MICROHABITAT USE BY FISH
OF THE RIFFLE ZONE OF CATSKILL CREEK

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ABSTRACT

The fishes of Catskill Creek, in the Hudson River drainage of New York, were investigated to examine assemblage structure within the riffle zone mesohabitat. The riffle zone contained five distinct microhabitats: depression, run, behind rock, under rock, and eddy. The depression microhabitat is a depression in the substrate that has a sheltered area of low flow at its base with fast water above. The run is characterized by laminar flow and low-relief substrate. The behind-rock microhabitat is a sheltered region behind rubble or boulders. The under-rock microhabitat is the crevices found under rubble or boulders. The eddy is the sheltered shoreline found on the edge of the stream. Eleven species were observed. Six species (blacknose dace, common shiner, white sucker, longnose dace, slimy sculpin and cutlips minnow) made up 97% of the fish observed. The five microhabitats were utilized by the six dominant fish species in a highly structured manner. The depression was primarily utilized by blacknose dace, common shiner, and white sucker. These fish partitioned the microhabitat by feeding at different levels in the water column. The common shiner fed in the upper half of the water column, the blacknose dace in the lower half, and the white sucker on benthos. The under-rock microhabitat was utilized by two species, longnose dace and slimy sculpin. These species may have non-overlapping ranges within the stream with the sculpin inhabiting the upper regions and the longnose dace inhabiting the lower region. This study indicates that the Catskill Creek riffle zone assemblage has distinct structure.

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INTRODUCTION

The riffle mesohabitat is comprised of microhabitats with distinct physical structure. This quality makes the riffle an ideal area for testing ecological theory since habitat use is easily quantified. This paper describes the partitioning of fishes into five distinct physical niches of the riffle zone in Catskill Creek. The study extends current knowledge of resource partitioning in stream fishes by recognizing distinct physical niches at a small spatial scale.

At the scale of macrohabitat, fishes have been shown to segregate by habitat (stream size and gradient) and by mesohabitat (pools and fast water) (Moyle and Senanayake, 1984). Studies of microhabitat have shown segregation by water column position, water velocity, aquatic vegetation, substrate, conductivity, maximum depth and water quality (Daniels, 1987; Moyle and Senanayake, 1984; Moyle and Vondracek, 1985; Pyron and Taylor, 1993). Moyle and Senanayake (1984) made the qualitative observation that fish in fast water are found in the current, in crevices, behind rocks, and in depressions. The fishes observed during this study also utilized these microhabitats. Our goal was to describe the use of these microhabitats by the riffle-dwelling fishes of Catskill Creek by examining species distribution within available microhabitats.

METHODS

Study site

Catskill Creek is a tributary to the Hudson River entering the tidal portion of the river on the west side at river mile 111, near the town of Catskill (Figure 1). There are scattered small towns and farms in the sampling region. The stream edge is predominantly wooded, although there are portions that have been affected by agricultural fields, roads, and residences. The richness and diversity of the system are typical of Hudson River drainage tributaries (Anderson, 1988). A 1936 study found twenty-nine fish species in

