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DISTRIBUTION OF FISH WITHIN HEADWATER RIFFLES OF THE ILLINOIS RIVER SYSTEM, WASHINGTON COUNTY, ARKANSAS

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ABSTRACT

Quantitative sampling of fish was performed in five headwater riffles of the Illinois River System, Washington County, Arkansas during low flow conditions. This study revealed differing fish species composition, biomass and feeding guild segregation between head and tail riffle reaches in 1st through 3rd order. Thirty species representing 10 families were identified. Of this number, darters (Percidae), sculpins (Cottidae), mad-toms (Ictaluridae), and central stonerollers (*Campostoma anomalum*) (Cyprinidae) comprised 67 to 98 percent of riffle head populations. Fish biomass was greater for riffle head areas (0.58-6.6/0.28-2.0 g/m²) with insectivores and herbivores dominating. Total fish numbers decreased from riffle heads to tails, while number of species increased. Dominant fish groups in tail areas were minnows (Cyprinidae), darters (Percidae), and sunfishes (Centrarchidae). Feeding guild fish groups in tail areas were predominately insectivore and insectivore-piscivore. Stomach analysis of *Cottus carolinæ*, the dominant headwater riffle predator, indicated selective feeding of macrobenthic invertebrates and fish based on size class. Abundance of herbivore and insectivore fishes in riffles, particularly head reaches, suggests a correlation with positive rheotaxic behavior, microhabitat preference or abundance of macrobenthic invertebrate populations.

INTRODUCTION

Stream fish distribution, species number, and diversity have been found to increase with longitudinal distance from headwaters. Increase in species has been found by numerous investigators to be addition of species rather than replacement (Evans and Noble, 1979). Increase in diversity downstream has been steepest for those rivers with the steepest decrease in physical variability, and number of species in downstream sections was greater in rivers with more constant habitat conditions (Horwitz, 1978). Sheldon (1968) cited stream depth rather than longitudinal position in explaining observed changes. In biologically diverse streams distribution of fish species has been found to be constrained by environmental tolerances, competition, and predator-prey interactions (Smith and Powell, 1971). Distribution has also been correlated with habitat preference. Matthews and Hill (1979a; 1979b) and Matthews and Maness (1979) noted that seasonal changes and varying tolerances and preferences of cyprinids might result in differing patterns of distribution and movement.

Investigations into species preferences have suggested positive trends in specific habitat partitioning in a southern Mississippi river (Baker and Ross, 1981) and less structured overlap and transitory associations in a southwestern Oklahoma river (Matthews and Hill, 1980). Multivariate analysis has been used to delineate species preferences for habitat and distribution within stream reaches (Felley and Hill, 1983).

Community structure of fish populations has been shown to change with habitat type and season. Orth and Maughn (1984) working in a southeast Oklahoma stream stated that standing fish stocks were higher in pools than riffles. They also noted a difference in feeding structure between habitat type, with seasonal cycles dictating dominance of feeding guilds in riffles and pools. Matthews (1982) investigated six watersheds

in the White River drainage of northwest Arkansas and southeast Missouri and found that the mutual abundance of thirteen species of fish was no more structured than could be explained by random occurrence.

Dewey (1981) reported that seasonal fluctuations in fish abundance occurred throughout the year in Mud Creek, a tributary of Clear Creek, in the Illinois River system, north-central Washington County, Arkansas. Five species of fish, *Notropis boops*, *Pimephales notatus*, *Fundulus olivaceus*, *Labidesthes sicculus*, and *Etheostoma spectabile* populations were estimated by the mark-recapture method twice monthly for one year. Dewey (1981) found *E. spectabile* and *Campostoma anomalum* to be stable, dominant species in his riffle substation. He also noted that riffle substation fish populations remained relatively stable throughout the year while pool populations fluctuated. Gerking (1959), Reed (1968), and Winn (1958) reported that *E. spectabile* was restricted in its movement, seldom moving from one riffle to another.

Position of fish species in riffles may be dependent on food availability or prey selectivity. Lotrich (1973) and Todd and Stewart (1985) have commented on the insectivorous feeding of darters and sculpins. In both studies habitat partitioning and prey selection were important factors in feeding of darters and sculpins.

