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Michael R. Dewey
University of Arkansas, Fayetteville

SEASONAL ABUNDANCE, MOVEMENT AND DIVERSITY OF FISHES IN AN OZARK STREAM

MICHAEL R. DEWEY[1]
Department of Zoology
University of Arkansas
Fayetteville, Arkansas 72701

ABSTRACT

Seasonal fluctuations in fish abundance in Mud Creek occurred throughout the year at all sampling stations. At the two upper stations abundance was high and unstable during winter and early spring and decreased after heavy rainfall in mid-April. Abundance was low throughout the summer months, increasing in the fall due to large numbers of young-of-the-year. However, a different seasonal cycle occurred at the lower station which included deeper pools. Numbers were low and stable throughout the winter and early spring but high and unstable during the summer. Bigeye shiners (*Notropis boops*) and bluntnose minnows (*Pimephales notatus*) were the most mobile species marked. Populations of brook silversides (*Labidesthes sicculus*) remained fairly isolated, stable, and showed little mobility. Mean species diversity fluctuated during the winter, spring, and fall; diversity values were highest and most stable during summer months when high and relatively stable numbers were collected. The main difference in mean species diversity between stations was the greater stability throughout the year at the upper station.

INTRODUCTION

Little is known about the variability of movement among the various species of small fishes in streams. The movement of game fishes, especially the salmonids and centrarchids, has been studied extensively in streams with variable results. Thompson (1933), Stefenich (1951), Bjornn and Mallet (1964), Brown (1961), Behmer (1964), Hunt (1964), and Shetter (1968) found extensive movement by game fishes in streams. Bangham and Bennington (1938), Scott (1949), Tate (1949), Gerking (1950, 1953) and Gunning and Shoop (1963) concluded that there was relatively little movement of the fishes studies. Gerking (1959) discussed the restricted movement of fishes. Funk (1955) offered an explanation for the variability of movement among fishes by stating that there are "sedentary" and "mobile" segments within fish species, with the percentage of each segment varying according to species.

Some studies have dealt with the movement of small fishes in streams; however, most of these studies did not include a comparison of seasonal movement. The movement of small fishes has been shown when decimated areas were repopulated. These reported rates of repopulation have varied (Harrel et al., 1967; Gunning and Berra, 1969; Cairns et al., 1971; Olmsted and Cloutman, 1974). Wickliff (1941) found wide fluctuations in numbers of darters, minnows, and suckers in the riffle area of an Ohio stream with maximum periods of abundance occurring during the summer and fall. Lairmore (1954) reported that minnow populations followed cycles of abundance in an Illinois stream, with numbers low in the winter and spring but high in the summer due to the addition of young-of-the-year. Winn (1958) found some movement between pool and riffle areas by darters in Michigan streams. Reed (1968) studied the darters of Pennsylvania streams during the summer months and found that darters stayed in a riffle area or in an adjoining pool. Paloumpis (1958) studied an unstable Iowa stream and concluded that fish population changes were rather small considering the unstable habitat. Smith (1963) reported that numbers of fishes decreased sharply during the spring and early fall and increased during the summer and winter in an Illinois stream. The breaking up of winter aggregations, the increased alterness and activity of fishes as the water warmed, the establishment of breeding territories winter kills, and the diluting effects of spring rains were suggested as reasons for the low numbers in the spring and early summer. Movement of fishes in two North Carolina streams was shown by Hall (1972) and was found to be less during low water periods in late summer and winter. The movement of the largest number of fishes occurred from April until June. Hubbs and Wauer (1973) reported that seasonal changes of abundance varied among several species of minnows in a west Texas stream.