Microhabitat Study Region

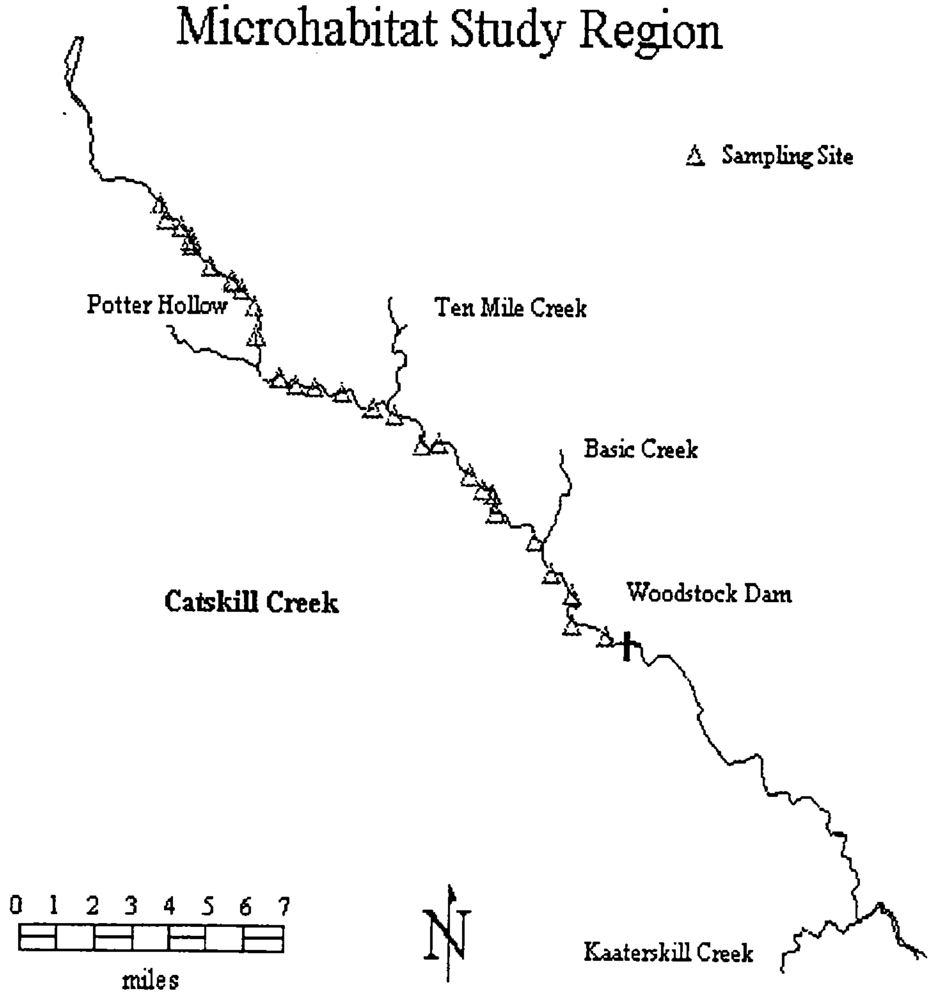

Figure 1. Catskill Creek sampling sites.

the drainage (Greeley, 1937). Catskill Creek is a popular angling stream with fishing pressure focused on rainbow trout and brook trout.

Twenty-eight sampling sites were chosen at 3/4 mile intervals between stream miles 13 and 35 (Figure 1). The lower boundary of the sampling region was defined by the Woodstock dam. Test samples taken below the dam indicate an assemblage different from the region above the dam. The upper boundary was reached at stream mile 35, where the stream became too shallow for visual observations. The research goal was to look at resource use within the community of fishes adapted to cold, fast water, so sampling was restricted to the upper reaches of the creek. The narrow focus of the sampling made it important to select physically diverse mesohabitats to provided enough species and habitat diversity to make meaningful comparisons (Douglas and Lake, 1994). Deep riffles with large rocks and boulders were chosen, which created a wide variety of depths, water velocities and microhabitats.

Microhabitat

Microhabitat observations were made during seventeen sampling days from July 14 to October 4, 1994. Using mask and snorkel, I observed fish along a diagonal transect delineated by streamside markers (first person refers to D.A.B. in all cases). Transect width was determined by visibility. Visibility usually was limited to two meters by physical structures such as rocks, boulders and gravel bars and by the difficulty of accurate fish identification beyond two meters. Most fish showed little reaction to my presence. While slowly working my way along the transect, I identified each fish to assess species composition and recorded its associated microhabitat type, vertical holding quartile, and vertical feeding quartile on an underwater slate.

