Fish Assemblage of Cedar Fork Creek, Ohio, Unchanged for 28 Years[1]

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ABSTRACT. A 270 m section of Cedar Fork Creek, a clear, gravel-bottomed, headwater stream of the Ohio River System in north-central Ohio, was sampled 48 times from 1975-2003. During the 28 year period 32,237 individuals of 10 fish families and 44 species were collected. Eight taxa made up 86% of the total number collected. Cyprinids (*Luxilus cornutus*, *Campostoma anomalum*, *Pimephales notatus*, *Semotilus atromaculatus*, and *Notropis buccatus*) accounted for 65% of the individuals. Two darter species (*Etheostoma caeruleum*, *E. nigrum*) made up 17.4% of the total, and the white sucker, *Catostomus commersoni*, accounted for 3.3%. The same common species were abundant throughout the 28 years, and the same rare species were consistently present in small numbers. Species richness averaged 23 species per year. Margalef's index of diversity varied only slightly from 2.8 to 3.6 during the study indicating the constancy of species composition. Two jackknife estimators (nonparametric resampling procedures) suggested that the collections detected 97-100% of the species present. Exotic species failed to make inroads into the Cedar Fork community except for carp, *Cyprinus carpio*, that have been in Ohio since 1879, and brown trout, *Salmo trutta*, that were recently stocked by the Ohio Department of Natural Resources.

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INTRODUCTION

Cedar Fork Creek is an unpolluted, clear, warm-water, gravel-bottomed, fourth-order stream in Richland County near the village of Bellville in north central Ohio at 40°37.019 N, 82°33.923 W. The Cedar Fork is 15.4 km long with a gradient of 3.5 m/km and drains an area of 124 km^2. Various measurements of its environmental quality such as the Index of Biotic Integrity, Modified Index of Well Being, Invertebrate Community Index, and the Qualitative Habitat Evaluation Index range from good to exceptional (Ohio EPA 2000). This locality is just a few km south of the generally accepted late Wisconsinan boundary (Totten 1973). Cedar Fork is a tributary of the Clear Fork of the Mohican River that is part of Ohio's largest watershed, the Muskingum River, which flows into the Ohio River at Marietta (Sanders 2002).

The fishes of Cedar Fork Creek, OH, have been sampled more or less regularly since 1975. In a study on the incidence of black spot disease in 4,175 fishes belonging to 29 taxa, pool-dwelling species were more likely than riffle-dwelling species to be infected by the fluke, *Uvulifer ambloplitis* (Berra and Au 1978). Berra and Au (1981) examined 18,361 fish specimens from 34 species for incidences of teratological fishes in Cedar Fork Creek. Only 47 defective fishes (0.26%) were found. The incidence of deformed fishes from heavy-metal polluted streams in the nearby Rocky Fork of the Mohican River was 0.53% (Reash and Berra 1989). Mohican watershed drainage maps, water chemistry, and a comparison of polluted and unpolluted stream fish populations were given by Reash and Berra (1986, 1987). Gleason and Berra (1993) studied the hybridization of *Luxilus cornutus* and *L. chrysocephalus* in Cedar Fork Creek. They reported a stable ratio of 91% *L. cornutus*, 7% *L. chrysocephalus*, and 2% hybrids, and demonstrated selection against young-of-year hybrids.

Matthews (1998, p 104-129) provided a review of the extensive literature of stream fish assemblages. By considering fluctuation and stability as part of the same long-term picture, Matthews' analysis reconciled the apparent contradiction between two seemingly mutually exclusive statements, namely that fish populations fluctuate in abundance and composition annually and yet one can collect essentially the same species in the same numbers at the same locality from year to year. Grossman and others (1998) demonstrated that variability in mean and peak flows has a stronger effect on fish assemblage structure and use of spatial resources in a North Carolina stream than either interspecific competition for space or predation. Fish assemblage structure in a Texas prairie stream was determined more by differences in environmental conditions among sites than by seasonal variation in environmental conditions (Ostrand and Wilde 2002).

Meffe and Berra (1988) examined the persistence (constancy of species composition) and stability (constancy of relative species abundance) of the fish assemblage in Cedar Fork Creek based on 38 collections made from July 1975–July 1984. They concluded that the assemblage was both persistent and stable over the 9-year period. The purpose of the present paper is to extend the analysis to 28 years.