Changes in abundance, mark-recapture data, and diversity indices were used in this study to gain some understanding about the movement and population stability of stream fishes. The objectives of this study were to (1) study the seasonal movement or stability of fishes in Mud Creek, an Ozark stream, (2) compare the mobility of the bigeye shiner (*Notropis boops*), the bluntnose minnow (*Pimephales notatus*), the blackspotted topminnow (*Fundulus olivaceus*), the brook silverside (*Labidesthes sicculus*), and the orangethroat darter (*Etheostoma spectabile*), and (3) determine the seasonal changes in diversity of a stream fish community.

Mud Creek, a tributary of Clear Creek, in the Illinois River system, is located in north-central Washington County, Arkansas. It is approximately 9 km long and flows in a northwest direction (Fig. 1). The drainage area consists of pastureland and residential areas. Compared with many Ozark upland streams, Mud Creek has a relatively low gradient and muddy substrate.

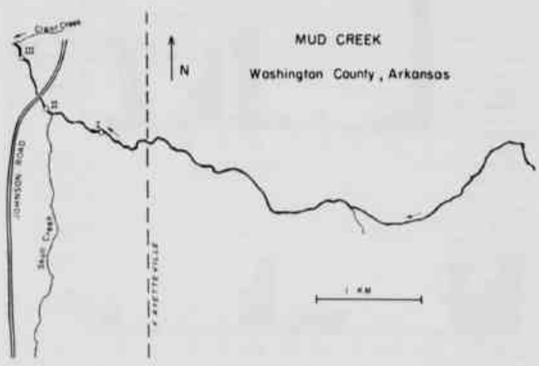

Figure 1. Sampling stations on Mud Creek, Washington County, Arkansas.

[1]Present address: U. S. Fish and Wildlife Service, Multi-Outlet Reservoir Studies, P.O. Box 705, Ouachita Baptist University, Arkadelphia, Arkansas 71923.

METHODS AND MATERIALS

Three sampling stations, designated I, II, and III, were established in December 1971. Station I, the uppermost station, was approximately 1.5 km from the mouth of the stream. Stations II and III were located at progressive 0.5 km intervals downstream from Station I. In the area sampled, the average stream width and depth were 5.0 and 1.0 m, respectively. Each station was divided into three contiguous substations: A, B, and C. Substation A was uppermost at each station. Substations A and C were sections of pool areas connected by a riffle or riffle-raceway area which was designated Substation B.

Collections were made twice each month from December 1971, through November 1972. Sampling at Substation III-B was discontinued after the first collection in July because the riffle was covered by gravel after heavy rains. Sampling at Station II had to be discontinued after the first collection in September when much of the bank area was cleared of vegetation during the second and third weeks of September with trees and soil being pushed into the water.

A minnow seine, 6.1 m long with 6.4 mm mesh, was used to sample each station. Collections were made at Substations A and C by making one seine haul the length of the substation. At Substation B of each station, the seine was held at the lower end of the riffle, while one person, beginning at the upper end and moving toward the seine, kicked the riffle and displaced the gravel.

After each substation collection, the captured fish were identified and counted. The five species of fishes fin-clipped to study their movements were the bigeye shiner, the bluntnose minnow, the blackspotted topminnow, the brook silverside, and the orangethroat darter. If any of these species were captured in large numbers at a substation, usually 20 to 30 fish were fin-clipped and the rest released unmarked. A different combination of fin marks were used at each substation. Only two fins were used in each combination, and only half of the caudal fin was removed from any fish. Small fish of many species (usually less than 25-30 mm in length) which first appeared in the collections during late May, were classified as young-of-the-year (YOY).

The diversity index used in this study (mean diversity per individual), (Wilhm and Dorris, 1968), is expressed as follows:

$$\bar{d} = -\sum_{i=1}^{s} \left(\frac{n_i}{n}\right) \log_2 \left(\frac{n_i}{n}\right)$$

Where n is the total number of individuals, n_i is the number of individuals of species i, and s is the number of species per unit area. Mean diversity indices derived from information theory are independent of sample size. Also, when $\bar{d}$ is used, the contribution to total diversity by rare species is small (Wilhm and Dorris, 1968).