Each fish was identified to species or, in the case of trout, to family. The trout species were disturbed by my presence; I was rarely close enough for positive identification to species. On all other fish sight identification was simplified by the small number of abundant species and obvious color and morphological differences among species. Microhabitat in the riffle mesohabitat was classified into five distinct groups. The run is an area with smooth substrate and laminar flow throughout the water column. The depression is a hollow, often formed behind a rock or boulder. This microhabitat has a refuge at the deepest point with low water velocity and uninterrupted flow above. The eddy is a region of low water velocity found on each side of the stream. The behind-rock microhabitat is the region directly behind a rock or boulder that has not formed a depression. The under-rock microhabitat is a crevice under a rock or boulder. Quartile refers to the vertical quarter of the water column, counting from top to bottom. Holding quartile is the vertical water column quarter in which the fish spent the most time during the observation period. Feeding quartile is the vertical region into which the fish moved to feed on drift or benthos.

At each microhabitat I placed a flagged washer. After examining all microhabitats along the transect I measured depth and water velocity within the holding quartile of each of the fishes present. I then measured water temperature, velocity and depth at the site. Water velocity was measured with an electromagnetic flow meter.

Data analysis

The methods were designed to allow analysis at three spatial scales: microhabitat, mesohabitat, and macrohabitat. At the smallest scale there were 196 microhabitats sampled. Each microhabitat is associated with the following variables: fish species, water velocity, behavior, feeding level, and holding level associated with that microhabitat. At the next larger scale there were thirty-one mesohabitats sampled, which contain all 196 microhabitats. Six mesohabitat samples did not contain microhabitat data because of methodological changes made part way through the field season. Each mesohabitat is a represented by a transect of a riffle zone and is associated with the variables: species abundance, stream mile, temperature, substrate type, velocity profile, and depth profile.

The final level of analysis is at the macrohabitat level. The macrohabitat is the entire region sampled, and has species abundance totals associated with it.

Multivariate statistical analysis utilized the statistical program SPSS for exploratory principal components analysis and simple pairwise correlations. Since data reduction techniques tend to capitalize on chance variation when using small sample sizes (Jobsen, 1992), only the six most common species were used. Graphs and linear regressions were produced by SPSS.

RESULTS

Species composition

Table 1. Fishes observed in Catskill Creek. Total number of individuals = 1449.

Species	Observations: 24 mesohabitats 196 microhabitats
Blacknose dace, Rhinichthys atratulus (BND)	836 (58%)
Common shiner, Luxilus cornutus (COM)	259 (18%)
Longnose dace, Rhinichthys cataractae (LND)	112 (8%)
White sucker, Catostomus commersoni (SKR)	111 (8%)
Slimy sculpin, Cottus cognatus (SCP)	45 (3%)
Cutlips minnow, Exoglossum maxillingua (CLP)	41 (3%)
Smallmouth bass, Micropterus dolomieui (SMB)	16 (1%)
Spottail shiner, Notropis hudsonius (SPT)	12 (0.8%)
Rainbow or brown trout, Onchorhynchus mykiss or Salmo trutta (TRT)	9 (0.6%)
Yellow perch, Perca flavescens (YLP)	6 (0.4%)
Creek chub, Semotilus atromaculatus, CCB	2 (0.1%)

Blacknose dace was the primary species, and made up more than half of all observations (Table 1). Blacknose dace and the common shiner were the dominant species in the water column and were abundant throughout the region. Longnose dace and white sucker were also common and were most often observed low in the water column, grazing on substrate. All white sucker observed were juveniles less than 13 cm. Although low in overall abundance, slimy sculpin were very common under rocks in the upper third of the sampling region (above stream mile 30). Sculpin were rare downstream of mile 30. Cutlips minnow were found scattered throughout the region, although they rarely formed a significant portion of the assemblage.

Smallmouth bass and yellow perch were rare; they usually occupied the sheltered shoreline region. All observations of these species were of juveniles. Spottail shiner were found only in a seven-mile section of stream between Preston Hollow and Oak Hill. Trout species were more common than observations indicate. Trout were very skittish, and could be seen flashing out of microhabitats making it impossible to determine their species or take measurements of their microhabitat use. Creek chub were rare.

