samples (0.09 m^2, 750 μm mesh) stratified along a longitudinal transect within the thalweg (i.e., path of deepest thread of water) of a cobble-pebble riffle. This habitat was targeted to ensure the highest species richness and abundance of macroinvertebrates (Brown and Brussock 1991; Feminella 1996). Samples were elutriated with a wash basin and a 600 μm (U.S. No. 30) sieve and preserved in pint jars containing 95% ethyl alcohol. An effort was made to remove much of the leaf debris and many of the larger stones collected in the Surber samplers prior to sieving. This was accomplished by inspecting and washing individual leaves and stones in the wash basin. Qualitative species collections were gathered from multiple-habitat (i.e., woody debris, leaf packs, moss, large slab rocks, etc.) hand picking and dipnet (D-frame, 800 × 900 μm mesh) sampling for ca. 30 min. (except 45 m. for winter sample), and specimens were preserved in 70% ethyl alcohol. In the laboratory, entire samples were picked in an enamel pan without magnification until no more invertebrates were found and then briefly viewed at 20× under a dissecting microscope to search for smaller, cryptic forms. Temperature, dissolved oxygen, pH, and conductivity were measured on each sampling date with a portable Hydrolab meter. Water samples were collected from each stream on 12 Dec 1998, and chemical variables were analyzed by the Kentucky Department for Environmental Services, Frankfort, Kentucky.

Data Analysis

Various community metrics were calculated in an effort to describe macroinvertebrate community structure between sites and seasons. Measures of richness and abundance were determined for all seasons. The Ephemeroptera, Plecoptera, and Trichoptera (EPT) index (a measure of the richness of those generally pollution-sensitive insect orders) was also calculated. For comparison, the Shannon diversity index (H′, Shannon 1948) was determined using the base$_e$ logarithm. Overall biotic health of the stream was measured with the modified Hilsenhoff Biotic Index (mHBI), or North Carolina Biotic Index (NCBI, Lenat 1993), a weighted index based on individual pollution tolerance values and species proportions in the community. Tolerance values range from 0 (intolerant) to 10 (tolerant). Among sites and seasons, Mann Whitney U-tests were used to test for significant differences in means of taxon and EPT richness, abundance, and diversity at $P < 0.05$. The relative abundance of functional feeding groups was also calculated. Functional feeding group assignments followed Merritt and Cummins (1996) and Thorp and Covich (1993). Differences in overall taxonomic composition were illustrated with the % community similarity index (Sokal and Rohlf 1973), and the Ten Dominants in Common metric (DIC_{10}). To demonstrate differences in community composition, % community similarity dendrograms were constructed using hierarchical (UPGMA) cluster analysis (Romesburg 1990).

RESULTS

Water Chemistry

Although a detailed investigation of water quality was not conducted, notable differences were found between sites (Table 1). Compared to BEH, elevated conductivity, various metals, sulfate, and total hardness were the most distinctive parameters found in PBH. In some instances, values in PBH were several times higher than those in BEH. The ranges of temperature and pH between sites were nearly identical on each sampling occasion (Table 1).

Community Composition

A total of 118 taxa representing 14 orders and 45 families was collected in both streams combined during all sampling efforts (Appendix A). The most taxa were recorded in BEH (106 taxa) compared to PBH (83). In BEH, the insect order Diptera had the most taxa (37), followed by Trichoptera (21), Plecoptera (15), and Ephemeroptera (15) in all seasons combined. By contrast, in PBH Diptera had the most taxa (31), followed by Ephemeroptera (17), Trichoptera (13), and Plecoptera (12). Seasonal trends in total taxon richness are shown in Appendix A.

Comparisons of site and seasonal trends in taxon richness, EPT richness, density, diversity, and the mHBI for both streams are shown in Table 2. Within individual streams, mean taxon richness, EPT richness, and densities were significantly higher in spring and winter samples ($P < 0.05$), suggesting a strong seasonal component to community structure. Seasonal differences in Shannon diversity were negligible in both streams. With regard to pollution tolerance (mHBI), all streams consistently scored in the excellent range (mHBI < 3.3). Between sites, taxon richness was higher in BEH throughout all seasons, although the difference during the winter was not significant (Table 2). Although mean EPT richness in BEH was greater among all sea-

Table 2. Mean (±95%CI, n = 4) benthic macroinvertebrate richness, combined number of taxa within the insect orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) richness, density m^{-2}, and Shannon Diversity (H′) among Surber samples (0.09 m^2) taken from Big Everidge Hollow (BEH) and Poll Branch Hollow (PBH), Letcher County, Kentucky. The modified Hilsenhoff Biotic Index (mHBI), % community similarity, and number of the top 10 dominant taxa in common (DIC$_{10}$) were calculated from the four composited Surber samples. Spring (Sp), summer (Su), fall (F), and winter (W) correspond to mid-April, late-June, early December, and early February, respectively. An asterisk (*) indicates significantly higher values at the $P < 0.05$ level.