RESULTS AND DISCUSSION

Seasonal Abundance and Stability.

December through February (Winter): Twenty-one species representing eight families were collected during the study (Table 1). Throughout the winter, large fluctuations in abundance were found between and within months at Stations I and II (Fig. 2). The winter abundance levels were relatively high at both stations compared to the entire study period. The fluctuations were smaller at Substation I-C because of a population of brook silversides that remained fairly stable throughout the winter. Distinct differences were shown between the two pool substations at Station II during the winter. Substation II-A showed relatively low, stable abundance levels because of stable numbers of orangethroat darters. However, at Substation II-C, where a wider variety of species was collected, large fluctuations in abundance occurred mainly because of changes in abundance of bigeye shiners. The riffle substation, where the fish population consisted mainly of orangethroat darters and stonerollers (*Campostoma anomalum*), also showed great stability in numbers. At Station III, the fish population remained relatively constant. During the winter months the abundance of fishes showed greatest stability in the deeper waters of Station III, possibly indicating less movement in the deeper waters than in the shallower pool areas at the other two stations.

March through May (Spring): Large changes in abundance were found at all three stations (Fig. 2). High abundance levels in March and early April at Stations I and II were due to increasing numbers of bigeye shiners and bluntnose minnows. The numbers of fishes collected at Stations I and II decreased from the second collection in April through May. Rainfall totaling over 8 cm caused high water during the second week of April. After this period, the numbers of fishes collected increased at Station III, the lowermost station. Gerking (1950) reported that high waters had very little effect on the stability of a stream population consisting mainly of centrarchids. However, in Mud Creek the heavy runoff caused by excessive rainfall was followed by definite reductions in the fish populations at the two upper stations and a definite increase of fishes at the lowermost station through May, indicating a downstream movement of fishes.

Changes in abundance throughout the spring were caused mainly by fluctuating and increasing numbers of bigeye shiners, bluegills (*Lepomis macrochirus*) and longear sunfishes (*L. megalotis*). Fish

Table 1. Seasonal occurrence of fishes collected in Mud Creek (Roman numerals are station numbers).

Fishes collected	Dec.			Jan.			Feb.			Mar.			Apr.			May		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Notemigonus crysoleucas	+		+	+			+				+	+		+				
Notropis boops	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
N. chrysocephalus																		
N. umbratilis																		
Pimephales notatus	+	+	+	+	+	+	+	+	+				+	+	+	+	+	+
Dionda nubila			+							+				+				
Semotilus atromaculatus										+								
Nocomis asper																+		+
Campostoma anomalum		+	+		+	+		+			+			+		+		
Ictalurus melas													+					
Moxostoma erythrurum																		
Fundulus olivaceus	+			+				+	+		+		+	+	+			
Gambusia affinis						+						+						
Labidesthes sicculus	+			+	+					+	+	+						
Micropterus salmoides	+						+			+			+			+		
Lepomis macrochirus	+	+	+				+	+	+	+	+	+	+	+		+		+
L. cyanellus		+	+	+		+	+	+	+	+	+					+	+	+
L. megalotis			+			+	+	+	+	+			+	+	+			
L. microlophus										+								
Etheostoma spectabile	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
E. flabellare		+				+			+									