Microhabitat use

Exploratory principal components analysis extracted two variable groups (Table 2). The first group was made up of variables associated with the depression microhabitat assemblage which was numerically dominated by blacknose dace and common shiner. This assemblage tolerated fast water but was most strongly associated with the depression microhabitat. The second factor described a physical dimension negatively correlated with water velocity.

Table 2. Principal component analysis of species abundance and microhabitat variables (40.1% of variance accounted for by two factors; N= 196 microhabitats).

	Factor 1	Factor 2
Blacknose dace	**0.81172**	-0.27324
Cutlips minnow	**0.52401**	0.27856
Common shiner	**0.75112**	0.35569
Longnose dace	-0.15298	-0.02574
Slimy sculpin	-0.31063	0.15467
White sucker	**0.58689**	0.31708
Behind Rock	-0.08149	-0.03674
Depression	**0.64908**	**0.42179**
Eddy	**0.48193**	0.19237
Run	0.37644	**-0.74196**
Under rock	**-0.45506**	0.36187
Velocity	**0.44429**	**-0.58258**

Correlation analysis of species microhabitat data (Table 3) indicates relationships similar to those extracted by the factor analysis. Blacknose dace, common shiner, white sucker, and cutlips minnow abundance correlated positively with each other, which reflected their depression microhabitat use. Slimy sculpin correlated negatively with all members of the depression assemblage except white sucker. This result was expected since sculpin typically use the under-rock habitat over the depression habitat. However, even though both slimy sculpin and longnose dace utilized the under-rock microhabitat they were negatively correlated.

Table 3. Pearson pairwise correlations between species. Significant correlations in bold. N = 196 microhabitats. * P< .05; ** P<.005

	Blacknose dace	Cutlips minnow	Common shiner	Longnose dace	Slimy sculpin
Cutlips minnow	**.2661****				
Common shiner	**.4847****	**.3882****			
Longnose dace	-.0340	-.1039	-.1095		
Slimy sculpin	**-.1801***	**-.1544***	**-.1432***	**.2225****	
White sucker	**.2982****	**.2621****	**.3337****	.0284	-.1379

Correlation analysis (Table 4) indicates that each microhabitat was utilized differently by each species. The behind-rock microhabitat was not preferentially utilized by any species. The depression microhabitat was utilized by blacknose dace, cutlips minnow, common shiner, and white sucker. The eddy microhabitat was utilized by blacknose dace, cutlips minnow, and common shiner. The eddy microhabitat was also used by juvenile smallmouth bass and yellow perch and may serve as a refuge for juveniles of species which are usually found in pools. Blacknose dace is well adapted morphologically for fast water and is the only fish with a significant positive correlation with water velocity and the run microhabitat. Longnose dace abundance correlated with the under-rock microhabitat.

Table 4. Cross correlations between species abundances and microhabitat variables. (N=196 microhabitats, * P< .05; ** P<.005)

	Blacknose Dace	Cutlips Minnow	Common Shiner	Longnose Dace	Slimy Sculpin	White Sucker
Behind-rock	-.1307	.0925	-.1052	-.0950	-.0133	-.0196
Depression	**.4189****	**.2804****	**.4874****	-.0454	-.1266	**.6968****
Eddy	**.4607****	**.2963****	**.6459****	-.0749	-.0565	-.0302
Run	**.6117****	.0440	.0662	.0986	-.1310	.0680
Under-rock	**-.2933****	-.0567	-.1291	**.3085****	.1186	**-.1977***
Velocity	**.3422****	.1156	.1236	-.1323	**-.1812***	.0913

Closer examination of individual fish shows that each fish used the available microhabitats differently (Figures 2 and 3). White sucker primarily used the depression. Blacknose dace split between run and depression. Common shiner primarily used depression but regularly used other habitats. This species could tolerate high water velocities found in the run microhabitat. Cutlips minnow showed no strong overall

preference for a microhabitat. In contrast, longnose dace and slimy sculpin shunned the depression and the other microhabitats in favor of the under-rock microhabitat. These two species are also found in significantly lower water velocities than the dominant species of the depression assemblage (Figure 3).

