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Chronology of Appearance & Habitat Partitioning by Stream Larval Fishes

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CHRONOLOGY OF APPEARANCE AND HABITAT PARTITIONING BY STREAM LARVAL FISHES

A Thesis

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In Partial Fulfillment of the

Requirements for the Degree

Master of Science

by

Keith Brian Floyd

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CHRONOLOGY OF APPEARANCE AND HABITAT PARTITIONING

BY STREAM LARVAL FISHES

Recommended March 7, 1983
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(Date)

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BY STREAM LARVAL FISHES

Keith Brian Floyd May 1983 28 pages

Directed by: R. Hoyt, H. Shadowen, and F. Toman

Department of Biology Western Kentucky University

ABSTRACT

Larval fish were studied on the Middle Fork of Drake's Creek from 18 March 1982 to 9 September 1982. A total of 6,057 individuals representing 28 species and six unidentified cyprinids was collected. Micropterus sp. was the dominant species representing 33% of the total. Most of the remaining taxa were,generally,equally represented. Juvenile banded sculpins were the first larvae observed -- followed by darters, suckers, minnows, and sunfishes. The percid species, logperch, greenside darter, and Etheostoma (Ulocentra), illustrated the longest spawning periods, their larvae being taken from 24 March to 8 July. Maximum species occurrence was observed from 7 July to 15 July when over 20 species of larvae were collected. Larvae avoided the stream current, selecting for low-flow shoreline habitat areas, with few larvae being taken in stream drift. Two-way analyses of variance showed significant differences in habitat selection by nine species of larvae. The two habitats having the highest larval abundance were an emergent vegetation shoreline area and a limestone rock outcrop.

INTRODUCTION

During the past decade, most larval fish studies have dealt primarily with spatial and temporal distributions of larval fish within large lotic environments (Johnson and Edwards 1977, Harrow and Schlesinger 1980, Gale and Mohr 1978, Gerlach and Kahnle 1982, Bliss 1977, Cloutman and Edwards 1977) and reservoirs (Graser 1979, Kindschi et al. 1979, Edwards et al. 1977, Krause and Van Den Avyle 1979). Additional larval fish studies have originated from investigations of or resulted from environmental impacts of impingement (Edwards et al. 1977, Bliss 1977).

By contrast, field studies concerning larval fish in small lotic environments are relatively rare. Baker (1979) and Kranz et al. (1979) worked with small lotic systems but limited their interest to single species descriptions. Studies identifying feeding profiles, distribution patterns, chronology, habitat selections, etc., of complex larval communities in small streams are at this time not available.

The objectives of this investigation were to identify the spawning chronology and habitat selection by larval and juvenile fishes in the Middle Fork of Drake's Creek, a small free-flowing stream in south central Kentucky.

STUDY AREA

The study area included eight stations on the lower reaches of the Middle Fork of Drake's Creek, Warren County, Kentucky.

The Middle Fork of Drake's Creek originates in north central Tennessee and courses 33.8 km through portions of Allen, Simpson, and Warren counties, Kentucky. The convergence of the Middle Fork, West Fork, and Trammel Fork forms Drake's Creek which courses through the southeastern portion of Warren county, Kentucky, emptying into the Barren River 6.4 km east of Bowling Green, Kentucky.

The Middle Fork has characteristics which are typical of the karst topography of south central Kentucky having a bedrock or rubble substrate with alternating pool and riffle areas. The stream flows over a layer of Fort Payne, Salem and Warsaw limestone, siltstone and shale. The flood plain and higher elevations are capped with Salem, Warsaw, and St. Louis limestone covered with various thicknesses of alluvium. This alluvium consists of poorly sorted clay, silt, sand, and gravel (U.S.G.S. Adolphus and Hickory Flat, 1966, and Drake Quadrangle, 1973). Riparian vegetation consisted of oak, hickory, sycamore, beech, and some cedar of various density. Non-forested areas are utilized for agriculture, both crop and pasture land.

The creek descends from an elevation of 186 meters above mean sea level (msl) at the Tennessee-Kentucky boundary to an elevation of 146 meters above msl at its mouth with an average gradient of 3.0 m/km (Bell and Hoyt 1980).

Dissolved oxygen (DO) ranged from 11 mg/l on 18 March, 5 and 29 April, 10 May, and 9 September to 7 mg/l on 22 and 29 July. Temperatures varied from a low of 11 C on four occasions, 22 March, 5, 8, and 22 April to a high of 27 C on 26 July. Stream velocity ranged from 80 cm/s on 18 and 22 April to 8 cm/s on 12 August (Figure 1).

The study area was located 3.8 km upstream from the mouth of the Middle Fork. Sampling areas (Figure 2) were established on the basis of varying habitat type and included the following:

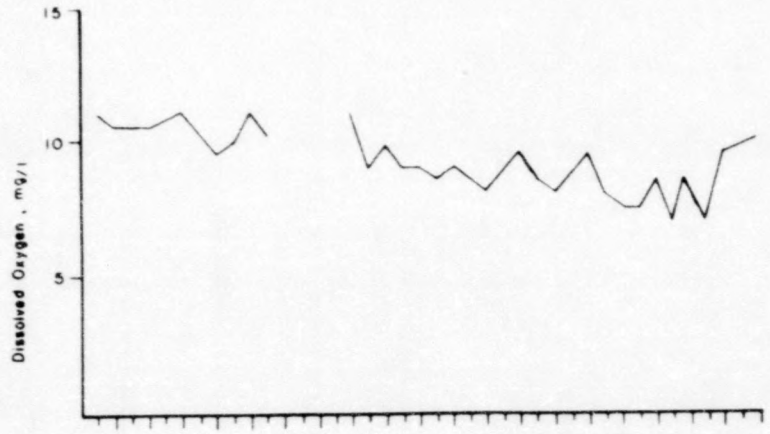
Station 1 & 2 - Vegetated Shoreline -- two sampling stations were identified along the outer edges of shoreline vegetation. The habitat included prominent stands of water willow, Justica sp., in backwater areas having a substrate of silt over clay. Both areas were quiet, eddy water zones separated from the current by exposed shoal bodies. Mean depth of the two sampling areas was 57 cm.