	Sp		Su		F		W	
	BEH	PBH	BEH	PBH	BEH	PBH	BEH	PBH
Taxon Richness	32.0 ± 5.1*	19.2 ± 6.1	20.2 ± 5.4*	11.7 ± 0.5	24.0 ± 7.4*	15 ± 2.4	25.3 ± 3.2	24.5 ± 4.5
EPT Richness	17.5 ± 1.9	13.2 ± 3.2	11.0 ± 2.9	7.2 ± 2.5	12.8 ± 2.9	10.2 ± 0.2	16 ± 2.1	14.3 ± 3.0
Density m^{-2}	1936 ± 871*	811 ± 370	844 ± 449*	317 ± 52	572 ± 232	381 ± 117	1433 ± 58	1330 ± 298
H′ Diversity	2.7 ± 0.1	2.5 ± 0.2	2.6 ± 0.3*	2.2 ± 0.1	2.9 ± 0.3*	2.3 ± 0.2	2.7 ± 0.2	2.6 ± 0.1
mHBI	2.49	2.60	1.93	2.79	3.27	2.49	1.81	1.97
% Similarity	47		41		43		67	
DIC$_{10}$	8		4		4		6	

sons, values were not significantly different ($P < 0.05$). Densities of macroinvertebrates were consistently higher in BEH, but only spring and summer collections were significant. Shannon diversity was also higher in BEH among seasons but was not significant in spring. Relatively low percent community similarity was seen in all seasons, with the exception of winter where the communities were 67% similar. The lowest similarity was found in summer (40%). Comparatively, the DIC$_{10}$ metric portrayed the greatest similarity in spring and winter. A dendrogram illustrating community similarity among sites is shown in Figure 1.

A few individual taxa consistently showed higher abundances in quantitative samples among sites and seasons. Table 3 lists the top five taxa occurring at each site among seasons. The leptophlebiid mayfly *Paraleptophlebia* was a dominant taxon during all seasons in BEH; it was dominant in PBH three of the four seasons. For PBH, the heptageniid mayfly *Epeorus* and the hydropsychid caddisfly *Diplectrona* were dominant taxa during three of the four seasons; in BEH these taxa were abundant in two and three seasons, respectively. The stonefly *Leuctra* was another notable taxon, being common in both streams two of four seasons.

Functional Feeding Groups

Functional feeding groups were very similar among sites and seasons (Figure 2). The relative proportion of shredders (detritivores adapted to feed upon leaf and woody debris, or coarse particulate organic matter (CPOM, >1 mm)) and invertebrate predators were the most consistent between sites and seasons. Collectors (detritivores feeding primarily upon fine particulate organic matter (FPOM, 0.5–1 mm) deposited either on the substrate surface or within the interstices, or suspended in the water column) and scrapers (grazing herbivores feeding upon periphyton and associated material) were more variable in their abundances among sites and seasons. Collectors were the most abundant group in both streams in all seasons, ranging from 33% to 56% in BEH and 42% to 50% in PBH. Scrapers were the second most abundant group and reached their greatest abundance in winter with lowest proportions observed in summer

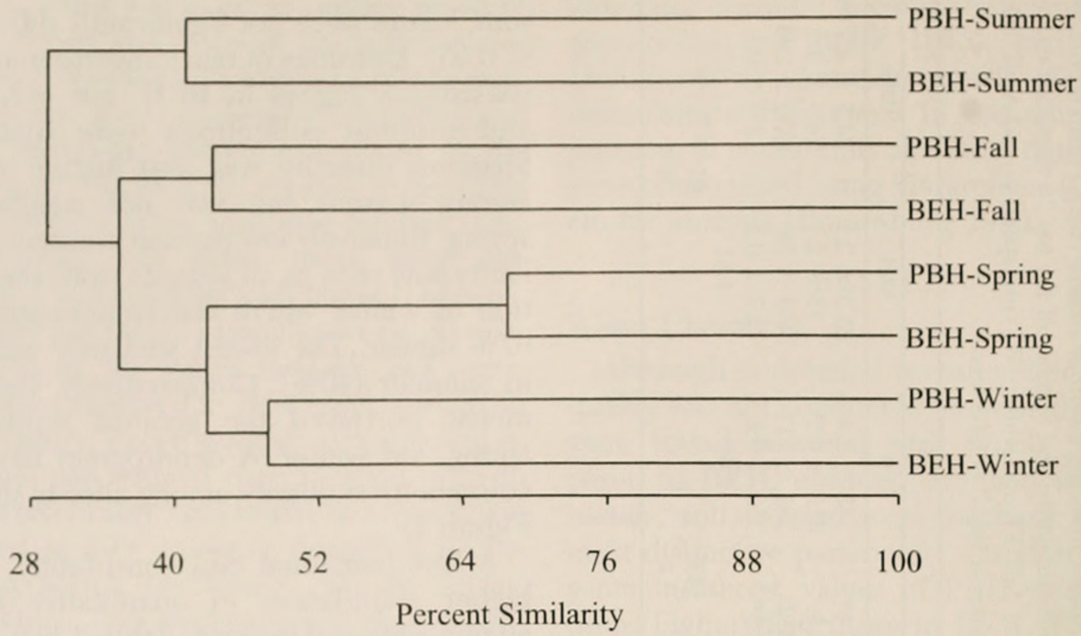

Figure 1. Dendrogram showing percent similarity between Poll Branch Hollow (PBH) and Big Everidge Hollow (BEH), Letcher County, Kentucky among seasons 1998-1999.

and fall. Relative proportions ranged from 17% to 33% in BEH and 13% to 32% in PBH. Shredders represented a smaller proportion at both sites, being most abundant in summer and least in winter. The relative abundance of shredders ranged from 12% to 20% in BEH and 9% to 23% in PBH. Similarly, predators were most abundant in summer and least in winter. Predator abundance ranged from 13% to 21% in BEH and 12% to 20% in PBH.