+ denotes the collection of fishes

Fishes collected	June			July			Aug.			Sept.			Oct.			Nov.		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Notemigonus crysoleucas							+						+			+		
Notropis boops	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+		+
N. chrysocephalus			+			+			+				+			+		
N. umbratilis			+															
Pimephales notatus	+	+	+	+	+	+	+	+	+	+	+		+		+			
Dionda nubila					+													
Semotilus atromaculatus																		
Nocomis asper	+	+	+			+												
Campostoma anomalum	+	+	+		+	+	+	+										
Ictalurus melas				+				+										
Moxostoma erythrurum										+								
Fundulus olivaceus	+	+	+	+	+	+	+	+	+	+	+	+	+		+			
Gambusia affinis					+		+	+	+	+	+	+	+		+			
Labidesthes sicculus	+	+	+	+	+	+	+	+	+	+	+	+	+		+			
Micropterus salmoides	+	+	+		+	+												
Lepomis macrochirus	+	+	+	+	+	+	+	+	+	+	+	+	+		+			
L. cyanellus	+			+		+	+						+			+		
L. megalotis	+		+	+	+	+	+	+	+	+	+	+	+		+	+		
L. microlophus				+														
Etheostoma spectabile	+	+		+	+		+			+	+		+		+	+		

+ denotes the collection of the fishes

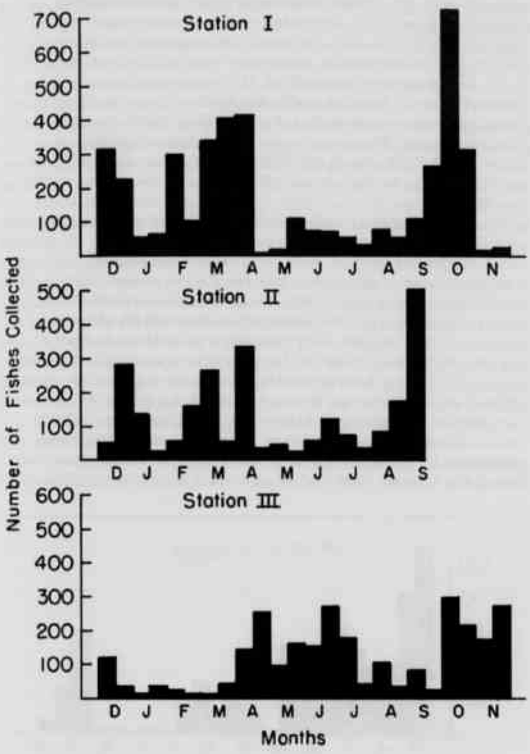

Figure 2. Seasonal occurrence of fishes at three sampling stations.

populations at riffle substations remained relatively stable throughout the spring, while fish populations in the pools fluctuated at all stations.

June through August (Summer): Abundance levels were comparatively low and stable at Station I and II (Fig. 2). The increase in fishes at Station II during the last collection in June was due to an aggregation of YOY brook silversides. High abundance levels at Station III during June and July were due to the presence of YOY of 12 species, mostly cyprinids. The number of fishes at all stations declined during late July, possibly due to rainfall of over 12 cm during a two-day period in mid-July. During the summer months, numbers were low in the warm, shallower pools at Stations I and II, while numbers in the deeper pools at Station III increased.

Populations at riffle substations remained relatively stable throughout the summer. Fluctuations in abundance at the pool substations were caused mainly by fluctuating populations of YOY cyprinids, centrarchids, and atherinids.

September through November (Fall): Abundance of YOY fishes peaked in September and October at all stations, and increasing numbers of fishes were collected at all stations (Fig. 2). This increase was due to the abundance of bigeye shiners, bluntnose minnows, and bluegills. The extent of the spawning periods of these species in Mud Creek is unknown. Paloumpis (1958) found that bluntnose minnows spawned throughout the summer in an Iowa stream. Throughout the fall, at all stations in Mud Creek, the numbers of YOY fluctuated, indicating the mobility of the young fishes.

Table 2. Mark and recapture data of five fin-clipped species in Mud Creek, Washington County, Arkansas.

	Species				
	Bigeye Shiner	Bluntnose Minnow	Brook Silverside	Blackspotted Topminnow	Orangethroat Darter
Number of fish marked	1,188	529	494	120	263
Percentage of marked fish recaptured	11.9	6.5	36.0	10.0	3.8
Percentage of recaptured fish caught at same station where marked	84	83	98	83	100
Percentage of recaptured fish caught at same substation where marked	39	48	97	75	90

It is difficult to make generalizations concerning this stream-fish community, since variations between stations were noted throughout the year. Changes in numbers of fishes collected indicated dynamically fluctuating populations in Mud Creek throughout the year.