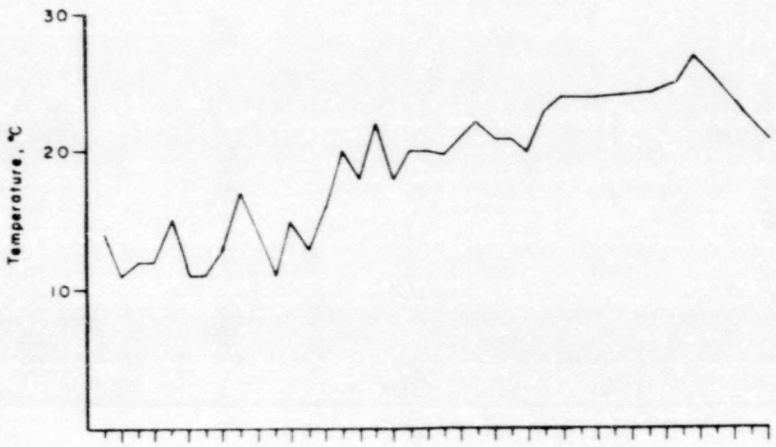
Station 3 - Undercut Bank-Tree Roots -- this area was adjacent to an undercut mud bank in the middle of a prominently exposed tangle of tree roots. The bank overhang was approximately 50 cm in height and 30 m long over a substrate of sheet bedrock overlain with small to medium sized rubble. Mean depth of the area was 38 cm.

Station 4 - Rock Outcrop-Gravel -- the upstream shoreline end of a limestone outcropping having a substrate of bedrock completely overlain with large gravel. The rock ledge was approximately 1.5 m in height, 55 m long, and extended out into the stream 0.5 m at its widest point. The sampling area was 44 cm deep at the face of the outcrop.

Station 5 - Rock Outcrop-Algal Mat -- the downstream end of the rock outcrop, nine meters downstream from Station 4. The substrate was bedrock and rubble completely matted over with filamentous algae,

Figure 1. Dissolved oxygen (mg/l), water temperature (degrees Celsius), and stream flow (cm/s) of the Middle Fork of Drake's Creek Kentucky, by sampling date, 18 March to 9 September 1982.


15
10
5
Dissolved Oxygen, mg/l


30
20
10
Temperature, °C

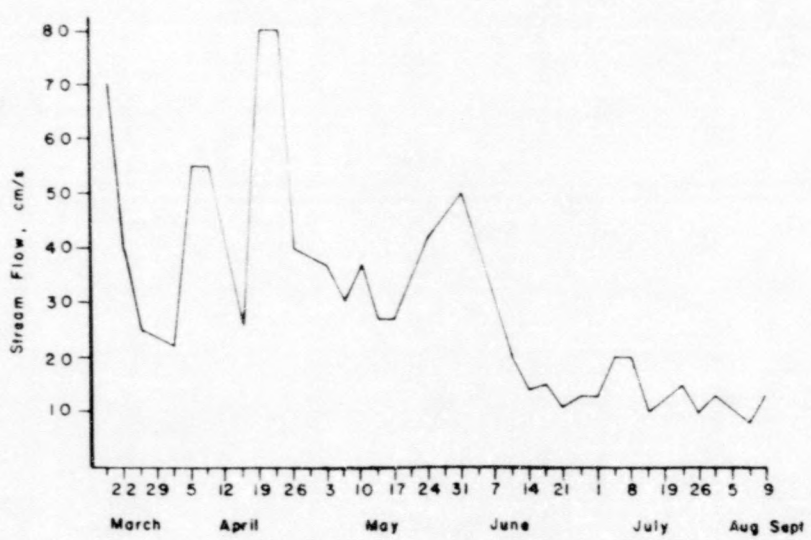
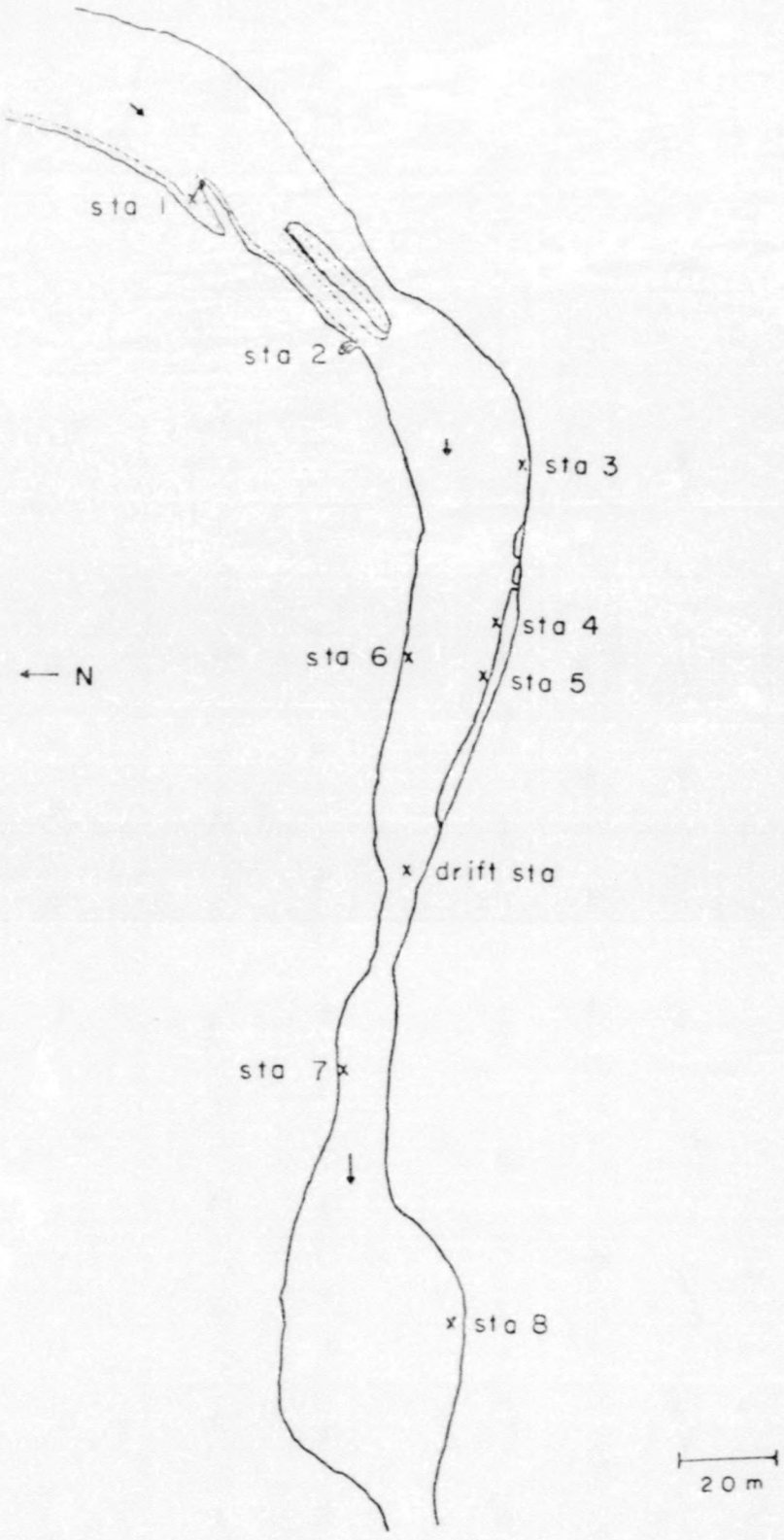