DISCUSSION

Community Composition

The invertebrate fauna in BEH and PBH consisted mainly of insect larvae typically associated with clean, high-gradient streams in the region. The dominant taxa found in this survey were immature insects that are considered to have univoltine life cycles (Brigham et al. 1982; Merritt and Cummins 1996; Stewart and Stark 1988; Wiggins 1996) and are known to inhabit both intermittent or perennial streams (Feminella 1996). With regard to life history, only a few species were thought to undergo semivoltinism in the study streams (e.g., *Acroneuria, Nigronia, Cordulegaster,* and *Stylogomphus*). The thermal regime exerts considerable influence on insect voltinism (Sweeney 1984) and in small, forested streams like BEH and PBH, cool annual temperatures may limit the degree of multivoltinism, which is common in larger, warmer streams (Hynes 1970).

I considered overall taxon richness in both study areas to be fairly high, but values varied markedly among sampling season. By contrast, Harker et al. (1980) suggested that small pristine mountain streams in Kentucky may have reduced richness and diversity due to low nutrient or alkalinity values. Vannote and Sweeney (1980) also indicated that low flow, lower habitat diversity, and greater thermal constancy may limit invertebrate taxon richness in small streams. Seasonal differences in species richness are typical of small streams including BEH and PBH that are faced with periods of intermittency where life history adaptations determine species presence and absence. Total EPT richness, which is often highly correlated with taxon richness, was also high in each stream. Those EPT taxa, in general, represent a group of organisms that are intolerant of environmental stress including water pollution (Lenat 1988) and typically proliferate in clean mountain streams. In my study, BEH had 51 EPT taxa including 14 taxa not encountered in PBH, while PBH had 42 EPT taxa with 6 taxa not collected in BEH.

Based on my results, significant differences among richness in BEH and PBH cannot be entirely explained. Wagner and Benfield

Table 3. Seasonal differences in the percent composition of the 5 most abundant taxa occurring in composited Surber samples (n = 4) in Big Everidge Hollow (BEH) and Poll Branch Hollow (PBH), Letcher County, Kentucky during spring (mid-April), summer (late-June), fall (early-December), and winter (early-February).

	BEH	PBH
Spring	*Paraleptophlebia* (31)	*Paraleptophlebia* (15)
	Epeorus (9)	*Epeorus* (12)
	Leuctra (9)	*Cinygmula* (11)
	Baetis intercalaris (4)	*Amphinemura* (7)
	Diplectrona (4)	*Tanytarsus* (7)
Summer	*Stenonema meririvulanum* (17)	*Leuctra* (21)
	Leuctra (15)	*Ectopria* (10)
	Paraleptophlebia (9)	*Paraleptophlebia* (10)
	Leucrocuta (7)	*Diplectrona* (7)
	Sweltsa (7)	*Acroneuria* (7)
Fall	*Paraleptophlebia* (12)	*Diplectrona* (30)
	Diplectrona (10)	*Neophylax* (10)
	Ectopria (7)	*Leuctra* (10)
	Ameletus (5)	*Epeorus* (5)
	Parametriocnemus (5)	*Paraleptophlebia* (4)
Winter	*Epeorus* (24)	*Ephemerella* (21)
	Ephemerella (10)	*Epeorus* (19)
	Diplectrona (8)	*Diplectrona* (10)
	Baetis tricaudatus (5)	*Sweltsa* (5)
	Paraleptophlebia (5)	*Neophylax* (4)

(1998) found that old-growth forested streams in North Carolina had less biodiversity than catchments logged 85+ yr ago but greater biodiversity than watersheds logged 25 to 50 yr ago. Their data suggested that macroinvertebrate communities continue to be influenced by logging long after reforestation. In my study, it had been over 50 yr since PBH was clearcut, and 25 yr since it was strip-mined. Observations on substrate composition and microhabitat availability revealed that a moderate degree of embeddedness (~50%) was evident in PBH riffles and pools, indicating that interstitial spaces were more frequently clogged with fine sediment. This can result in decreased colonization area for benthic macroinvertebrates. Chronic bank erosion from upstream channel modification (i.e., past coal mining and associated instream settling pond and roads) contributes to substantial sedimentation and substrate embeddedness. Other factors contributing to lower taxon richness in PBH may be related to water chemistry (i.e., elevated metals and conductivity from coal mining) or disturbance history (i.e., logging and mining) and the possible extirpation of headwater species from PBH. With regard to water chemistry, the data found in my study are in very close agreement with those found by Dyer (1982) who sampled mined and unmined streams having similar sized watersheds within the Line Fork drainage. In mined streams, he found elevated conductivity and metals in similar proportions as those found in PBH in my study. In undisturbed streams, his values were very similar to those I found in BEH.