MATERIALS AND METHODS

Collection Site and Methods

A total of 48 samples from July 1975-August 2003 was collected from the same 270 m section of Cedar Fork Creek. Collections were made in 15 years of the 28-year period. All collections were made with a 1.6 mm mesh, 3.0 m seine, with the exception of 3 samples obtained by pulsed direct-current electrofishing. Most collections (75%) were made during the warm months

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May-September, when water temperature averaged 19° C (range = 7.5-23.5° C). No collections were made in January and February when ice lined the banks. The stream was very active geomorphologically especially during spring flooding. Erosion and deposition constantly rearranged the pools and riffles, but the locations of the downstream and upstream boundaries of the study area were the same for each collection. Land usage in the rural rolling hills of the watershed was recreational and agricultural, consisting of corn, soybeans, and dairy cattle, and changed little during the course of the study. Water depth varied from a few cm in riffle areas to nearly 2.0 m in deep pools. The stream ranged from 5-20 m wide during normal flow. The dominant aquatic vegetation was attached filamentous algae. There was little floating or emergent plant cover. One or occasionally two teams of seiners covered the study area for each sample. Sampling times averaged 127 min (60-170 min), usually in the afternoon. If two teams were utilized, their times were additive. Three collections were made with multiple teams of students. Those times are not included in the 127 min average. Specimens were fixed in 10% formalin and stored in 40% isopropyl alcohol for later identification using Trautman (1957, 1981). Because of the difficulty of positively identifying some small scaleless juveniles and hybrids, *Luxilus cornutus* and *L. chrysocephalus* were lumped as *Luxilus* spp., *Moxostoma dusquesnei* and *M. erythrurum* were lumped as *Moxostoma* spp., and *Lepomis cyanellus*, *L. gibbosus*, and *L. macrochirus* were lumped as *Lepomis* spp. (Table 1). Voucher specimens were retained in the fish collection of the first author.

TABLE 1

Taxa collected in Cedar Creek in a 28-year period between 1975 and 2003. Number of samples = 48

Family/ Species	n	% Total	Mean %/ Samples	No. Years Present	No. Coll. Present
Petromyzomtidae					
Lampetra aepyptera (least brook lamprey)	2	0.006	0.012	2	2
Clupeidae					
Dorosoma cepedianum (gizzard shad)	1	0.003	0.006	1	1
Cyprinidae					
Campostoma anomalum (central stoneroller)	5582	17.316	18.421	15	48
Clinostomus elongatus (redside dace)	62	0.192	0.311	8	15
Cyprinella spiloptera (spotfin shiner)	4	0.012	0.027	2	3
Cyprinus carpio (common carp)	6	0.019	0.028	3	3
Hybopsis amblops (bigeye chub)	83	0.257	0.236	11	26
Luxilus cornutus [1] (common & striped shiners)	7827	24.280	22.618	15	48
Notropis buccatus (silverjaw minnow)	1251	3.881	3.157	15	46
Notropis photogenis (silver shiner)	220	0.682	0.850	12	25
Notropis rubellus (rosyface shiner)	206	0.639	0.835	12	32
Notropis stramineus (sand shiner)	135	0.419	0.779	10	16
Notropis volucellus (mimic shiner)	38	0.118	0.167	2	7
Phoxinus erythrogaster (southern redbelly dace)	20	0.062	0.066	6	10
Pimephales notatus (bluntnose minnow)	3888	12.061	9.967	15	47
Pimephales promelas (fathead minnow)	51	0.158	0.199	5	12
Rhinichthys atratulus (eastern blacknose dace)	674	2.091	2.993	15	44
Semotilus atromaculatus (creek chub)	2396	7.432	7.958	15	48

TABLE 1 (*Cont.*)

Taxa collected in Cedar Creek in a 28-year period between 1975 and 2003. Number of samples = 48

Family/ Species	n	% Total	Mean %/ Samples	No. Years Present	No. Coll. Present
Catostomidae					
Carpiodes cyprinus (quillback)	190	0.589	0.476	6	12
Catostomus commersoni (white sucker)	1073	3.328	3.135	15	46
Hypentelium nigricans (northern hog sucker)	492	1.526	1.619	14	43
Moxostoma spp.[2] (black and golden redhorse)	272	0.844	0.644	9	24
Ictaluridae					
Ameurus melas (black bullhead)	1	0.003	0.005	1	1
Salmonidae					
Salmo trutta (brown trout)	4	0.012	0.059	1	2
Gasterosteidae					
Culaea inconstans (brook stickleback)	11	0.034	0.042	8	9
Cottidae					
Cottus bairdii (mottled sculpin)	778	2.413	2.479	15	48
Centrarchidae					
Ambloplites rupestris (rock bass)	52	0.161	0.166	9	20
Lepomis spp.[3] (green, pumpkinseed, bluegill)	161	0.499	0.722	11	28
Micropterus dolomieui (smallmouth bass)	58	0.180	0.153	8	16
Micropterus punctatus (spotted bass)	1	0.003	0.002	1	1
Micropterus salmoides (largemouth bass)	51	0.158	0.172	10	13
Pomoxis annularis (white crappie)	1	0.003	0.005	1	1
Pomoxis nigromaculatus (black crappie)	2	0.006	0.016	3	2
Percidae					
Etheostoma blennoides (greenside darter)	614	1.905	1.854	15	46
Etheostoma caeruleum (rainbow darter)	3310	10.268	11.350	15	48
Etheostoma flabellare (fantail darter)	297	0.921	1.155	14	37
Etheostoma nigrum (johnny darter)	2287	7.094	6.879	15	48
Etheostoma zonale (banded darter)	127	0.394	0.412	11	35
Percina caprodes (logperch)	4	0.012	0.011	3	4
Percina maculata (blackside darter)	5	0.016	0.012	2	4
Total	32237				