80
70
60
50
40
30
20
10
Stream Flow, cm/s
22 29 5 12 19 26 3 10 17 24 31 7 14 21 1 8 19 26 5 9
March
April
May
June
July
Aug Sept

Figure 2. Map showing collecting stations on the Middle Fork of Drake's Creek, Kentucky.


sta 1
sta 2
sta 3
sta 4
sta 5
sta 6
sta 7
sta 8
drift sta
N
20 m

Cladophora and Oedogonium sp. This area was deeper, 71 cm, and located closer to the bank.

Station 6 - Undercut Bank-Stream Current -- immediately across the stream from the rock outcrop and Stations 4 and 5. The substrate consisted of large gravel and mud along a mud bank. Sampling depth was 61 cm.

Station 7 - Pool-Tree Roots -- exposed tree roots along the bank at the upstream end of a small downstream pool. The substrate was bedrock overlain with silt. The sample site was 41 cm deep.

Station 8 - Pool-Open Water -- an open water, eddy area of the downstream pool identified in Station 7. The substrate was of silt and sand. The depth of the sample area was 47 cm, 2.5 m from the bank.

MATERIALS AND METHODS

Larval fish were collected from the Middle Fork of Drake's Creek from 18 March 1982 through 9 September 1982. Samples were taken with larval seines (mesh size 0.5 mm), 0.5 m conical drift nets (mesh size 0.5 mm), and light larval fish traps. Collections were made bi-weekly from 18 March to 29 July, except for May 27 when high water made sampling impossible. Additional collections were made on 5 and 12 August and on 9 September.

Drift net samples were taken at the lower end of Station 5 at a depth of 0.5 meter. Samples were five minute duration -- the first having been taken 30 minutes after sunset, the second one hour later, and the last sample two hours after sunset. Larval seines were swept through the different habitat areas prior to the setting of light traps.

Light traps were used from 29 April to 9 September. Turbid water conditions from 20 May to 3 June and from 18 July to 5 August rendered the traps ineffective for collecting.

Light traps were designed and constructed at Western Kentucky University and included four plexiglas tubes mounted in flat plexiglas plates forming an animal chamber with a stainless steel pan attached to the bottom. Four vertical openings, with an average width of 0.15 cm, running the height of the animal chamber allowed entrance of organisms from all sides. The light source was one incandescent bulb powered by two 1.5 volt "D" flashlight batteries. Light radiated from the trap for a radius of 1.5 m in normal water quality conditions.

Light traps were suspended from tripods, tree roots, or overhanging limbs depending upon the habitat of the stations. One trap was set in each habitat area with the top flush with the water surface for a period of 40 minutes. Larvae were washed into collection jars and fixed in 10 percent formalin.

Stream current velocity was determined with a General Oceanics flow meter. Dissolved oxygen and temperature were measured with a YSI Model 54A oxygen meter.

Samples were sorted and all meristic and morphometric data taken using a dissecting microscope equipped with an ocular micrometer and polarized filters. Specimens were stained with alizerin red-S to accentuate myomere and fin ray elements.

Identifications were made with the use of existing keys by May and Gassaway (1967), Hogue et al. (1976), and Lathrop (1982). Developmental terminology used is that of Snyder (1976). Specimens which could not be identified were sent to the Tennessee Valley Authority Regional Larval Fish Identification and Information Center.

RESULTS

A total of 6,057 larval and juvenile fishes representing six families and 28 species were collected from the Middle Fork of Drake's Creek from 22 March to 9 September 1982 (Table 1; Figure 3). Cyprinid species represented the greatest diversity with 12 species followed by six percid darters, five sunfishes, two suckers, two catfishes, and one sculpin. Fourteen species comprised over 95% of the total number while 13 species (mostly cyprinids) were each represented by fewer than 100 individuals (Table 1). Micropterus sp. was the most abundant species making up 33% of the total.

Larval Chronology - The appearance of larvae was staggered throughout the study period (Figure 3). The banded sculpin, Cottus carolinae, was the first species observed, being taken on 22 March at a water temperature of 11 C. In general, the sculpin was followed in order by the percid darters, catostomids, cyprinids, sunfishes, and catfishes. The duration of larvae of the different species was markedly different. Darter species represented the greatest larval time span with an average of 12 weeks followed by suckers seven weeks, cyprinids six weeks, sunfishes four weeks, and catfishes three weeks. The logperch, Percina caprodes, and greenside darter, Etheostoma blennioides, were represented by larval forms of 16 and 15 weeks, respectively, while the carp, Cyprinus carpio, occurred for only one week.