Although many of the dominant taxa I found were common to both streams, differences in the less frequently collected taxa in BEH appeared to affect total and mean richness indices. For example, sensitive habitat specialists that are locally rare (e.g., the caddisflies *Molanna, Theliopsyche,* and *Goerita*), may be locally extirpated when exposed to severe or long-lasting disturbance events such as forest clear-cutting and mining. Drastic changes in the food resource base and increased water temperature are probably the driving factors behind faunistic change (Gurtz and Wallace 1984; Stone and Wallace 1998). However, severe sedimentation and embeddedness can cause substantial declines in insect abundance (Waters 1995) or perhaps eliminate rare species from particular stream reaches. Temporary extirpation is probable when severe disturbance events occur at the stream source where reinvasion by drifting organisms is dis-

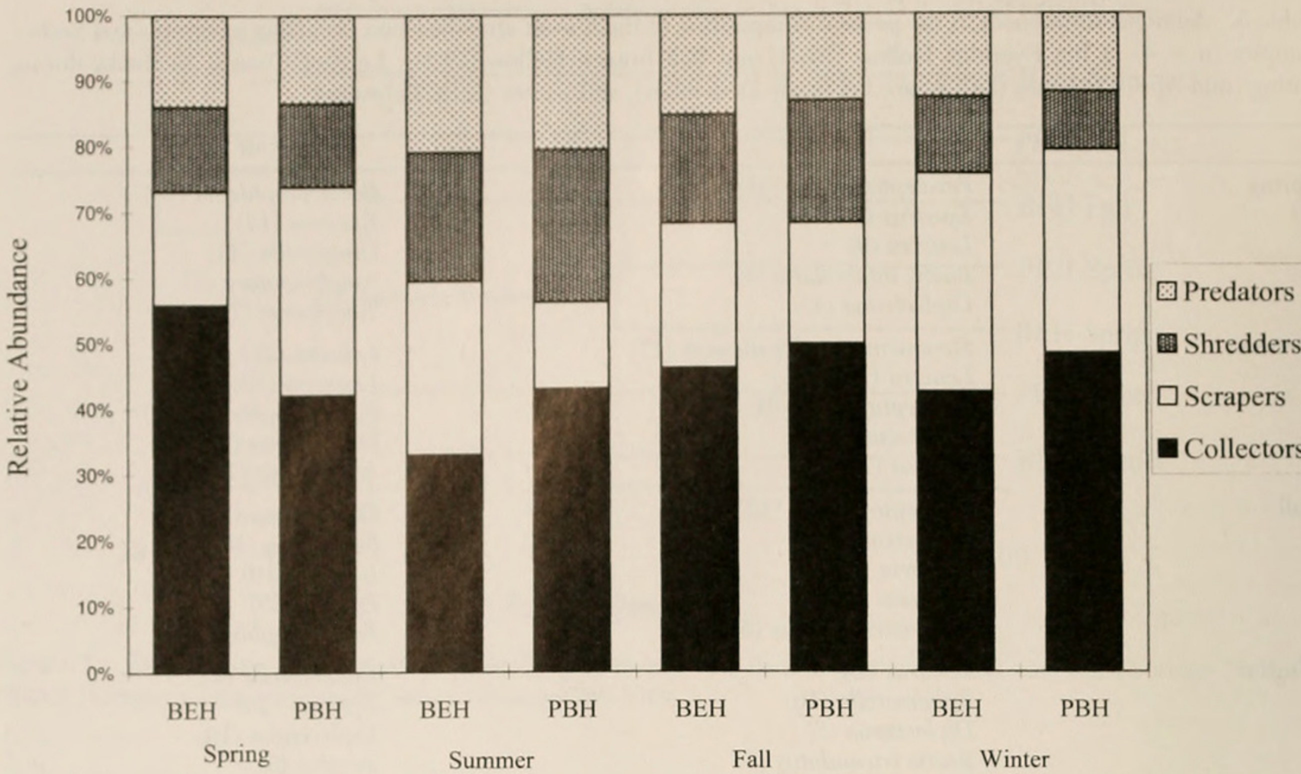

Figure 2. Relative Proportion of Functional Feeding Groups in Big Everidge Hollow BEH) and Poll Branch Hollow (PBH), Letcher County, Kentucky among seasons 1998-1999.

rupted. Recolonization by adult dispersal is possible, although fauna restricted to headwater streams become somewhat isolated when the stream drains directly into larger streams (e.g., Line Fork Creek). In this case, colonization must occur by "over the mountain" adult dispersal which for some EPT taxa, is a "chance event" or may take considerable time (J. Morse, Clemson Univ., pers. comm., 6 Aug 1998).

Seasonal trends in estimated densities were consistently found among both study streams. Significant differences between the study streams are probably a result of previously mentioned embeddedness; however, water chemistry and disturbance history may also have an affect on macroinvertebrate abundance in PBH. Small headwater streams including BEH and PBH frequently undergo periods of intermittency during the summer months. This has a considerable impact on macroinvertebrate recruitment and overall relative densities from season to season as well as from year to year (Feminella 1996). Moreover, low nutrient or alkalinity levels associated with pristine streams may limit macroinvertebrate densities and secondary production on an annual basis.