[1]includes 91% *Luxilus cornutus* and 7% *L. chrysocephalus*.
[2]includes *Moxostoma dusquesnei* and *M. erythrurum*.
[3]includes *Lepomis cyanellus*, *L. gibbosus*, and *L. macrochirus*.

Statistical Methods

Inter-annual species diversity differences were analyzed using Margalef's diversity index $D_{Mg} = (S\text{-}1)\ln N^{-1}$ where S is the number of species in sample i, and N = total number of specimens in sample i. This index is a function of species captured accounting for the sum of all specimens in each sample. It also accounts for the difference in sampling effort, thus providing an unbiased comparison among years. Samples from the same year of collecting were pooled for analysis. Total species richness for Cedar Fork Creek was estimated using two Jackknife estimators, which are nonparametric re-sampling procedures (Palmer 1990, 1991) implemented in PCORD (McCune and Mefford 1997).

RESULTS

Forty-four fish species and 32,237 individuals belonging to 10 families were recorded in 48 collections from Cedar Fork Creek between 1975 and 2003 (Table 1). Of these, 8 taxa numbered greater than 1000 individuals each and made up 86% of the total. Minnows (Cyprinidae) were the dominant family accounting for 65% of the individuals. Two darter species (Percidae) made up 17.4% of the total catch, and white suckers, *Catostomus commersoni,* composed 3.3%. Eleven species, belonging to 7 families, were represented by 6 or fewer individuals each and accounted for less than 0.1% (Table 1). The remaining 14% of the fish fauna was composed of 21 taxa from 6 families whose individuals numbered from 11-778.

Eleven taxa were represented in all 15 years of the study in which collections were made, and 10 taxa were present in at least 46 of the 48 collections (Table 1). Most of these species were numerically abundant but others were always present at lower levels. Species richness varied among years from 17 to 31 species, with an average of 23 species per year. Margalef's index of diversity varied from 2.8 to 3.6 over the 28-year period of sampling, indicating that the fish community remained largely constant with little variation in species composition once sampling effort was accounted for (Fig. 1). The highest observed value was in 1987 after a major flood that apparently introduced some farm pond species into the system raising the number of species detected during that year's sampling. Estimates of total number of species were 44 and 45 for the first and second order Jackknife estimators, respectively, suggesting that the sampling procedure detected 97-100% of the estimated number of species present in Cedar Fork Creek.

DISCUSSION

The fish assemblage of Cedar Fork Creek has changed very little in the 28 years since collections began in 1975. Species richness remained largely unchanged between years for the entire sampling period (Fig. 1). The same core group of taxa that dominated the fauna between 1975-1984 (Meffe and Berra 1988) is still dominant today, and the same rarely collected species are still rarely, but consistently, encountered. The mean percent of a given taxon/sample closely mirrors its percent of the total number of specimens over the 28-year study (Table 1). For example, *Campostoma anomalum* composed 17.3% of the total number of specimens, and its representation in each of the 48 samples averaged 18.4%. This indicates that the relative proportion of the various species did not change much over time. Invasive species other than carp, *Cyprinus carpio*, have made little headway in this stream. Carp have been in Ohio since 1879 (Trautman 1981). Brown trout, *Salmo trutta*, have been stocked by the Ohio Department of Natural Resources in the Clear Fork and have thereby gained access to the Cedar Fork. The presence of brown trout was confirmed by electrofishing. This species did not appear in the