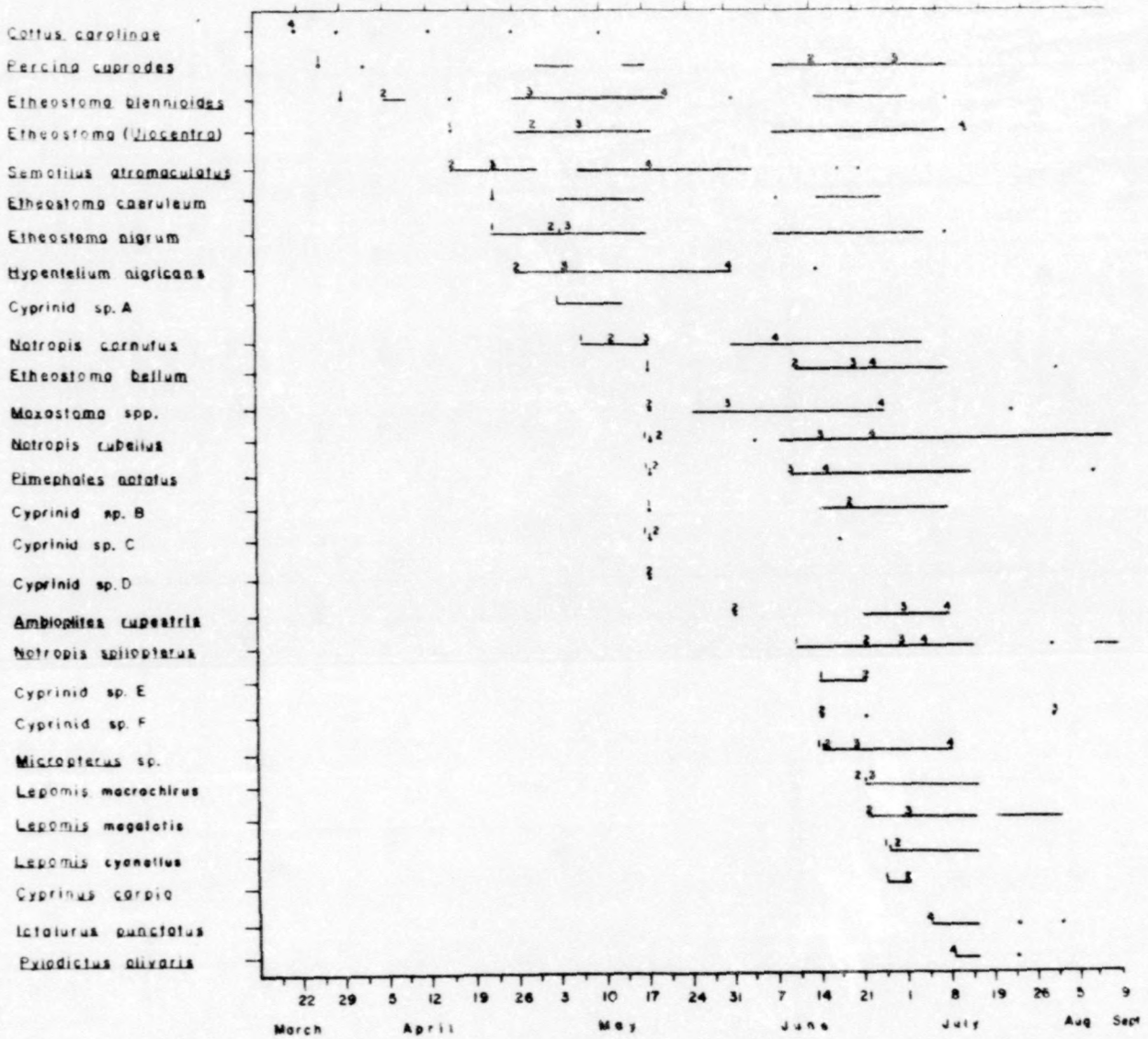
Table 1. Species list and number of individuals of larval and juvenile fishes collected by light traps, larval seines, and larval drift nets from the Middle Fork of Drake's Creek, Kentucky, 18 March to 9 September 1982.

Species	Light Trap	Seine	Drift	Total
Cottus carolinae	0	12	0	12
Percina caprodes	111	1	2	114
Etheostoma blennioides	442	94	0	536
Etheostoma (*Ulocentra*) sp.	337	6	0	343
Semotilus atromaculatus	33	227	1	261
Etheostoma caeruleum	183	8	0	191
Etheostoma nigrum	215	3	0	218
Hypentelium nigricans	218	72	0	290
Cyprinid Sp. A.	69	3	0	72
Notropis cornutus	174	11	0	185
Etheostoma bellum	77	4	0	81
Moxostoma sp.	52	226	1	279
Notropis rubellus	182	19	9	201
Pimephales notatus	317	5	1	323
Cyprinid Sp. B	41	0	0	41
Cyprinid Sp. C	18	0	0	18
Cyprinid Sp. D	1	0	0	1
Ambloplites rupestris	18	1	0	19
Notropis spilopterus	362	0	1	363

Table 1. continued

Species	Light Trap	Seine	Drift	Total
Cyprinid Sp. E	36	0	0	36
Cyprinid Sp. F	3	0	1	4
Micropterus sp.	1805	262	2	2069
Lepomis macrochirus	97	9	6	112
Lepomis megalotis	151	27	5	183
Lepomis cyanellus	21	3	1	25
Cyprinus carpio	17	0	0	17
Ictalurus punctatus	0	1	55	56
Pylodictis olivaris	0	0	7	7
TOTALS	4980	994	83	6057

Figure 3. Time of occurrence and duration of larval species in the Middle Fork of Drake's Creek, Kentucky, 18 March through 9 September 1982. 1 denotes the appearance of the first protolarvae; 2 denotes the first mesolarvae, 3 denotes the first metalarvae; 4 denotes the first juvenile.


Cottus carolinae
Percina cuprodes
Etheostoma blennioides
Etheostoma (Diocentra)
Semotilus atromaculatus
Etheostoma caeruleum
Etheostoma nigrum
Hypentelium nigricans
Cyprinid sp. A
Notropis cornutus
Etheostoma bellum
Moxostoma spp.
Notropis rubellus
Pimephales notatus
Cyprinid sp. B
Cyprinid sp. C
Cyprinid sp. D
Ambloplites rupestris
Notropis spilopterus
Cyprinid sp. E
Cyprinid sp. F
Micropterus sp.
Lepomis macrochirus
Lepomis megalotis
Lepomis cyanellus
Cyprinus carpio
Ictalurus punctatus
Pylodictus olivaris
22 29 5 12 19 26 3 10 17 24 31 7 14 21 1 8 19 26 5 9
March
April
May
June
July
Aug
Sept

Four periods of larval abundance were observed, 17 May, 21 June, 1 and 8 July, when 12%, 19%, 12%, and 8%, respectively, of the total were taken (Figure 4). On 17 May, larval representatives of 15 species were observed including seven cyprinids, six darters, and two catostomids (Figure 3). Six species, including the common shiner, Notropis cornutus, 19%, Etheostoma (Ulocentra) sp. (15%), northern hog sucker, Hypentelium nigricans, 12%, johnny darter, Etheostoma nigrum, 10%, and logperch 5% made up 61% of the total on 17 May (Figure 5). By 21 June, the number of species had increased to 19 with the net gain of one cyprinid and four sunfishes and the loss of one catostomid. Blackbass constituted 89% of the total on 21 June and 77% on 1 July (Figure 5). The fourth peak of abundance on 8 July included 16 species of which the bluntnose minnow, Pimephales notatus, spotfin shiner, Notropis spilopterus, rosyface shiner, Notropis rubellus, bluegill, Lepomis macrochirus, and longear sunfish, Lepomis megalotis, represented 85% of the total. These periods of collective larval fish abundance coincided with the period of maximum abundance of the individual species for each date (Figure 5). Four species, greenside darter, creek chub, Semotilus atromaculatus, orangefin darter, Etheostoma bellum, and Moxostoma sp. had maximum larval densities at times other than those listed above (Figure 5).