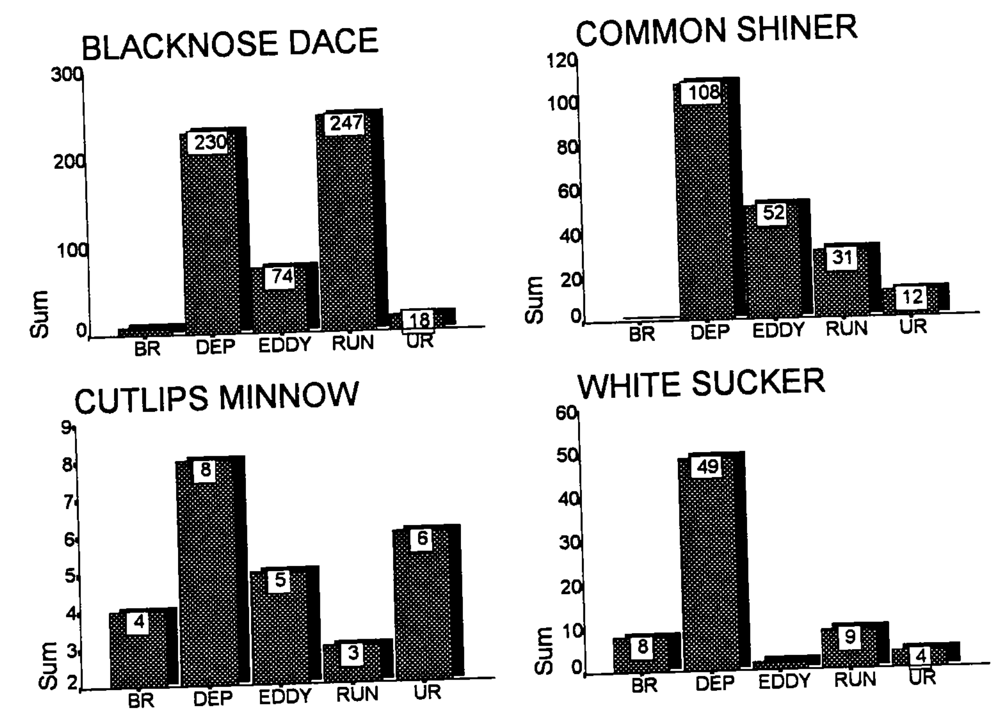

Figure 2. Microhabitat utilization by the depression assemblage. Microhabitats: BR = behind-rock, DEP = depression, EDDY = eddy, RUN = run, UR = under-rock.

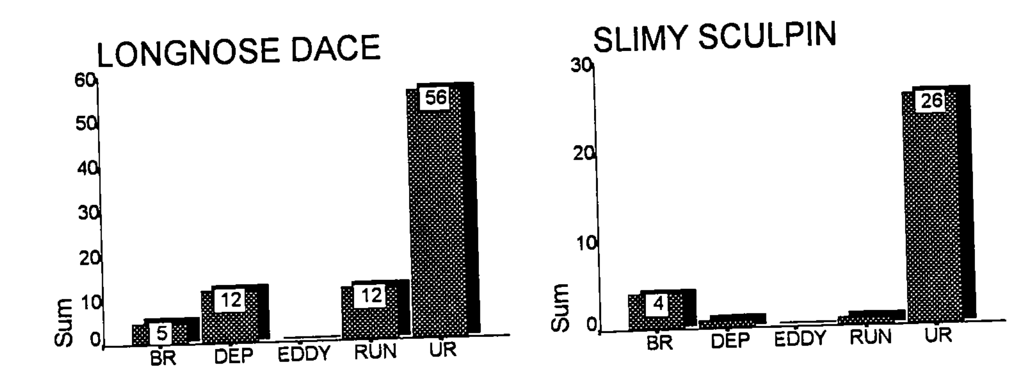

Figure 3. Microhabitat use by the under rock assemblage. Microhabitats: BR = behind-rock, DEP = depression, EDDY = eddy, RUN = run, UR = under-rock.