Mobility of Some Selected Stream Fishes.

A paucity of work exists concerning the differences in mobility among the smaller streams. Funk (1955) reported that fish species consist of "mobile" and "sedentary" segments, but he studied only the movements of game fishes. In Mud Creek, mobility was analyzed by

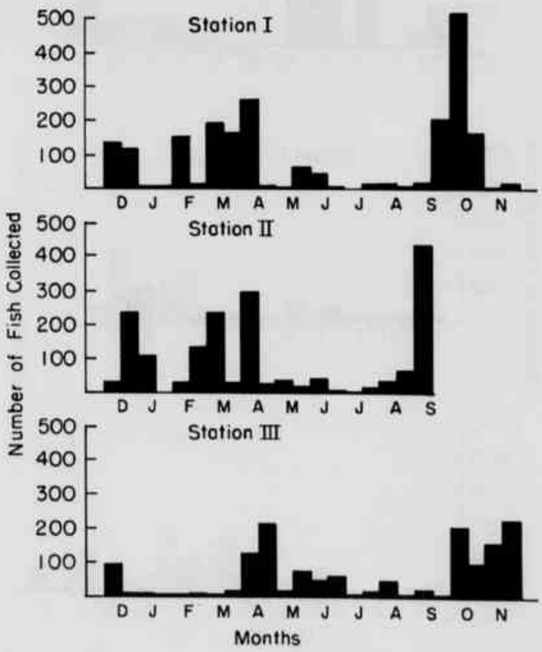

Figure 3. Seasonal abundance of the bigeye shiner.

using both changes in abundance and mark and recapture data. The division of each station into three substations allows for a more intensive study of the localized movements at each station. The percentage of recaptures collected at the same station where they were marked was relatively high for all species, probably because of the limited area sampled outside each station. Recaptured fish were returned to the stream population. Therefore, it was possible to capture a marked fish more than once. This could inflate the recapture percentages to some extent.

Bigeye shiners were the most common of the species marked. Abundance fluctuated greatly throughout the study (Fig. 3). Fluctuations were smallest during the summer months. Of 1,188 bigeye shiners fin-clipped, 11.9% were recaptured, and 84% of those were recaptured at the same station where they were marked (Table 2). This species had the lowest percentage of recaptured at the substation where they were marked, indicating greater mobility within the stations, compared with the other species. Of the fish recaptured at a different station than where they were marked, 68% had moved upstream, while 32% had moved downstream. Although the numbers of fish used in calculating these percentages were low, this did indicate a tendency to move upstream. Smith and Powell (1971) found little migration by this species between pools during low-water periods.

Fluctuations in abundance of bluntnose minnows occurred throughout the year (Fig. 4). Generally, bluntnose minnows seemed more abundant during spring and fall in Mud Creek. However, seasonal abundance varied noticeably from station to station, so it is difficult to generalize concerning cycles of abundance. Of 529 fish marked, only 6.5% were recaptured. Of those, the percentage of fish collected at the substation where they were marked was 48%, relatively low compared with all of the other species except bigeye shiners (Table 2). One fish marked at Station II was accidentally collected in another study during April in Clear Creek approximately 5 km downstream. These data seem to indicate a high degree of mobility. Smith (1963) found that bluntnose minnows showed the greatest fluctuations in abundance of all fishes collected in an Illinois stream.