Habitat Selection - One percent of the larvae observed was captured as drift in the open stream channel (Table 1). All remaining larvae were taken in low to no-flow stream areas representing some combination of environmental habitat features. By far the greatest number of

Figure 4. Total number of fish larvae observed by sample date in the Middle Fork of Drake's Creek, Kentucky, 18 March through 9 September 1982.

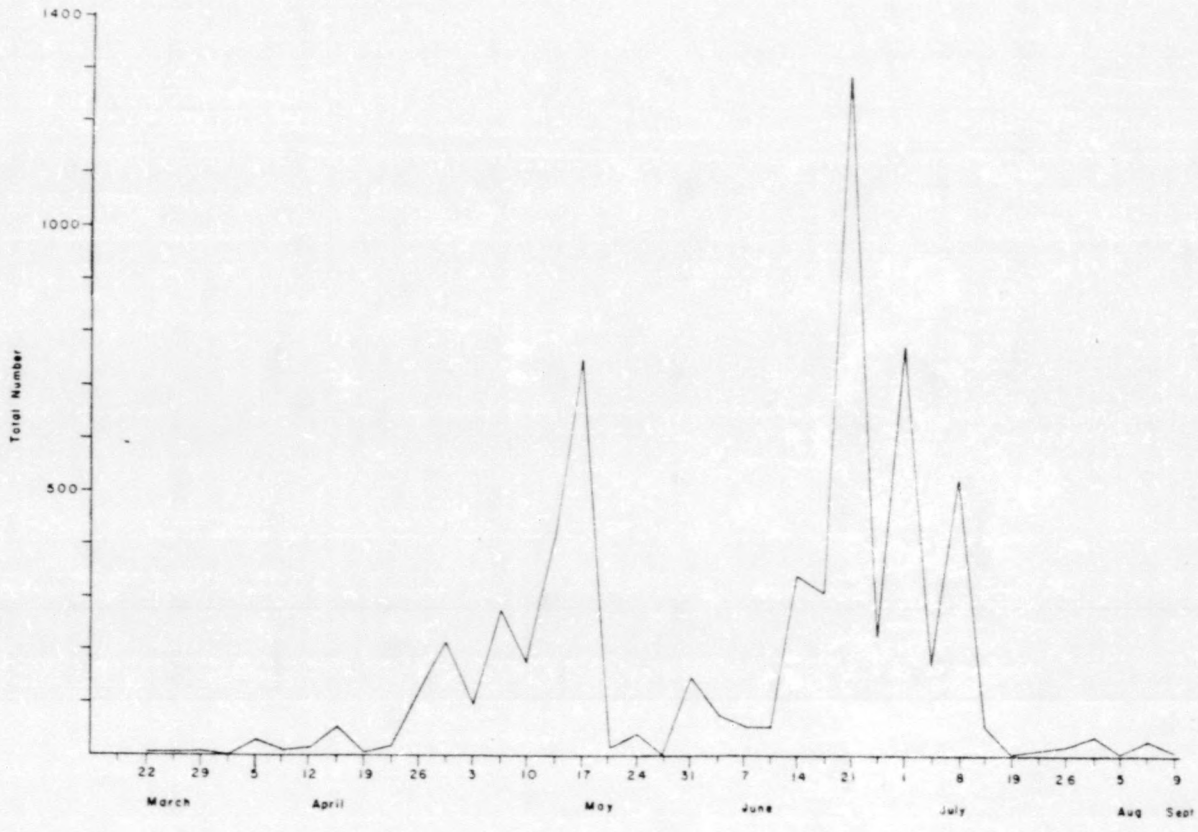
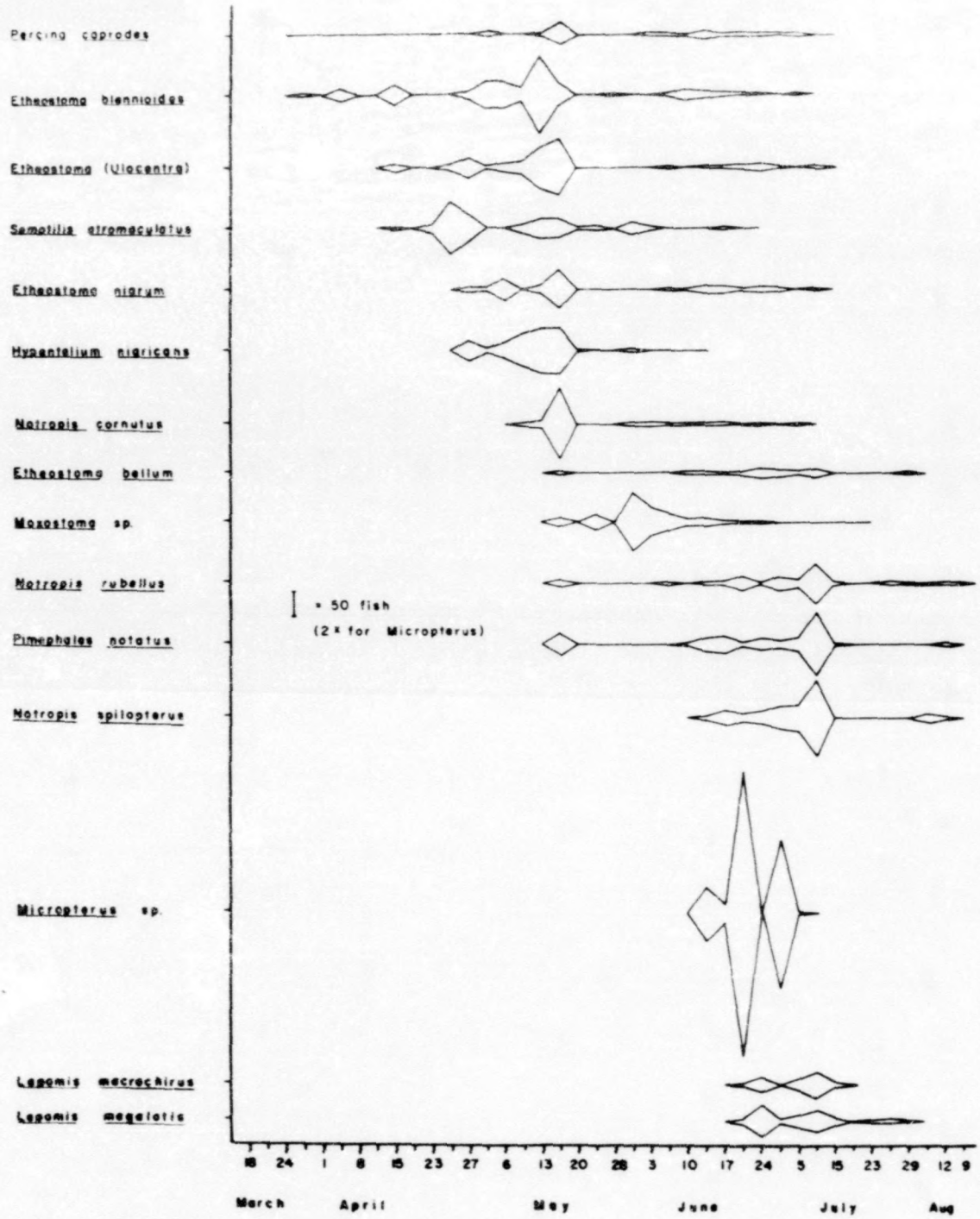