Functional Feeding Groups

Although most benthic macroinvertebrates are considered omnivorous feeders, they can be categorized into "guilds," or groups of organisms using a particular resource class. An analog to the trophic guild idea is the use of functional feeding groups based on an organism's morpho-behavioral adaptations for food acquisition (Cummins 1973) rather than solely on the basis of what food is eaten. There is much debate on the overall utility of functional feeding group analysis since certain species are facultative feeders, or may show marked differences in food use among various life history stages (Allan 1995). However, the relative abundances of feeding guilds still provide useful information on the overall trophic organization and food resource dynamics of stream reaches.

The abundances of the various functional feeding groups did not vary greatly between streams. I expected shredders to be dominant in both streams based on observed inputs of leaf and wood debris into the stream from riparian vegetation. However, since quantitative sampling was conducted in riffles, the shredder component could be underestimated as the niche of many shredders (e.g., *Eurylophella funeralis, Pycnopsyche* spp.) were found in pools that had accumulated more detritus than in riffles. Because benthic algal communities are limited by light in small streams, grazing herbivores (scrapers) are predicted to be less represented in forested headwater streams and to reach their greatest abundance in mid-order streams (Vannote et al. 1980). This was not the case in my study; scrapers were well represented in both streams. The unusually high abundance of scrapers was probably a relict of riffle sampling. Collectors further contribute to detritus breakdown in all aquatic systems and their abundance gives a general indication of how much organic matter is stored within a stream reach or specific habitat. Collectors outnumbered other feeding groups in both study streams in each season, indicating fine detritus as the dominant food-particle size. Unlike the seasonally available food resources used by shredders and scrapers, collectors are not generally limited by seasonality since FPOM transport and deposition is flow dependent and may be affected by biological processing rates (Webster 1983). The relative abundance of predators is generally predicted to remain constant both spatially and temporally along the stream continuum (Vannote et al. 1980). The proportion of this trophic group in each stream appeared to follow this prediction with respect to seasonality and the headwater position of the stream.

Diversity and the Biotic Index

The diversity and biotic indices implied exceptional water quality in BEH and PBH. Very little seasonal differences were observed in these community-level attributes, suggesting temporal stability in the communities. The low biotic index values showed that pollution-intolerant species dominated both streams. Although the mHBI responds primarily to organic or other toxic pollution, it is less sensitive to sedimentation unless the problem is both severe and chronic (pers. obs.). Stone and Wallace (1998) reported that after 16 years of forest succession, mHBI (NCBI) values were not significantly different between a reference stream and one disturbed by clearcut logging. Since BEH is undisturbed, the presence of several tolerant taxa (TV > 7.0) may suggest that these taxa are "colonists" or "ecological generalists" and that the tolerance values demonstrate euryoecic characteristics. However, the proportion of invertebrates having high tolerance values in BEH was low, implying that these taxa were sporadic colonizers of the stream.

Although the % similarity metric strongly suggested different communities among sites (except in winter), assemblages generally contained many overlapping taxa. Despite low % similarity between sites, it appeared that seasonality was the main factor affecting community composition as indicated by the cluster analyses. The lower degree of community similarity between seasons was anticipated since many of the univoltine species can be temporally absent from the community depending on individual life histories. Egg diapause is common in headwater stream invertebrates, and many species remain within hyporheic habitats for extended periods (Williams 1987) and thus appear to be seasonally absent. These seasonal influences appeared to outweigh differences possibly associated with disturbance history.

CONCLUSION

In this study I found that the macroinvertebrate communities in BEH and PBH represented rich and diverse faunas dominated by aquatic insects that are considered to be highly sensitive to anthropogenic disturbances. However, significant differences and dissimilarities in community structure were observed. The reduced number of species and density of individuals in PBH were possibly related to microhabitat differences among riffle substrates or water chemistry. Riffle embeddedness was probably the most notable microhabitat feature limiting macroinvertebrates in PBH. Both logging and mining through stream channels have the potential to affect downstream habitats by intensified erosion and sedimentation. The fact that BEH could consistently support more species and individuals sheds light on the importance of undisturbed watersheds for sustaining invertebrate biodiversity and production. Despite these pair-wise differences, seasonality was the driving force behind overall community structure within respective streams. Functionally, the study streams displayed similar feeding guild abundances, indicating no differences in the food-energy base. No exceptionally rare species were collected; however, one stonefly genus (*Yugus*) is reported for the first time in Kentucky; infrequently collected caddisflies like *Molanna* and *Theliopsyche* were found in BEH. Based on my observations of other first-order streams in southeastern Kentucky, the present study revealed that the stream draining BEH did not necessarily harbor a unique stream assemblage but nevertheless characterized a sensitive and diverse community that has adapted to relatively continuous, natural ecosystem processes and may be suggestive of the prehistoric norm. However, because of the intermittent nature of BEH and PBH, extreme variation in community structure is possible from year to year. This necessitates the need for continued biological monitoring in these streams. Furthermore, research on other aspects of stream ecosystem structure and function (e.g., nutrient cycling, organic matter retention and transport, primary and secondary production) in BEH and PBH would be valuable to our understanding of the dynamics of old-growth forested watersheds in Kentucky.