Brown and Brown (1984) have documented a strong upstream-biased distribution of lotic insects within riffles of the Brazos River, Palo Pinto County, Texas, with greater abundance of insects toward the heads of riffles. Hoover (1985) noted that five species of fish inhabiting riffles of the Illinois River in Oklahoma fed on a diverse assemblage of invertebrates, primarily mayflies and chironomids. Todd and Stewart (1985) working in Flint Creek, Delaware County, Oklahoma found mayflies, chironomids, amphipods and crustaceans to be important dietary items of *E. spectabile*, *E. punctulatum* and *C. carolinæ*. These

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investigations suggest that if invertebrates are distributed in riffles with an upstream bias, fish feeding on invertebrates might show a similar bias.

This investigation tested the hypothesis that stream fishes inhabiting headwater riffles in the Illinois River System, Arkansas are partitioned in their distribution based on food and/or microhabitat preference during low flow conditions. And that fish biomass will change from head to tail within riffle reaches.

STUDY AREA

The Illinois River System lies in the extreme northeastern portion of Arkansas draining an area of approximately 1,200 km². The river is located in the Ozark Plateau, flows out of the Boston Mountains Plateau, across the predominantly limestone Springfield Plateau for 64 km attaining fifth order before being impounded at Lake Francis on the Arkansas-Oklahoma border (Limbeck, 1986). The majority of the drainage basin is karst-chert substratum covered by oak-hickory forest and pasture. Continuous flow in the headwater stream reaches is dependent on extended rainfall. Intermittent flow occurs in late summer and early fall (Borengasser, 1968).

Stream channels in the Illinois River System are fluvially-formed alluvial, riffle-pool structure from headwaters to at least fifth order. Long, deep, slow flowing pools alternate with short, shallow riffles. Gravel is concentrated in riffle areas and slopes of pools, while pool bottoms are predominantly bedrock (Brussock, 1986).

MATERIALS AND METHODS

Quantitative fish samples were collected in headwaters through third order reaches of the Illinois River system, Washington County, Arkansas (Fig. 1). Each riffle was visually inspected, measured, then partitioned into two areas, (head-tail) based on depth, flow, and substrate. Small mesh block nets were placed at the ends of each area to prevent fish movement in and out of the study area. Fishes were captured by electrofishing with a generator coupled to a variable voltage pulsator (Coffelt VVP-2C) and hand held electrodes. Specimens were pre-

served in 10% formalin in the field. Upon return to the laboratory, fish were identified to species (Buchanan, 1973), weighed, measured, preserved in 50% isopropanol and catalogued.

Population size for each species was estimated. Areas within sites were compared for fish community distribution and partitioning. Food preference was estimated for selected species. All species were grouped by feeding guilds based on general descriptions of food habits (Pflieger, 1975).

Food habits were determined for *C. caroliniae*. After collection specimens were placed on ice. Upon return to the laboratory individual fish were weighed (gm), measured (mm), and 10% formalin was injected into abdominal cavities to preserve stomach contents. Individuals were segregated according to riffle head or tail and size class. Ten representatives were randomly selected from each size class, stomach contents analyzed (Hyslop, 1980), and identified to order. Surber samples were collected in head and tail riffle areas at two sites. Samples were preserved in 10% formalin in the field, upon return to the laboratory samples were washed in tap water, benthic organisms separated, enumerated and identified to order (Merritt and Cummins, 1984; Usinger, 1956).

Structure of the fish community at each site and habitat type was summarized using percentage composition of biomass by species and by feeding guild. Flow, dissolved oxygen, temperature and substrate particle size were determined in each study area following Platts *et al.* (1983).

RESULTS

A total of 1,720 individuals comprising ten families and thirty species were represented in electrofishing samples (Table 1). Although headwater riffle areas had fewer species (6-12/6-15) biomass was consistently

Table 1. Species list for selected riffles, 1st through 3rd order reaches of the Illinois River System, Washington County, Arkansas (1 = herbivore-detritivore; 2 = omnivore; 3 = insectivore; 4 = insectivore-piscivore).