Fluctuations of abundance based on mark and recapture data indicate that brook silversides are relatively sedentary (Fig. 5). Of 4949 brook silversides marked, 36% were recaptured—the highest recapture percentage of all marked species. Of the recaptured fish, 98% were collected at the same station where they were marked, and 97% were recaptured at the same substation. Populations of brook silversides seemed to remain fairly isolated with little exchange between populations in different areas. Large numbers were collected at Substation I-C during the winter, while few were collected at all other substations. Population levels remained high and fairly stable through the spring only at Substation I-C. These data indicate that brook silverside populations may congregate in certain areas, with population levels remaining fairly stable. Numbers of adults collected during the summer were low. High natural mortality of adults could

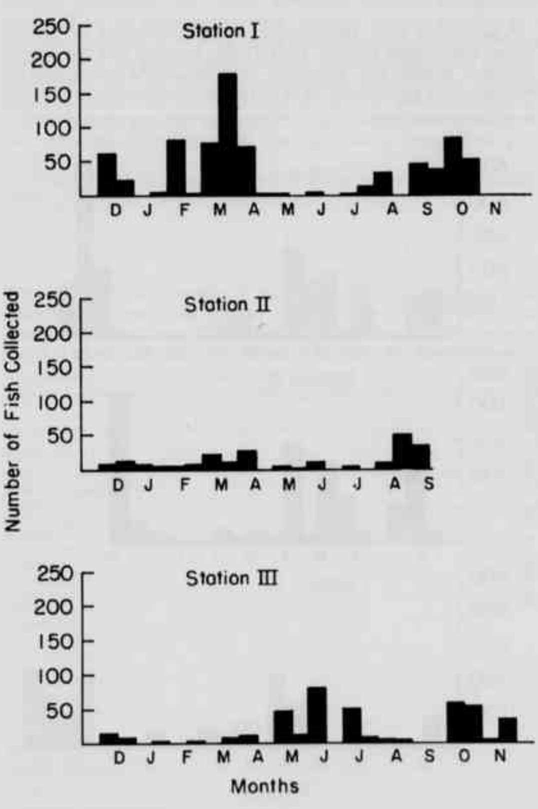

Figure 4. Seasonal abundance of the bluntnose minnow.

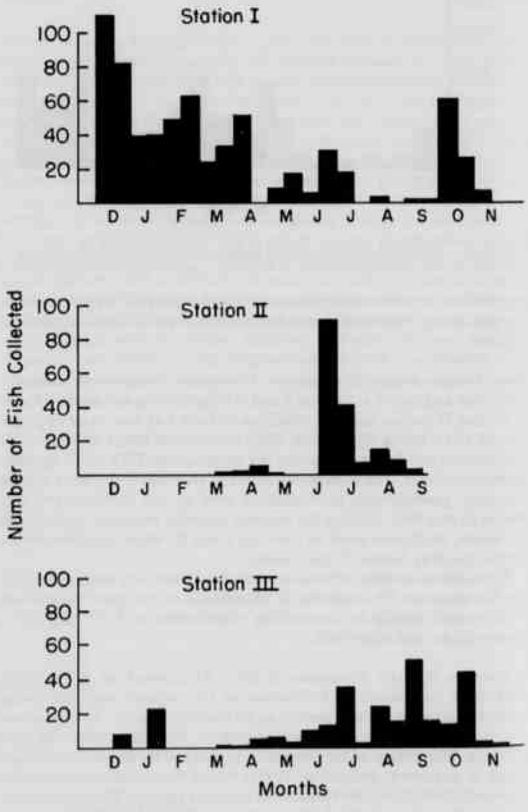

Figure 5. Seasonal abundance of the brook silverside.

have occurred. Hubbs (1921) stated that brook silversides probably die before the second winter of life. Nelson (1968) found no second annuli on scales from brook silversides collected at Crooked Lake, Indiana. However, Fogle (1959) found second annuli on scales from a few male silversides collected at Lake Fort Smith, Arkansas.