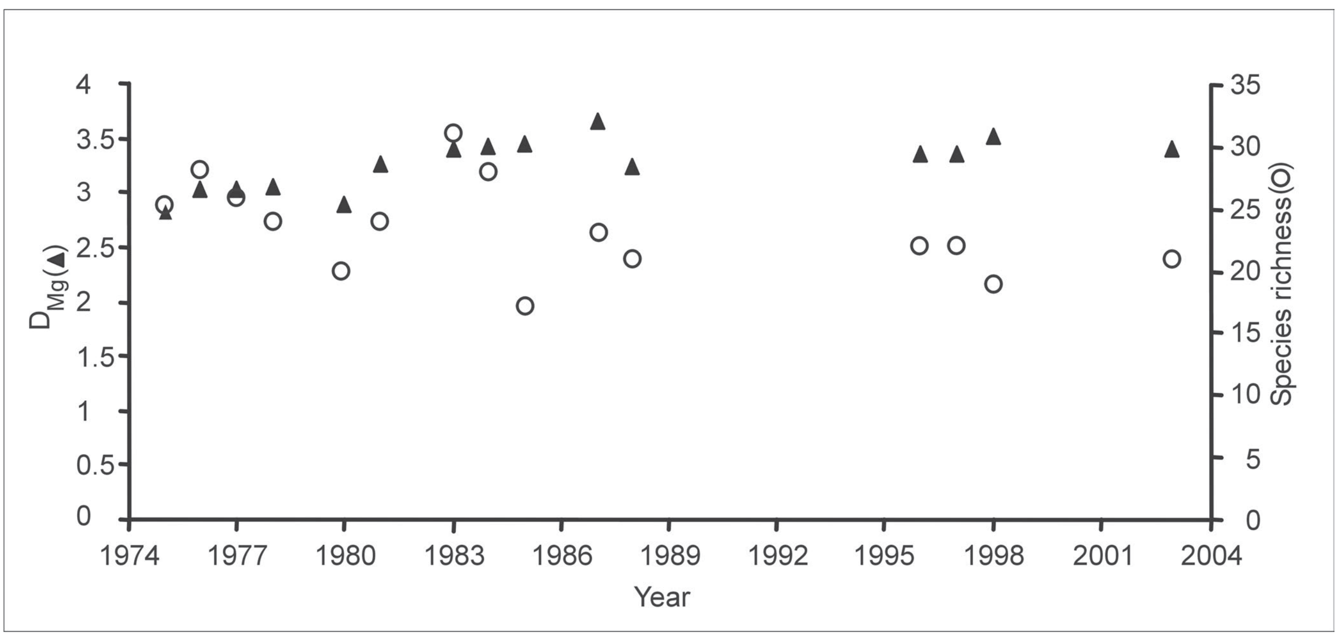

FIGURE 1. Temporal variation of species diversity represented as Margalef's Diversity Index (triangles), and species richness (circles).

samples obtained by seining. The Clear Fork and its tributary, Cedar Fork, are two of only a few "trout streams" in Ohio. The emergence of cool spring water from the bottom of the streambed makes trout survival possible, but summer temperatures are too warm for natural reproduction. Other Ohio trout streams include the Mad River (Great Miami River drainage) and Clear Creek (Hocking River drainage) (Sanders 2002). Only one catfish specimen was taken. A small black bullhead, *Ameurus melas*, was seined after a large flood in July 1987. This fish almost certainly was washed into the Cedar Fork from farm ponds in the area. The two species of crappies, *Pomoxis* (Table 1), are also most likely escapees from farm ponds during floods.

We make no pretense that our sampling effort was identical for each collection. This would be impossible due to the constantly changing stream morphology, water depth, temperature changes, seasonal variation, time spent, number of helpers, and so on. However, the overall trend is abundantly clear and the samples are representative of the system. The fish species composition has not changed significantly in 28 years. In an analysis of stream fish assemblages from 50 undegraded northern watersheds Wang and others (2003) wrote that a diverse assemblage of cyprinids, catostomids, centrarchids, and percids, like we report in Table 1, existed in warm, wide, gravel-bottomed streams similar to those in our study area.

It should be noted that the 32,237 fishes collected in the 48 samples were removed from the population, yet the community consistently reassembled. This is reminiscent of the repopulation studies conducted by Berra and Gunning (1970) who demonstrated that longear sunfish (*Lepomis megalotis*) populations removed from Louisiana stream segments could recover within one year. Meffe and Sheldon (1990) reported a similar post-defaunation recovery of fish assemblages in South Carolina streams. Longitudinal movement within the overall stability of the larger system is thought to be responsible for the repopulation in both of the above reports and the current study.

Even though numbers change from year to year, the overall pattern of persistence and stability remains the same over an extended period of time. This apparent paradox can be explained by viewing the assemblage as a whole. In the absence of anthropogenic factors (pollution, habitat degradation, invasive species), most stream fish assemblages oscillate about stable conditions and are relatively resistant to change (Matthews 1998). The year-to-year variation of relative abundance among the dominant species is most likely the effect of inter-annual variation of recruitment success. It is reassuring that the Cedar Fork fish assemblage has remained intact for 28 years. Barring any human disturbance, it should persist with only minor natural variation for the foreseeable future.

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