The blacknose dace and common shiner are the only depression assemblage species with a significantly higher (p=0.05) water velocity preference than the species in the under-rock assemblage (Figure 4).

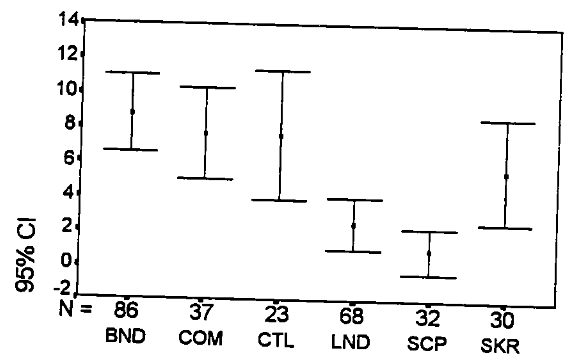

Figure 4. Average water velocity and 95% confidence interval for common fish species. Species: BND=Blacknose dace, COM=Common shiner, CTL=Cutlips minnow, LND=Longnose dace, SCP=Slimy sculpin, and SKR=White sucker.

An examination of feeding depth further separates the species. The first feeding quartile is utilized by white sucker, blacknose dace, and cutlips minnow (Figure 5). Blacknose dace and white sucker are the more abundant and have very different body morphologies and feeding strategies. The second quartile is primarily used by blacknose dace. The upper half of the water column is dominated by common shiner, which was the only species to feed at the surface.