Blackspotted topminnows, although not present in large numbers, showed seasonal fluctuations (Fig. 6). They were first collected in relatively large numbers in the spring at the lowermost station, which might indicate movement from Clear Creek into Mud Creek. Numbers fluctuated at all stations during the summer. Young-of-the-year were collected from June through October with all the YOY collected at the lowermost station. The YOY may have moved out of Mud Creek into Clear Creek during late summer or early fall, causing a decline at all stations.

Small fluctuations in abundance of orangethroat darters in Mud Creek indicated population stability. Numbers were highest in the winter months. Of the numbers collected, 76% were from pools, and 24% were from riffles (Fig. 7). During the spring, numbers remained high only at Station III which included the largest riffle of all the stations. After March, less than 10 orangethroat darters were found at Station I, possibly because they had left the pool to spawn in riffles and didn't return. Station II had a relatively stable population during summer. Numbers were high and stable at Station III until late July when heavy rainfall destructed the riffle substation. For three months afterwards, none of this species was collected in the pool substations of Station III. Winn (1958) reported that orangethroat darters remained in calm raceway areas or in pools during the non-breeding season. Gerking (1959) stated that orangethroat darters are restricted in their movements. Reed (1968) studied six species of darters from Pennsylvania streams and found that relatively few moved from one riffle to another.

Of 263 orangethroat darters marked, only 3.6% were recaptured (Table 2), for several reasons. The destruction at the lower station destroyed the largest riffle sampled. Also, fin regeneration could have influenced the recognition of recaptures. Reed (1968) began marking darters in June, and by late summer many recaptures possessed a temporary white-tipped fin which eventually became normally colored. The efficiency of collecting darters, especially in the deep or rocky pool areas, was relatively low because many darters probably escaped under the lead line of the seine. The mark and recapture data were not enough to determine the extent of mobility of this species. However, the stability of numbers at the lower station seems to indicate that population levels of orangethroat darters remained relatively stable.

Differences in both fluctuations in abundance and recapture rate were noted for the five species studied. The mark and recapture data for bigeye shiner, bluntnose minnow, and brook silverside were the most significant, since the number of fish marked was considerably higher for those species. Bigeye shiners and bluntnose minnows seemed to be the most mobile of the marked species.

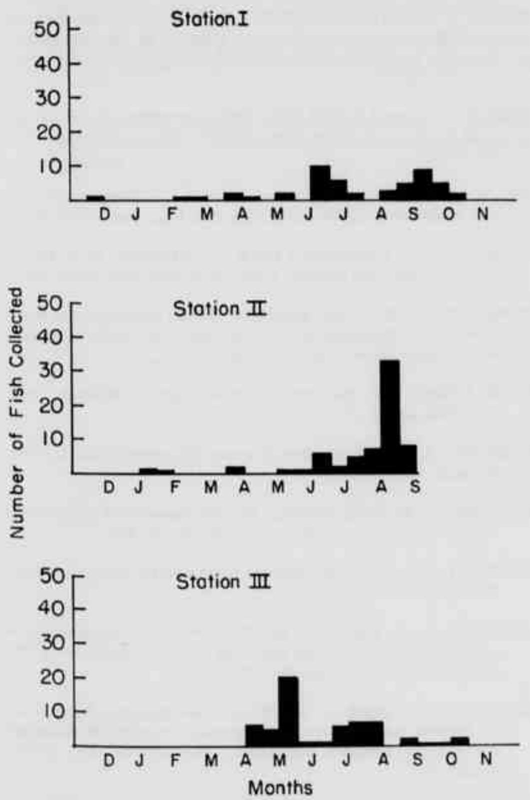

Figure 6. Seasonal abundance of the blackspotted topminnow.