1400
1000
500
Total Number
22
29
5
12
19
26
3
10
17
24
31
7
14
21
1
8
19
26
5
9
March
April
May
June
July
Aug
Sept

Figure 5. Numerical abundance of the major larval fish species observed by sample date in the Middle Fork of Drake's Creek, Kentucky, 18 March through 9 September 1982.


Percina caprodes
Etheostoma blennioides
Etheostoma (Ulocentra)
Semotilus atromaculatus
Etheostoma nigrum
Hypentelium nigricans
Notropis cornutus
Etheostoma bellum
Moxostoma sp.
Notropis rubellus
= 50 fish
(2 x for Micropterus)
Pimephales notatus
Notropis spilopterus
Micropterus sp.
Lepomis macrochirus
Lepomis megalotis
18 24 1 8 15 23 27 6 13 20 28 3 10 17 24 5 15 23 29 12 9
March
April
May
June
July
Aug

larvae (39%) was taken in the vegetated shoreline area. The two habitat areas associated with the rock outcrop had the second highest number of larvae with the downstream matted algae substrate zone having more larvae than the upper bedrock region. The undercut bank-tree root habitat and downstream pool habitats had generally similar numbers of larvae, while the undercut bank-stream current area across the stream from the rock outcrop had the fewest specimens (Table 2).

The channel catfish, Ictalurus punctatus, and flathead catfish, Pylodictis olivaris, were observed to be drift specimens (Table 2). Only one channel catfish was captured in a non-drift area, being captured along the rock outcrop with a push seine. No catfish were taken in light traps in any habitat area.

The two-way analysis of variance indicated habitat to be statistically more important than time in determining larval density of individual species. The blackbass, Micropterus sp., was observed to select for the upstream vegetated shoreline area with 98% of the total ($P>0.05$) being taken there. The creek chub also showed a significant preference for habitat. Eighty-five percent ($P>0.05$) of all creek chubs were taken in the matted algae at the lower end of the rock outcrop. The darter, Etheostoma (Ulocentra) sp., showed a significant habitat preference with 75% ($P>0.05$) of the specimens being collected along the rock outcrop. Six species, greenside darter (85%), johnny darter (72%), and orangefin darter (84%), the bluegill (81%), and longear sunfish (74%), along with one unidentified cyprinid, Species A (71%), occurred in significantly greater numbers along the rock outcrop and in the undercut bank-tree root area ($P>0.5$).

Table 2. List of species and number of individuals collected at each of eight sample areas and drift in the Middle Fork of Drake's Creek, Kentucky, 18 March to 9 September 1982.

Species	Sample Area 1	2	3	4	5	6	7	8	Drift	Total
Cottus carolinae	1	0	0	0	11	0	0	0	0	12
Percina caprodes	19	7	9	17	35	1	17	7	2	114
Etheostoma blennioides	24	0	106	115	231	9	50	1	0	536
Etheostoma (Ulocentra) sp.	13	26	19	140	103	0	24	18	0	343
Semotilus atromaculatus	22	2	3	9	222	1	0	1	1	261
Etheostoma caeruleum	11	3	22	32	59	7	46	11	0	191
Etheostoma nigrum	28	3	30	46	80	0	21	10	0	218
Hypentelium nigricans	9	8	40	30	126	13	61	3	0	290
Cyprinid Sp. A	0	0	19	19	33	0	0	1	0	72
Notropis cornutus	54	18	17	77	4	2	3	10	0	185
Etheostoma bellum	3	2	18	14	36	3	0	5	0	81
Moxostoma sp.	119	15	22	12	109	1	0	0	1	279
Notropis rubellus	12	5	25	36	72	2	30	19	0	201
Pimephales notatus	68	8	36	71	59	3	19	58	1	323

Table 2. continued

Species	Sample Area 1	2	3	4	5	6	7	8	Drift	Total
Cyprinid Sp. B	4	0	3	19	13	0	0	2	0	41
Cyprinid Sp. C	0	0	0	0	0	0	0	18	0	18
Cyprinid Sp. D	0	0	1	0	0	0	0	0	0	1
Ambloplites rupestris	3	1	3	4	0	7	1	0	0	19
Notropis spilopterus	25	14	95	55	64	5	15	89	1	363
Cyprinid Sp. E	0	0	0	0	3	0	9	24	0	36
Cyprinid Sp. F	0	0	0	1	2	0	0	0	1	4
Micropterus sp.	2033	9	7	9	9	0	0	0	2	2069
Lepomis macrochirus	4	6	17	16	55	1	1	6	6	112
Lepomis megalotis	21	8	11	77	55	1	3	2	5	183
Lepomis cyanellus	5	0	2	10	7	0	0	0	1	25
Cyprinus carpio	0	0	2	5	10	0	0	0	0	17
Ictalurus punctatus	0	0	0	0	1	0	0	0	55	56
Pylodictis olivaris	0	0	0	0	0	0	0	0	7	7
TOTALS	2478	135	507	814	1399	56	300	285	83	6057

Although non-statistically significant, the sucker, Moxostoma sp., predominantly utilized two habitats. The majority of individuals (48%) were observed at the upstream vegetated shoreline area while 39% were taken in the algal mat at one end of the limestone rock outcrop. The remaining nine species also showed no significant preferences for specific habitat areas.

Species which occupied the same general habitats were usually found in equal numbers within these habitats unless influenced by time of spawning. The darters, northern hog sucker, and common shiner were taken from the rock outcrop during the late spring when peak spawning was occurring for these species. Creek chubs also utilized the rock outcrop as a primary nursery area, but peak abundance for this species occurred two to three weeks before the above species (Figure 5).