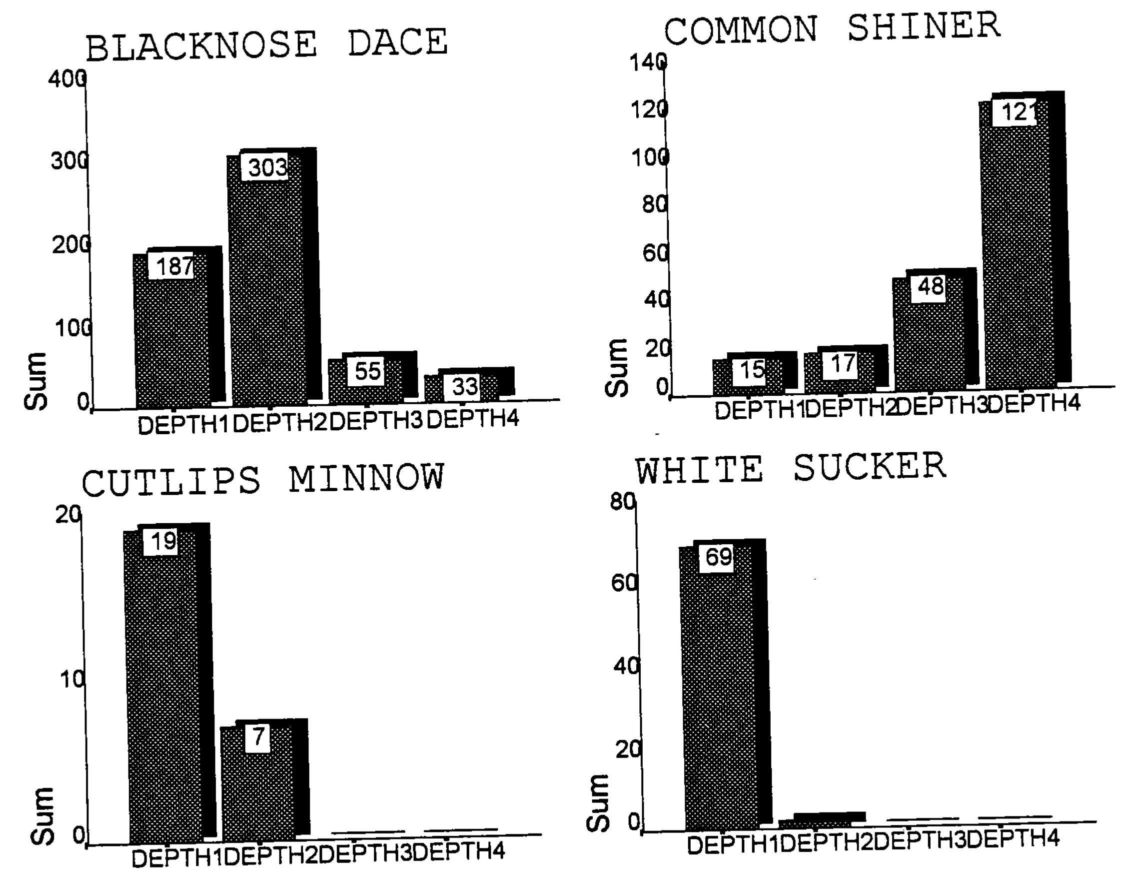

Figure 5. Feeding depth utilization by fish species of the depression assemblage

One aspect of the microhabitat use of the longnose dace and the slimy sculpin is that both utilize the under rock habitat (Figure 3) yet their abundances are negatively correlated (Table 3). A plot of sculpin and longnose dace abundance at each mesohabitat site against stream mile (Figure 6) indicates that longnose dace abundance is constant whereas sculpin abundance increases upstream. So, although these two species utilize similar microhabitats, they appear to partition the habitat along a longitudinal stream gradient.