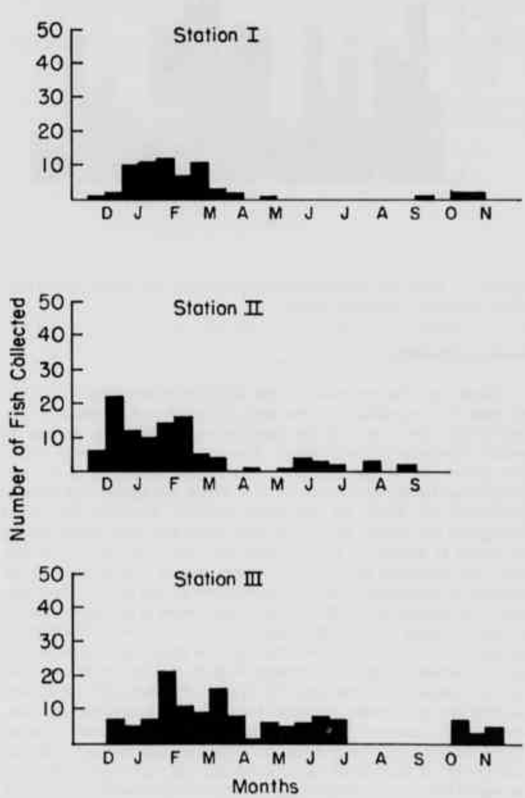

Figure 7. Seasonal abundance of the orangethroat darter.

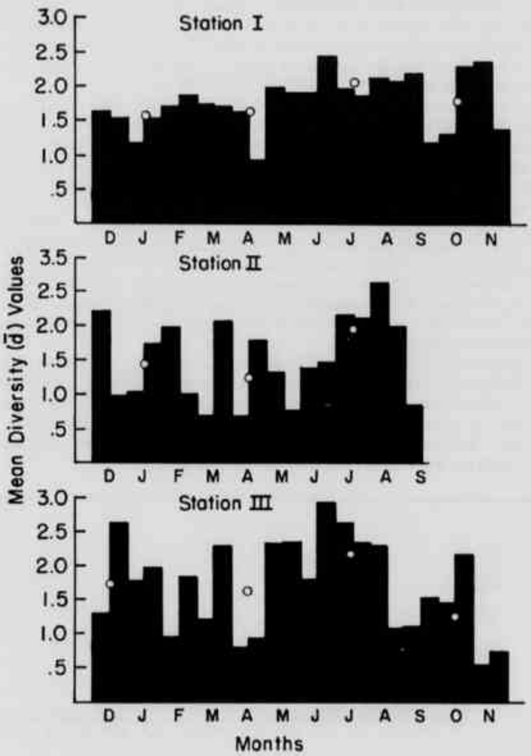

Figure 8. Seasonal changes in mean diversity (d). Open circles represent seasonal average d values.

Seasonal Diversity.

Community structure refers to the complex of individuals of different species comprising a community (Prather and Prophet, 1969). Community structure can be quantitatively defined by the use of species diversity indices. Mean diversity (d) values were stable throughout the winter months at the upper station (Fig. 8); one reason may be the stable numbers of brook silversides collected at Substation I-C then. At the other stations, d values fluctuated throughout the winter. Mean diversity values also were stable during the spring at Station I. The extreme low value for Station I in late April was probably the result of heavy rainfall which affected the community structure. However, at Stations II and III, d values also fluctuated greatly during the spring, with Station II having the lowest average d value during that time. The number and diversity of centrarchids collected at the other stations probably accounted for this fluctuation. From June through August, d values were high and relatively stable at all stations. The highest d values and the highest seasonal average d value occurred during the summer at each station. Smith (1963) reported that the richest species representation in an Illinois stream community occurred in late spring and early fall. In Mud Creek, d fluctuated throughout the fall. At Station III, the seasonal d value was noticeably lower, due to the absence of the riffle substation. Another factor responsible for these fall fluctuations in mean diversity was the changing numbers of YOY collected.

The seasonal patterns of mean diversity were generally similar at all stations, with the exception of the seasonal stability of d at the upper station. However, fluctuations in mean diversity occurred throughout the year, indicating dynamic stream-fish communities.

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