Clupeidae	Poeciliidae
<i>Dorosoma cepedianum</i> (2)	<i>Gambusia affinis</i> (3)
Cyprinidae	Atherinidae
<i>Campostoma anconium</i> (1)	<i>Labidesthes sicculus</i> (3)
<i>Hybopsis x-punctata</i> (3)	Centrarchidae
<i>Nocomis asper</i> (3)	<i>Ambloplites aricomus</i> (4)
<i>Notropis boops</i> (3)	<i>Lepomis cyanellus</i> (4)
<i>Notropis chrysocephalus</i> (3)	<i>Lepomis macrochirus</i> (3)
<i>Notropis nubilus</i> (3)	<i>Lepomis megalotis</i> (3)
<i>Notropis spp.</i> (3)	<i>Micropterus dolomieu</i> (4)
<i>Notropis rubellus</i> (3)	<i>Micropterus salmoides</i> (4)
<i>Notropis telescopus</i> (3)	
<i>Pimephales notatus</i> (2)	
Catostomidae	Percidae
<i>Hypentelium nigricans</i> (3)	<i>Etheostoma biennioides</i> (3)
<i>Moxostoma spp. juvenile</i> (3)	<i>Etheostoma flabellare</i> (3)
	<i>Etheostoma punctulatum</i> (3)
Ictaluridae	<i>Etheostoma spectabile</i> (3)
<i>Noturus exilis</i> (3)	<i>Etheostoma zonale</i> (3)
	<i>Percina caprodes</i> (3)
Cyprinodontidae	Cottidae
<i>Fundulus olivaceus</i> (3)	<i>Cottus caroliniae</i> (4)

higher than tail areas (0.58-6.6/0.28-2.0 g/m²). Fish biomass did not show an increase with stream order, but numbers and total weight of fish samples increased with stream order (Table 2). Mean length and weight per individual also increased with stream order. Darters (Percidae), sculpins (Cottidae), stonerollers (Cyprinidae), and madtom catfish (Ictaluridae) dominated riffle head samples (67-98%) and comprised a substantial percentage of tail area populations (35-77%).

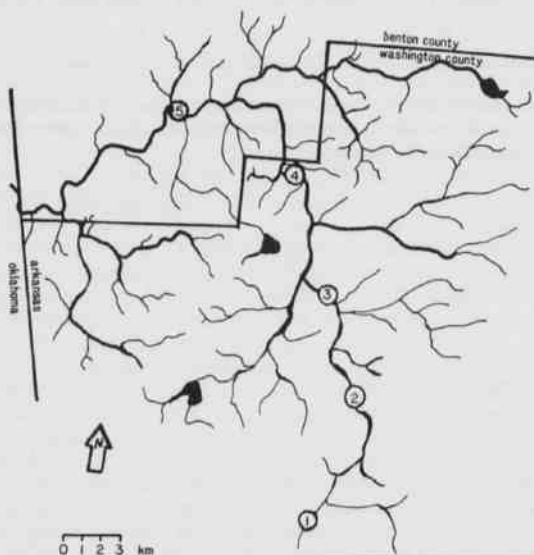


Figure 1. Map of Illinois River System, northwestern Arkansas from Brussock (1986). Stream orders in circles.

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Sunfishes (Centrarchidae) and minnows (Cyprinidae) were abundant in tail areas (23-61%) (Table 3).

Dominant feeding guilds in riffle head areas were herbivores and insectivores, while riffle tails were dominated by insectivores, insectivores-

Table 2. Fish biomass, numbers, and area for head/tail riffle areas of selected reaches (1st - 3rd order) of the Illinois River System, Washington County, Arkansas.

	3rd order ----->----->-----> 1st order									
	Hwy 31		Savoy Road		Harmon Road		Great House		Small Trib.	
	H	T	H	T	H	T	H	T	H	T
Length (m)	29	43	12	21	60	60	8	30	7	30
Width (m)	17.6	14.3	22.3	7.4	32.0	32.0	17.5	7.3	4.2	6.3
Area (m ²)	510.4	614.9	276.6	255.4	1920	1920	140	219	29.2	189
Number Fish	305	123	706	167	114	72	94	34	47	58
Weight Total (g/m ²)	528	568	1384	315	1113	538	262	122	192	153
Biomass (g/m ²)	1.03	0.92	5.00	2.03	0.58	0.28	1.87	0.56	6.60	0.81
Species Number	7	15	12	15	11	11	8	6	7	6

piscivores, and omnivores (Table 1). *C. anomalum*, a herbivore, was the most numerous specimen collected at all sites, and was primarily concentrated in head areas of riffles. Large-size *C. carolinae*, insectivore-piscivore, *E. flabellare*, *E. spectabile* and *Noturus exilis*, insectivores, were also abundant in riffle heads. Smaller sizes of *C. carolinae* were

Table 3. Percent composition by number of fish group in head and tail riffle areas (1st - 3rd order), Illinois River System, Washington County, Arkansas.