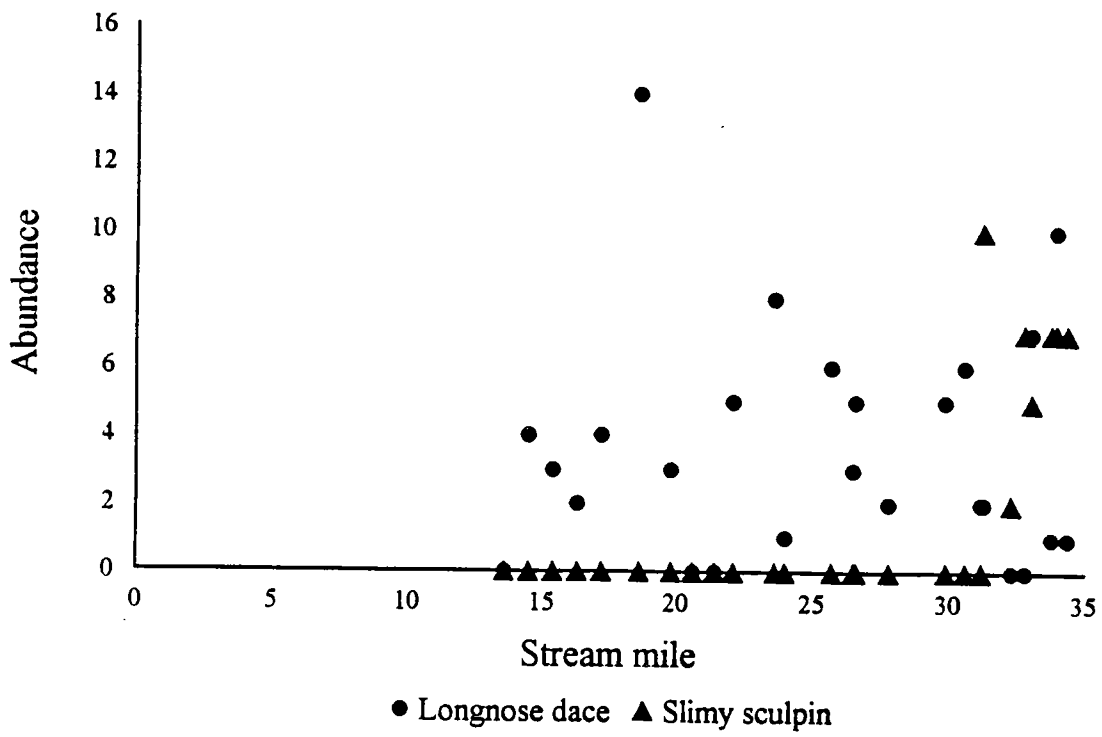

Figure 6. Linear regression of slimy sculpin and longnose dace abundance against stream mile (Slimy sculpin $R^2 = 0.43$; Longnose dace $R^2 = 0.00$)

DISCUSSION

The riffle zone mesohabitat of upper Catskill Creek contained five distinct microhabitats which were utilized by the six dominant species in a highly structured manner. Although only the depression, under-rock, and run microhabitats were consistently utilized, the six dominant fish species decreased contact with each other by partitioning the microhabitat.

The depression microhabitat was used by more species and individuals than any of the other microhabitats. This microhabitat contained a low velocity rest region with faster water above to provide drift for feeding. It was a multidimensional microhabitat, defined in part by differential water velocity. The run was the second most frequently used microhabitat. The high water velocity in the run region makes this microhabitat energetically expensive (Hynes, 1970). The eddy microhabitat was used infrequently,

although species traditionally associated with lakes and pools, such as yellow perch and smallmouth bass, (Smith, 1985) were observed in this region. The under-rock microhabitat supported relatively few individuals, yet was the most densely packed area of the stream due to its small size.

Every measured dimension of the depression microhabitat was utilized. White sucker and cutlips minnow grazed on benthos. The water column was utilized by blacknose dace and common shiner, with dace feeding in the lower half and common shiner feeding in upper half of the water column and at the surface. The fine partitioning of the microhabitat is characteristic of a deterministic assemblage of fishes which has coevolved to avoid competition (Giller, 1984; Grossman et al. 1982). The assemblage observed in this study may be a geographically cohesive group throughout the Hudson drainage, with the possible interchange of the creek chub for common shiner in some communities (Anderson, 1988). This group of six fishes may have occupied the Northeastern Coastal Refugium during 70,000 years of the latest ice age, which may have provided sufficient time for their coevolution (Schmidt, 1986).

Baltz et al. (1982) showed competition and macrohabitat partitioning by riffle sculpin, Cottus gulosus and speckled dace, Rhinichthys osculus in a California cold-water stream. A similar non-overlapping relationship may exist between longnose dace and slimy sculpin in Catskill Creek, as shown by Table 3. Similar to the California study, sculpin are absent from the lower regions. Baltz et al. (1982) demonstrated that spatial segregation of dace and sculpin in the California stream resulted from the sculpin's reduced ability to compete with dace at higher temperatures. This may explain the distribution patterns of sculpin and dace observed in Catskill Creek. However, other factors associated with headwaters, such as decreased turbidity, or changes is water chemistry may also provide an explanation of the distribution of these two species. In contrast to the California study, longnose dace abundances are consistent throughout the sampling region and are not affected by the increase in sculpin abundance in the upper reaches.

The physical niches found in the Catskill Creek riffle habitats were clearly defined and hydrodynamically distinctive. The limited space and the distinctive quality of the niches should serve to intensify competition resulting in an observed specialization among the fishes present in the assemblage (Begon et al. 1986). Interestingly, all fishes inhabiting cold, fast-water streams must adapt to niches with physical characteristics similar to those observed in Catskill Creek. This may explain the observed similarity among fast-water fish assemblages throughout North America. This may also explain why strong community structure was found in the relatively young Catskill Creek riffle fish assemblages.

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