The sunfishes, which were selective for the undercut bank-tree root and rock outcrop habitats, utilized these areas during the summer in association with several minnow species including the spotfin and rosyface shiners and bluntnose minnow (Figure 5).

Eighty percent of the total number of larvae captured in the study were taken with lighted traps. The majority of larvae showed a positive phototaxic response. The creek chub and redhorse suckers showed a slight phototaxis, but greater numbers were taken with a push seine than with light traps. Channel catfish, flathead catfish, and banded sculpins showed complete avoidance for the light traps.

DISCUSSION

The time of occurrence of larvae of the different fish species in the Middle Fork of Drake's Creek generally agreed with that reported by Wallus and Grannermann (1978), Gale and Mohr (1978), Gerlach and Kahnle (1981) and Lathrop (1982). Cottids, percids and catostomids were the first larvae to appear in early to mid-spring followed by cyprinids, sunfishes and catfishes in late spring and summer.

The occurrence of juvenile banded sculpins in mid-March in this study suggested a very early spawning period for the species. Wallus and Grannermann (1978) reported banded sculpins in North Alabama to spawn in late January and February. Kindschi et al. (1979), however, reported sculpin larvae as late as May from Rough River Lake, Kentucky. Based upon the early growth history of the Alabama sculpin (Wallus and Grannermann 1978) and the time of occurrence of juveniles in this study, it was felt that sculpins spawned in the Middle Fork of Drake's Creek in mid to late February.

The prolonged spawning periods observed for darters and several cyprinids were consistent with findings by Faber (1982), Lathrop (1982), and Baker (TVA, personal communication). Darters, considered to be mainly spring spawners (Winn 1958), were present as proto-larvae from late March until early July. Hess and Winger (1976) suggested prolonged or repeated spawning activities to be adaptations to an uncertain food supply and unstable spawning conditions. No influence of these factors could be evidenced in this study however.

The spawning periods of sunfishes, Lepomis spp., observed in Drake's Creek occurred later and were of shorter duration than those reported for reservoirs (Kindschi et al. 1979, Krause and Van Den Avyle 1979) and rivers (Gerlach and Kahnle 1981 and Lathrop 1982). This later spawning activity may have resulted from the slower warming of the stream due to its spring fed nature, or to unusually high water levels in late May and early June. Water temperatures during this time averaged 20 C, slightly below the range of optimum spawning temperatures for Lepomis species as reported by Pflieger (1975). Pflieger (op. cit.) further stated that in Missouri, green sunfish (Lepomis cyanellus) spawning activity in spring fed Ozard streams lagged two to three weeks behind the spawning activity of the same species in Missouri prairie streams. Other factors influencing the length of the lepomid spawning period in Drake's Creek may have been a different set of physico-chemical variables affecting the onset and timing of reproductive activity in small lotic environments, or an extended more rigid time frame for spawning for species in a complex community.

The occurrence of catfish alevins in July in Drake's Creek was similar to findings by Potter et al. (1978) for channel catfish, but not consistent with their observations for flathead catfish which were also taken in July in Drake's Creek. Catfishes in this study were observed to have a short spawning period, occurring for only three weeks, while Kindschi et al. (1979) and Potter et al. (1978) reported catfish alevins for up to eight weeks.

The occurrence of several larval species as a multi-species complex in similar habitat areas and singular isolated species of larvae in Drake's Creek was similar to that of the community organization of adult fishes in the stream. This early aggregation and isolation of larval forms in occupying particular habitat sites appeared to be a function of the availability of food coupled with the suitability of the spawning site to serve as a nursery area or the protection against the current afforded the larvae by some habitat type away from the spawning area. These speculations were based upon the observations of Micropterus larvae in large numbers in protected vegetated shoreline areas where they were spawned and the aggregation of the logperch, greenside darter, johnny darter, and Etheostoma (Ulocentra) sp. along the rock outcrop, a habitat area away from the current areas where they were spawned.

The importance of low to no-flow conditions and an available food supply in the occupation of stream areas by larval fishes is supported in the literature. Hess and Winger (1975), Johnson and Edwards (1977), and Lathrop (1982) all reported fish larvae to concentrate along shorelines, out of the main channel of rivers and large streams, while Gerlach and Kahnle (1982) reported greater larval densities in vegetated shoreline areas. The benefits of shoreline vegetation may not be limited to affording cover or portection, but may also provide a concentrated food supply. Gerlach and Kahnle (1981) reported higher concentrations of zooplankton along and in vegetated areas in the Schuylkill River. Chandler (1937) suggested that macrophytes and algae filter out plankton as it moves downstream, while Pennak (1978) reported that dipteran larvae and other invertebrates accumulate in and around algae and other aquatic

plants. A concurrent detailed study of the drift food organisms available in Drake's Creek and consumed by larval fishes (Timbrook 1983) supported the above suggestion regarding available food and larval fish distribution.

An important observation regarding early larval dislocation and/or distribution should be presented at this time. In the case of the Micropterus species, there was no distribution by the larvae from the spawning areas in the shoreline vegetation; they simply swam up from the nest areas into the vegetation. There was some dislocation as a few individuals (less than 1%) were swept by the current to a variety of downstream habitats. However, in the case of the riffle, current spawners (darters and catostomids), these species, while not being dislocated by the current as drift, did manage to leave the spawning sites and, by some means, work their way through and over the substrate to the shoreline rock outcrop.

The chronology of spawning by the different species in Drake's Creek was so greatly overlapped that habitat and resource sharing was obvious throughout the time of larval occurrence. However, although larval representatives of as many as 19 species were present at one time during the study, the times of occurrence of maximum numbers of the species were staggered, allowing for some separation.

The community structure and habitats of some of the larvae of Drake's Creek were different from those of the adults while others were similar. As larvae, darters and lepomid sunfishes represented the largest species aggregate occurring along the rock outcrop and in the undercut bank-tree root zone. As adults, the darters moved from the rock outcrop to the current-riffle zone while the sunfish

stayed in the same area as the larvae. Cyprinid larvae were considered to be generalists in habitat selection on the basis of their being equally distributed through all but one habitat type. As adults, however, cyprinids aggregated in multispecies schools moving randomly through all stream sections, occasionally including the riffles. Larval suckers were generally similar to adults in being found in a variety of habitats. To summarize, whether a larval form occurred in a similar or different habitat area from that of the adult seemed to result from the suitability of the spawning site to serve as a nursery area.

The degree of antagonism among the larval species in Drake's Creek could not be determined. The only evidence of negative physical interaction was the case of piscivory by the Micropterus sp. on rosyface shiners and other non-identifiable cyprinid species (Timbrook 1983). Beyond that instance, it was assumed that sufficient resources were available to all species present.