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LITERATURE CITED

Allan, J. D. 1995. Stream ecology: the structure and function of running waters. Chapman and Hall, London, UK.

Barels, G. 1985. A study of the small mammal populations of Lilley Cornett Woods, Letcher County, Kentucky. M.S. Thesis. Eastern Kentucky Univ., Richmond, KY.

Brigham, A. R., W. U. Brigham, and A. Gnilka (eds). 1982. The aquatic insects and oligochaetes of North and South Carolina. Midwest Aquatic Enterprises, Mahomet, IL.

Brown, A. V., and P. P. Brussock. 1991. Comparisons of benthic invertebrates between riffles and pools. Hydrobiologia 220:99–108.

Cairns, J., Jr., and J. R. Pratt. 1993. A history of biological monitoring using benthic macroinvertebrates. Pages 10–27 in D. M. Rosenberg and V. H. Resh (eds). Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York, NY.

Conrad, P. 1983. The geology, hydrogeology, and paleoenvironmental interpretations of the Breathitt Formation (Pennsylvanian) of Lilley Cornett Woods, Letcher County, Kentucky. M.S. Thesis. Eastern Kentucky Univ., Richmond, KY.

Cupp, P. V., Jr., and D. T. Towels. 1983. A new variant of *Plethodon wehrlei* in Kentucky and West Virginia. Trans. Kentucky Acad. Sci. 44:157–158.

Cummins, K. W. 1973. Trophic relations of aquatic insects. Annual Rev. Entomol. 18:183–206.

Cummins, K. W. 1974. Structure and function of stream ecosystems. Bioscience 24:631–641.

Dyer, K. L. 1982. Stream water quality in the coal region of eastern Kentucky. USDA Forest Serv. Techn. Rep. NE-74. Northeastern Forest Experiment Station, Berea, KY.

Feminella, J. 1996. Comparison of benthic macroinvertebrate assemblages in small streams along a gradient of flow permanence. J. North Am. Benthol. Soc. 15: 651–669.

Gurtz, M. E., and J. B. Wallace. 1984. Substrate-mediated response of stream invertebrates to disturbance. Ecology 65:1556–1569.

Harker, D. F., M. L. Warren, K. E. Camburn, S. M. Call, G. J. Fallo, and P. Wigley. 1980. Aquatic biota and water quality survey of the Upper Cumberland River basin. Kentucky Nature Preserves Commission Technical Report.

Hudson, J. E. 1972. A comparison of breeding bird populations at selected sites in the southern Appalachians and in the Boston Mountains. Ph.D. Dissertation. Univ. Kentucky, Lexington, KY.

Hynes, H. B. N. 1970. The ecology of running waters. Univ. Toronto Press, Toronto, Canada.

Kentucky Division of Water. 1996. 1996 Kentucky Report to Congress on Water Quality. Natural Resources and Environmental Protection Cabinet, Frankfort, KY.

Lenat, D. R. 1988. Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. J. North Am. Benthol. Soc. 7:222–233.

Lenat, D. R. 1993. A biotic index for the southeastern United States: derivation and list of tolerance values, with criteria for assigning water quality ratings. J. North Am. Benthol. Soc. 12:279–290.

Martin, W. H. 1975. The Lilley Cornett Woods: a stable mixed mesophytic forest in Kentucky. Bot. Gaz. 136: 171–182.

Martin, W. H., and C. Shepherd. 1973. Trees and shrubs of Lilley Cornett Woods, Letcher County, Kentucky. Castanea 38:327–335.
Merritt, R. W., and K. W. Cummins (eds). 1996. An introduction to the aquatic insects of North America, 3rd ed. Kendall/Hunt, Dubuque, IA.
Muller, R. N. 1982. Vegetation patterns in the mixed mesophytic forest in eastern Kentucky. Ecology 63:1901–1917.
Pielou, E. C. 1975. Ecological diversity. Wiley, New York, NY.
Romesburg, H. C., 1990. Cluster analyses for researchers. Robert E. Krieger, Malabar, FL.
Shannon, C. E., 1948. A mathematical theory of communication. Bell Syst. Techn. J. 27:379–423, 623–656.
Sokal, R. R., and F. J. Rohlf. 1973. Introduction to biostatistics. Freeman, San Fransico, CA.
Sole, J. D., S. Lassetter, and W. H. Martin. 1983. The vascular flora of Lilley Cornett Woods, Letcher County, Kentucky. Castanea 48:174–188.
Stewart, K. W., and B. P. Stark. 1988. Nymphs of North American stonefly genera (Plecoptera). Entomological Society of America, Lanham, MD.
Stone, M. K., and J. B. Wallace. 1998. Long-term recovery of a mountain stream from clear-cut logging: the effects of forest succession on benthic invertebrate community structure. Freshwater Biol. 39:151–169.
Sweeney, B. W. 1984. Factors influencing life-history patterns of aquatic insects. Pages 56–100 in V. H. Resh and D. M. Rosenberg (eds). The ecology of aquatic insects. Praeger, New York, NY.
Thorp, J. H., and A. P. Covich (eds). 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, New York, NY.
Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Can. J. Fish. Aquatic Sci. 37:130–137.
Vannote, R. L., and B. W. Sweeney. 1980. Geographical analysis of thermal equilibria: a conceptual model for evaluating the effect of natural and modified regimes on aquatic insect communities. Am. Naturalist 15:667–695.
Wagner, P. F., and E. F. Benfield. 1998. The long-term effects of logging on aquatic insect assemblages in southern Appalachian streams. Abstract *in* Bull. North Am. Benthol. Soc. 15(1):131.
Waters, T. F. 1995. Sediment in streams: sources, biological effects, and control. Am. Fish. Soc. Monogr. 7.
Webster, J. R. 1983. The role of benthic macroinvertebrates in detritus dynamics of streams: a computer simulation. Ecol. Monogr. 53:383–404.
Wiggins, G. B. 1996. Larvae of the North American caddisfly genera (Trichoptera), 2nd ed. Univ. Toronto Press, Toronto, Canada.
Williams, D. D. 1987. The ecology of temporary waters. Timber Press, Portland, OR.