	3rd order ----->----->-----> 1st order									
	Hwy 31		Savoy Road		Harmon Road		Great House		Small Trib.	
	H	T	H	T	H	T	H	T	H	T
Darters % Total	0.05	0.06	0.05	0.19	0.06	0.11	0.64	0.21	0.57	0.02
Sculpins % Total	0.02	0.07	0.03	0.03	0.07	0.16	0.10	0.32	0.28	0.03
Stonerollers % Total	0.91	0.36	0.84	0.53	0.34	0.14	0	0.09	0.06	0.30
Madtoms % Total	0	0	0.03	0.02	0.02	0.03	0.13	0.08	0	0
Total (x100)	98	49	95	77	49	44	87	70	94	35
Sunfish % Total	0.02	0.08	0.02	0.01	0.06	0.16	0.07	0	0.06	0.01
Minnows % Total	0	0.25	0.03	0.22	0.42	0.39	0.04	0.26	0	0.60
Total (x100)	2	33	5	23	48	55	11	26	6	61

consistently collected in riffle tails. *Lepomis cyanellus*, *L. megalotis*, *Micropterus dolomieu*, and *M. salmoides*, insectivores-piscivores; *N. boops*, *N. spp.*, *N. telescopus*, insectivores; and *P. notatus*, an omnivore; dominated riffle tail areas.

A total of seventy-two *C. carolinae* (49 riffle heads; 23 riffle tails) were collected. Large-size *C. carolinae* (75-112 mm) were more abundant than small-size sculpins in riffle head areas. Dominant food items for this group consisted of Isopoda (17.4%), Decapoda (26.1%), and fish (43.5%), while Diptera (61.8%) and Ephemeroptera (18.1%) were

Table 4. Percentage of food items by number for two size classes of *Cottus carolinae*, Illinois River System, Washington County, Arkansas.

Food Item	Size Class	
	(37 - 59 mm)	(75 - 112 mm)
Diptera (Chironomids)	61.8	0
Ephemeroptera	18.1	8.7
Plecoptera	1.8	4.3
Tricoptera	7.3	0
Amphipoda	9.1	0
Isopoda	1.8	17.4
Decapoda (Orconectes)	0	26.1
Fish	0	43.5

major food items for small-size sculpins (37-59 mm) (Table 4). In forty percent of large *C. carolinae*, fish and *Orconectes* (Decapoda) were the only food items in stomachs. Surber samples at two sites showed a high abundance of Diptera (Chironomids) and Ephemeroptera in both riffle heads and tails (Table 5).

Study areas differed greatly in channel and water width, depth, substrate particle size, and length (Table 6). Riffle heads were smaller in area (m²), shallower, swifter and had a more heterogenous substrate than riffle tails. Channel water width was wider in head areas, but length

Table 5. Percentages of benthic organisms by number identified from Surber samples of two sites in headwater riffles, Illinois River System, Washington County, Arkansas.

Organism	Otter Creek		Great House Spring	
	Head	Tail	Head	Tail
Diptera	24.3	19.3	42.7	17.2
Ephemeroptera	44.3	22.7	33.0	41.3
Tricoptera	5.2	7.6	5.6	3.4
Decapoda	0.8	0.8	0.8	10.3
Amphipoda	9.6	18.5	0	0
Isopoda	0.8	2.5	0	0
Annelida	0	4.2	0	10.3
Odonata	13.9	17.6	8.1	0
Megaloptera	0	0	1.6	0
Coleoptera	0	0	0.8	13.8
Mollusca	0	0	5.6	3.4
Unidentified	0.8	3.4	0	0

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