LITERATURE CITED

Baker, J.M. 1979. Larval development of the greenside darter, Etheostoma blennioides newmanii. p. 70-91. In R.D. Hoyt (ed.). Proceedings of the Third Symposium on Larval Fish. Western Kentucky University, Bowling Green, Kentucky.

Bell, D.E. and R.D. Hoyt. 1980. Temporal and spatial abundance and diversity of fishes in a Kentucky stream. Trans. Kent. Acad. Sci. 41(1-2):35-44.

Bliss, Q.P. 1977. Fish larvae entrainment and distribution study. p. 75-95. In S.R. Carter (ed.). Missouri River Monitoring: Fisheries and Drift Population effects of the Calhoun Station. Annual Report for 1977. Nalco Environmental Sciences.

Chandler, D.C. 1937. Fate of typical lake plankton in streams. Ecol. Monog. 7(4):445-479.

Cloutman, D.G. and T.J. Edwards. 1977. Evaluation of potential entrainment at Cherokee Nuclear Station, South Carolina. p. 72-93. In L.L. Olmsted (ed.). Proceedings of the First Symposium on Freshwater Larval Fish. Duke Power Company, Huntersville, North Carolina.

Edwards, T.J., W.H. Hunt and L.L. Olmsted. 1977. Density and distribution of larval shad (Dorosoma sp.) in Lake Norman, North Carolina at McGuire Nuclear Station. p. 143-158. In L.L. Olmsted (ed.). Proceedings of the First Symposium on Freshwater Larval Fish. Duke Power Company, Huntersville, North Carolina.

Faber, D.J. 1982. Fish larvae caught by a light trap at Littoral sites in Lac Heney, Quebec, 1979 and 1980. p. 42-46. In J.V. Conner (ed.). Fifth Annual Larval Fish Conference. La. Coop. Fish. Research Unit.

Gale, W.H. and H.W. Mohr, Jr. 1979. Larval fish drift in a large river with a comparison of sampling methods. Trans. Amer. Fish. Soc. 107(1):46-55.

Gerlach, J.M. and A.W. Kahnle. 1981. Larval fish drift in a warmwater stream. p. 154-162. In L.A. Krumholz (ed.). The National Warmwater Stream Symposium. Southern Div. Amer. Fish Soc.

Graser, L.F. 1979. Spatio-temporal distribution of clupeid larvae in Barkley Reservoir. p. 120-138. In R.D. Hoyt (ed.). Proceedings of the Third Symposium on Larval Fish. Western Kentucky University, Bowling Green, Kentucky.

Harrow, L.G. and A.B. Schlesinger. 1980. The larval fish recruitment study. Omaha Public Power District. Environmental Bulletin No. 5.

Hess, T.B. and P.V. Winger. 1976. The occurrence and distribution of larval fish in the Cumberland River. Proc. Annual. Conf. S.E. Ass. Game Fish Comm. 30:295-310.

Hogue, J.J., R. Wallus and L.K. Kay. 1976. Larval Fishes in the Tennessee River. TVA Tech. Note B19, Norris, Tennessee. 67 p.

Johnson, S.R. and T.J. Edwards. 1977. Ichthyoplankton in the Yadkin River and potential entrainment at Perkins Nucelar Station. p. 117-142. In L.L. Olmsted (ed.). Proceedings of the First Symposium on Freshwater Larval Fish. Duke Power Company. Huntersville, North Carolina.

Kindschi, G.A., R.D. Hoyt and G.J. Overman. 1979. Some aspects of the ecology of larval fishes in Rough River Lake, Kentucky. p. 139-166. In R.D. Hoyt (ed.). Proceedings of the Third Symposium on Larval Fish. Western Kentucky University, Bowling Green, Kentucky.

Kranz, V.R., K.N. Mueller, and S.C. Douglas. 1979. Development of the young of the creek chub, Semotilus atromaculatus. p. 100-119. In R.D. Hoyt (ed.). Proceedings of the Third Symposium on Larval Fish. Western Kentucky University, Bowling Green, Kentucky.

Krause, R.A. and M.J. Van Den Avyle. 1979. Temporal and spatial variations in abundance and species composition of larval fishes in Center Hill Reservoir, Tennessee. p. 167-184. In R.D. Hoyt (ed.). Proceedings of the Third Symposium on Larval Fish. Western Kentucky University, Bowling Green, Kentucky.

Lathrop, B.F. 1982a. Ichthyoplankton density fluctuations in the lower Susquehanna River, Pennsylvania, from 1976 through 1980. p. 28-36. In J.V. Conner (ed.). Fifth Annual Larval Fish Conference. La. Coop. Fish. Res. Unit.

_____. 1982b. Keys to the larval and juvenile fishes from the lower Susquehanna River near Middleton, Pennsylvania. Ichthyological Associates, Inc.

May, E.B. and C.R. Gassaway. 1967. A preliminary key to the identification of larval fishes of Oklahoma, with particular reference to Canton Reservoir, including a selected bibliography. Oklahoma Fish Res. Lab. Contr. No. 164. Norman, Oklahoma. 42p.

Pennak, R.W. 1978. Freshwater invertebrates of the United States, second ed. J. Wiley and Sons, New York. 803p.

Pflieger, W.L. 1975. The fishes of Missouri. Missouri Dept. of Cons., Jefferson City. 343p.

Potter, W.A., K.L. Dickson and L.A. Nielson. 1978. Larval sport fish drift in the New River. Proc. Ann. Conf. S.E. Assoc. Fish and Wildl. Agencies. 32:672-679.

Snyder, D.E. 1976. Terminologies for intervals of larval fish development. p. 41-58. In J. Boreman (ed.). Great lakes fish egg and larval identifications: Proceedings of a Workshop. FWS/OBS 76/23 Natl. Power Plant Team. U.S. Fish and Wildl. Serv. Ann Arbor, Michigan.

Timbrook, S.K. 1983. Food Habits and the utilization of drift organism by stream larval fishes. Unpublished M.S. Thesis. Western Kentucky University, Bowling Green, Kentucky. 57p.

Wallus, R. and K.L. Grannermann. 1979. Spawning behavior and early development of the banded sculpin, Cottus carolinae (Gill). p. 199-235. In Wallus and Voigtlander (ed.). Proceedings of a Workshop on Freshwater Larval Fish.

Winn, H.E. 1958. Observations on the reproductive habits of darters (Pisces-Percidae). Am. Midl. Nat. 59(1):190-212.