Appendix A. List of macroinvertebrates collected from Big Everidge Hollow (BEH) and Poll Branch Hollow (PBH) during spring (mid-April), summer (late-June), fall (early-December), and winter (early-February) 1998–1999. Values are in percent composition; "X" denotes qualitative occurrence.

				BEH				PBH			
Class	Order	Family	Genus/Species	Sp	Su	F	W	Sp	Su	F	W
TURBELLAIRA	Tricladia	Planariidae	planariid (immature)	0.9	0.3		X				X
OLIGOCHAETA	Haplotaxida	Lumbriculidae	*Eclipidrilus* sp.	0.7	0.7	4.9	1.0	3.4	5.3	1.5	
		Naididae	*Dero nivea*								X
		Tubificidae	*Pristina aequisita*	0.1							
		Tubificidae	turbificid (immature)				X				
BIVALVIA	Veneroida	Sphaeriidae	*Pisidium* sp.	0.1		0.5	X				
INSECTA	Ephemeroptera	Ameletidae	*Ameletus* sp.	2.5		5.3	3.1	2.1		1.5	2.3
		Baetidae	*Acentrella ampla*	2.0	4.6				0.9		
			Baetis tricaudatus		0.3		5.4		3.5		0.6
			Baetis flavistriga		4.0				1.8		
			Baetis intercalaris	4.5				3.8			
			Baetis sp. A						1.8		
			Centroptilum sp.		0.3						
		Ephemeridae	*Ephemera guttulata*	0.1		0.5	X	0.3	3.5		X
			Ephemera simulans						0.9	X	
		Ephemerellidae	*Ephemerella* prob. *auravilii*	3.9		2.9	10.3	4.5		0.7	21.5
			Eurylophella funeralis		0.3	0.5	X	X	0.9	2.2	0.2
		Heptageniidae	*Cinygmula subaequalis*	X			0.4	11.3			3.6
			Epeorus prob. *namatus*	9.1		0.5	23.8	12.7		5.1	19.0
			Leucrocuta prob. *thetis*		6.9				1.8		
			Stenacron interpunctatum	0.4		X	X	0.3		X	1.5
			Stenonema meririvulanum	0.6	17.1	2.9	2.1		0.9		0.2
			Stenonema vicarium							0.7	0.2
		Leptophlebiidae	*Paraleptophlebia* prob. *ontario*	31.1	9.5	12.6	5.0	15.1	9.7	4.4	2.3
	Plecoptera	Capniidae	*Allocapnia* sp.			X	X			X	
		Chloroperlidae	*Alloperla* sp.					2.4			
			Haploperla sp.	0.1							
			Sweltsa sp.	2.2	6.9	1.9	3.5	0.3	2.6	0.7	4.6
		Leuctridae	*Leuctra* sp.	8.6	15.1	4.9	5.0	5.1	21.9	10.2	2.7
		Nemouridae	*Amphinemura delosa*	2.7			X	6.9	0.9		2.5
			Ostrocerca prob. *truncata*			X					
			Soyedina sp.			X	X				0.2
		Peltoperlidae	*Peltoperla arcuata*	0.1	2.3	1.5	2.9	X	X	4.4	0.6
		Perlidae	*Acroneuria caroliniensis*	1.0	2.3	0.5	0.8	1.0	7.0	3.7	3.1
			Paragnetina sp.	X							
		Perlodidae	*Clioperla clio*			0.5					
			Diploperla robusta	X				X		0.7	
			Isoperla holochlora	X	X		1.4	0.3			0.6
			Malirekus hastatus	0.3		X	1.2	0.3			0.2
			Yugus sp.	1.3		0.5	X	0.3			

Appendix A. Continued.

Class	Order	Family	Genus/Species	BEH				PBH			
				Sp	Su	F	W	Sp	Su	F	W
	Odonata	Calopterygidae	*Calopteryx* sp.	X		X	X				
		Aeshnidae	*Boyeria vinosa*		0.3		X				
		Cordulegasteridae	*Cordulegaster* sp.				X		X	X	X
		Gomphidae	*Lanthus* sp.	1.4	1.6			1.4	3.5		
			Stylogomphus albistylus			1.5	1.6	X	X	X	0.4
		Corydalidae	*Nigronia fasciatus*	0.4	1.3	1.0	0.2	0.3		0.7	0.2
	Trichoptera	Glossosomatidae	*Glossosoma* sp.						X		
		Goeridae	*Goera* sp.	0.1		1.0	0.4			X	
			Goerita betteni			0.5	0.2				
		Hydropsychidae	*Ceratopsyche sparna*		0.7	X			0.9		
			Diplectrona modesta	4.2	3.0	9.7	8.3	4.5	7.0	29.9	10.4
			Cheumatopsyche sp.							X	
			Hydropsyche betteni	X		X					
		Lepidostomatidae	*Lepidostoma* sp.	X							
			Theliopsyche sp.			1.0	0.2				
		Limnephilidae	*Ironoquia punctatissima*				X				X
			Pseudostenophylax uniformis				X				
			Pycnopsyche gentilis	0.1	0.7			0.3			
			Pycnopsyche prob. *guttifer*	X	X	1.9	0.4	X		X	X
		Molannidae	*Molanna blenda*				X				
		Philopotamidae	*Wormaldia* prob. *moesta*	0.3	4.3	1.0	1.7	1.0	2.6	2.9	0.8
		Polycentropodidae	*Lype diversa*							0.7	
			Nyctiophylax sp.	X			X				
			Polycentropus sp.	0.7	1.0	1.9	0.4	2.1		2.2	0.2
		Rhyacophilidae	*Rhyacophila carolina*	0.3		1.5	0.8			1.5	0.8
			Rhyacophila invaria gp.	0.4							
			Rhyacophila torva	X		X					
			Rhyacophila vibox				X				
		Uenoidae	*Neophylax* sp. A	3.0	X	3.4	3.9	5.1		10.2	4.2
			Neophylax sp. B	0.3			X				
	Coleoptera	Dryopidae	*Helichus fastigiatus*								X
		Elmidae	*Oulimnious latiusculus*	0.3			0.2				
			Stenelmis crenata	0.6			X				
			Stenelmis sp. larva		0.3						
		Psephenidae	*Ectopria nervosa*		2.0	6.3	1.9	0.7	9.7	0.7	0.2
			Psephenus herricki	0.1		0.5			0.9	0.7	
	Diptera	Ceratopogonidae	*Atrichapogon* sp.			1.0				0.7	
			Forcipomyia sp.		X						
			Palpomyia sp. complex	0.1		0.5					0.2

Appendix A. Continued.

Class	Order	Family	Genus/Species	BEH				PBH			
				Sp	Su	F	W	Sp	Su	F	W
		Chironomidae	*Brilla* sp.		0.7					1.5	1.5
			Constempellina sp.				0.4				
			Conchapelopia sp.	1.0	0.7	1.0	0.4	1.7	6.1		
			Corynoneura sp.			0.5	0.4	0.3		X	1.0
			Cricotopus trifascia gp.	0.1							0.2
			Diamesa sp.				0.2				0.6
			Diplocladius sp.							X	
			Eukiefferiella spp.	0.3	0.3		0.6				1.0
			Hydrobaenus sp.	X							
			Limnophyes sp.			0.5					
			Micropsectra sp.			3.4	4.1			1.5	2.1
			Microtendipes pedellus gp.	0.1				1.0			0.2
			Microtendipes rydalensis gp.	0.1		X	X			1.5	
			Nilotanypus sp.	0.4				0.3			
			Orthocladius annectens			0.5					
			Parachaetocladius sp.				0.2			0.7	0.6
			Parametriocnemus lundbecki	2.5	0.3	5.3	3.3	0.7		0.7	3.6
			Polypedilum aviceps gp.	X							
			Polypedilum convictum gp.	2.0	2.0	1.5		X	0.9		
			Polypedilum fallax gp.								0.2
			Polypedilum haltarare gp.			0.5					
			Potthastia sp.	0.1							
			Rheotanytarsus sp.	0.3	0.3				0.9		
			Synorthocladius sp.						1.8		
			Tanytarsus sp.	2.7	0.3	X		6.9			
			Thienimanniella sp.	0.3						2.2	0.2
			Tvetenia bavarica gp.	0.3		1.5	X			X	
			Tvetenia discloripes gp.								0.4
		Empididae	*Hemerodromia* sp.		0.3					1.5	
		Dixidae	*Dixa* sp.		0.3					1.5	X
		Simuliidae	*Prosimulium* sp.				0.8				1.0
			Simulium sp.	0.3	0.3						0.8
		Tipulidae	*Hexatoma* sp.	2.5	5.6	2.9	1.9	2.4	0.9	0.7	0.8
			Dicranota sp.		0.3	0.5	0.2			0.7	0.2
			Limnophila sp.			1.0	0.2				
			Pilaria sp.	0.6							
			Pseudolimnophila sp.			2.9					0.4
			Tipula sp.	1.2	1.0	3.9		0.3	X	1.5	0.4
CRUSTACEA	Decapoda	Cambaridae	cambarid (immature)	0.3	0.7	X	0.4	0.3	1.8		0.2
	Isopoda	Asellidae	*Caecidotea* sp.	X							
Taxon Richness				66	42	56	62	40	33	44	54
EPT Richness				35	20	29	35	25	19	23	26